# Soil & Water Conservation vis-a-vis Changing Climate to Sustain Food Production


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# Change analysis and projection/prediction of Runoff, Erosion, Sediment loss and Soil moisture Dynamics in a Production System (soil & water conservation in watershed mode)

## Factors affecting:

**Topography, geology and soils**
**= f(spatial variation)**

**Climate = f(changing climate)**
**Precipitation amount**
**Precipitation intensity**
**Temperature**
**Evapotranspiration = f(Precip., Temp., RH, Wind speed, Vapour pressure etc.)**
**Soil moisture = f(Precip., Runoff, SM storage, Evapotranspiration)**

**Anthropogenic influences**
**Land use changes = f(changing climate, externalities)**

**Biology**
**Vegetation cover**
**Animal activity**

Upstream Research:
At Global, National level
Intermediate Analysis and Strategic Planning:
At National, Regional level
Downstream implementation:
At Local level for adaptation to CC through corrective measures having a direct bearing on mitigation strategy on a formal **Watershed platform**

Analysis of the interactions within and amongst these factors is complex to project the effects of changing climate scenarios. However simulation is possible with a certain level of simplification?

# Climate Projections

**Av. Surface temperature: increase by 2 - 4°C during 2050s**

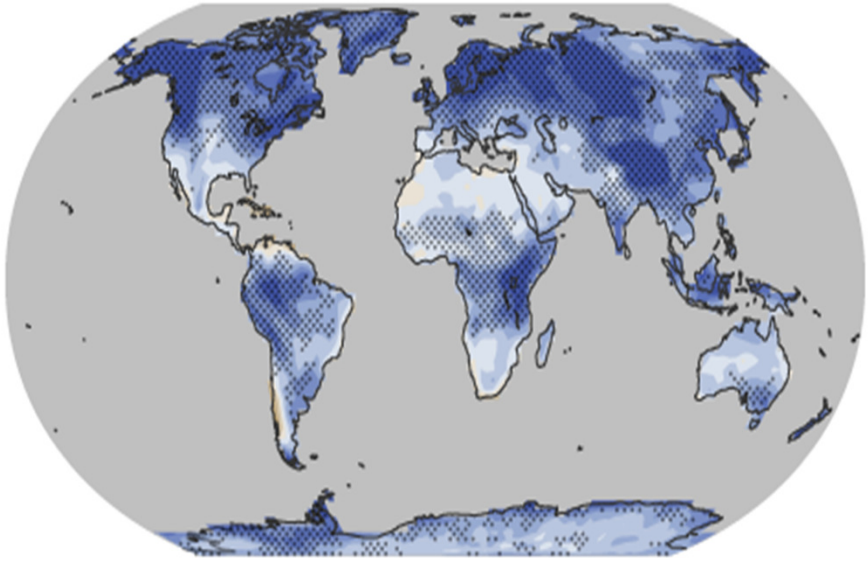
**Monsoon Rainfall: Marginal changes in monsoon months (JJAS)**

**: Large changes during non-monsoon months**

**No. of rainy days: set to decrease by more than 15 days**

**Intensity of rains : to increase by 1-4 mm/day**

**Cyclonic storms: Increase in frequency and intensity**

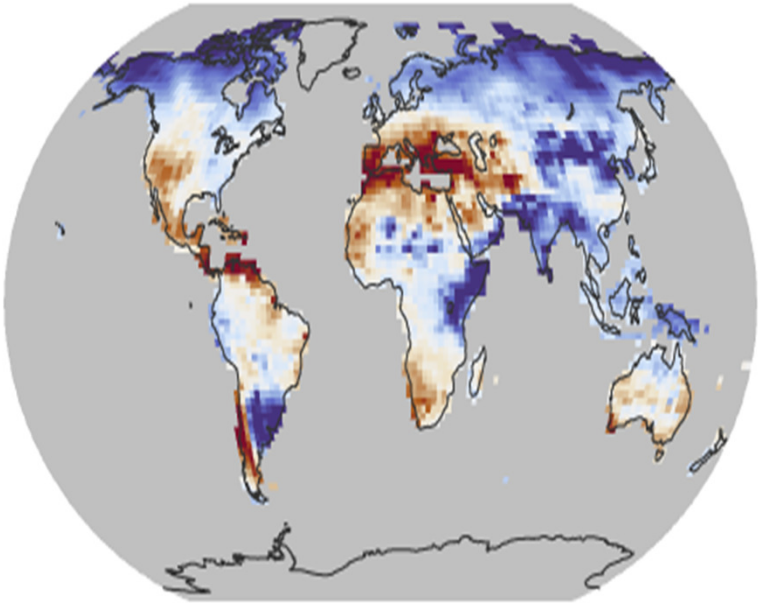


**Change in Precipitation Intensity** (standard deviations)

-1.5 -1 -.5 0 .5 1 1.5

One expected effect of climate change will be an increase in precipitation intensity: a larger proportion of rain will fall in a shorter amount of time than it has historically. Blue represents areas where climate models predict an increase in intensity by the end of the 21st century, brown represents a predicted decrease. (Map adapted from the IPCC Fourth Assessment Report.)

Source: NASA



**Change in Runoff** (percent)

-40 -20 0 20 40

Changes in water runoff into rivers and streams are another expected consequence of climate change by the late 21st Century. This map shows predicted increases in runoff in blue, and decreases in brown and red. (Map by Robert Simmon, using data from Chris Milly, NOAA Geophysical Fluid Dynamics Laboratory.)

# Climate Risks of Indus-Gangetic Basin in India

Temperature rise : High

Glacier retreat : High

Frequent floods : High

Frequent droughts: High

Sea-level rise : Modest

(Ref: Hosterman *et al.*, 2009)

**One of the most serious implications of Climate Change**

**is the increase in**

**Extreme Weather Events**

# Climate Change Impacts on Soil Erosion – Model Studies

Changes in rainfall amount associated with changes in storm rainfall intensity will likely have a much greater impact on runoff and erosion than changes in rainfall amount alone.

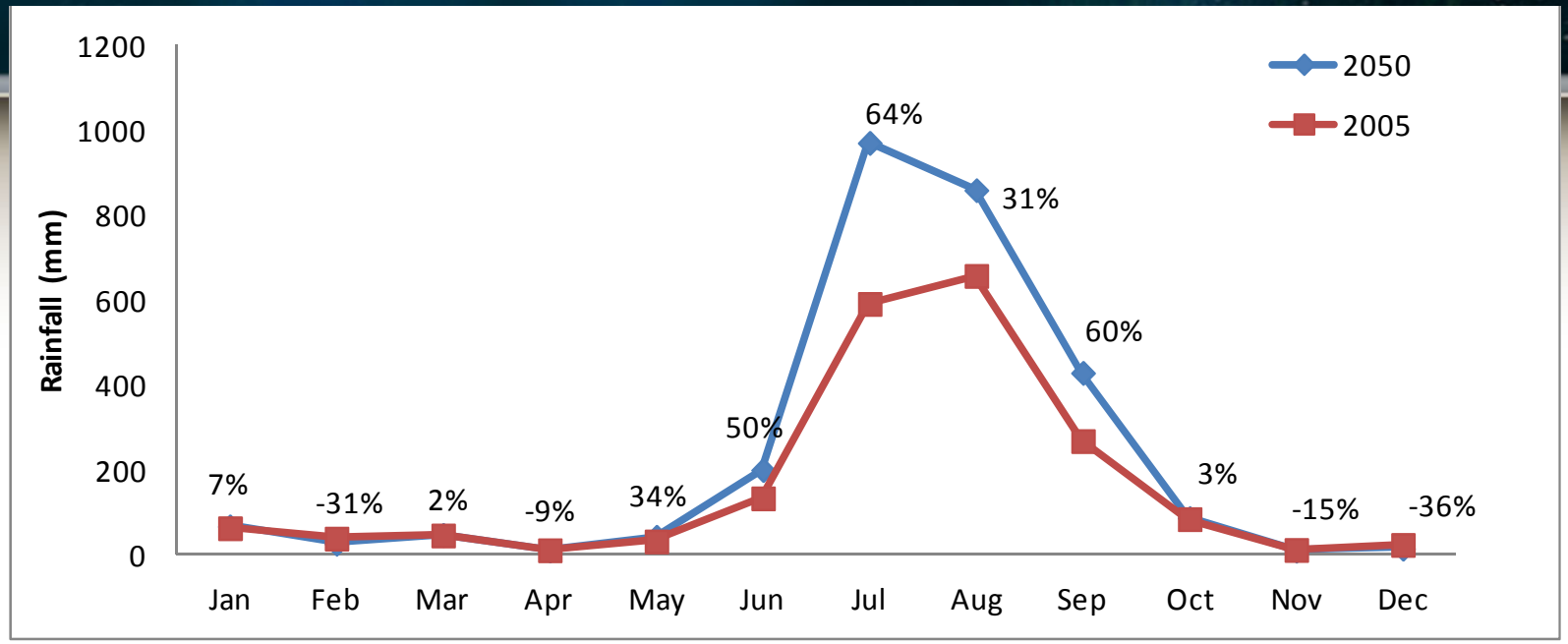
Changes in ground cover (cover in contact with the soil surface) have a greater impact on both runoff and erosion than changes in canopy cover alone.

Ref: Nearing et al. / Catena 61 (2005)

# Climate Change Impacts on Spatial Variability of Soil Moisture

- Soil moisture depends on exchange process of moisture amongst soil, vegetation, and atmosphere. This is important for productivity, vegetation dynamics and nutrient dynamics.
- Changes in soil moisture caused by future shifts in climate may have far-reaching implications for the structure and dynamics of ecosystems, and for water availability.
- It is important that projections of future impacts of climate change involve assessments of shifts in spatial and temporal patterns of soil moisture and related processes such as evapotranspiration

# Rainfall Scenario in Uttarakhand under Climate Change




- Rainfall likely to be more by 34-64% during the months May to September
- High monsoon rainfall and high intensity storms are being experienced at present
- Decline in rainfall during winter months by 15-36%
- Less Winter rainfall causes more water scarcity in hilly areas

# Rainfall Trend of Dehradun (UK)

| Parameters | 1957-2012 | | | 1983-2012 | | |
|---|---|---|---|---|---|---|
| | Kendall (Z) | Sen's Slope | Trend | Kendall (Z) | Sen's Slope | Trend |
| **Annual Rainfall** | -1.00 (0.16) | -2.34 | Decreasing | -1.20 (0.12) | -8.30 | **Decreasing** |
| **June Rainfall** | 0.56 (0.29) | 0.44 | Increasing | -0.43 (0.33) | -1.13 | **Decreasing** |
| **Monsoon Rainfall** | -0.42 (0.34) | -1.03 | Decreasing | 0.14 (0.44) | 1.72 | **Increasing** |
| **One day Maximum rainfall** | 0.27 (0.26) | 0.08 | Increasing | 1.30 (0.09) | 0.53 | **Increasing** |
| **>100mm/day** | 1.37 (0.08) | 0.00 | No trend | 0.15 (0.44) | 0.00 | **No trend** |
| **>100mm/3 day** | 0.32 (0.37) | 0.00 | No trend | 0.61 (0.27) | 0.08 | **Increasing** |
| **Rainy days** | -0.78 (0.22) | -0.07 | Decreasing | -1.07 (0.14) | -0.25 | **Decreasing** |
| **Rainy days (>75mm)** | 0.26 (0.27) | 0.00 | No trend | 0.824 (0.212) | 0.45 | **Increasing** |

## Climate Change Impacts on Watershed Hydrology

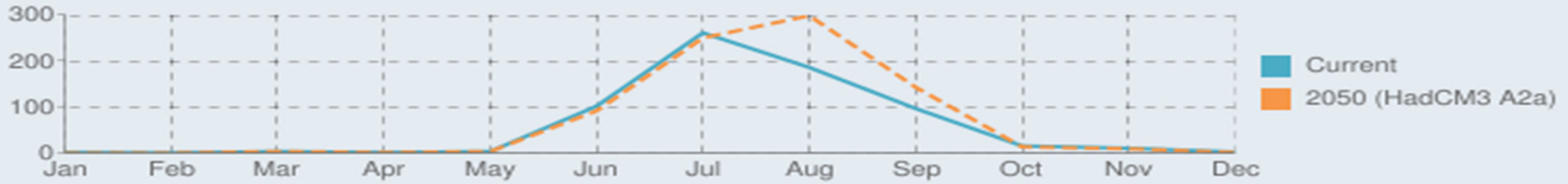
Monthly projection (HadCM3) for period 2071-2100 for A2a scenario and base line data (1961-1990) and SWAT model were used for watershed simulation

- Under the same cropping pattern surface runoff and sediment load likely to increase by 200.6% and 322.6% under projected climate with increase in rainfall by 48.7% (in Beluru Watershed in Maharashtra)
- Under the same cropping pattern surface runoff and sediment load likely to increase by 49.5% and 99.6% under projected climate with increase in rainfall by 16% (in Navamota watershed in Gujarat)
- Simulation studies with projected climate in 9 watersheds across the country reveals that the annual run off is likely to increase from 1.5 to 12 times. The frequency of flood and drought is also projected to change. The soil loss is expected to increase by 1.03 to 7.5 times.
- These simulations emphasize that due to increased precipitation amount and intensity, surface runoff may adversely impact the soil moisture storage
- Similarly, high soil loss conditions warrant adequate soil conservation activities in the critical areas of watershed.

MarkSim™ GCM - DSSAT weather file g...


Increased from 677 to 809 mm

Total Rainfall (mm) Max. Temp. (C) Min. Temp. (C)




| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current (1950-2000) | 1 | 0 | 3 | 1 | 3 | 101 | 260 | 185 | 96 | 15 | 10 | 2 |
| 2050 (HadCM3 with A2a) | 0 | 0 | 3 | 1 | 3 | 91 | 249 | 297 | 142 | 13 | 9 | 1 |
| Changes (mm) | -1 | 0 | 0 | 0 | 0 | -10 | -11 | 112 | 46 | -2 | -1 | -1 |

HarvestChoice Feedback Reference

# Weather information - Rajkot

| Historical trends in rainfall | | Decadal average | | |
|---|---|---|---|---|
| | | 1981-90 | 1991-2000 | 2001- 2010 |
| Rainfall ( mm) | | 522 | 522 | 831 |
| No. of rainy days | | 27 | 25 | 35 |
| No. dry spells during kharif season | > 10 days | 6 | 7 | 4 |
| | > 15 days | 4 | 5 | 3 |
| | > 20 days | 3 | 3 | 2 |
| No. Intensive rain-spells | > 60 mm per day | 2 | 2 | 3 |

NB: Increasing Trend

# Real Time Contingencies

## Climatic extremes and Measures (Bangalore Rural) - 2011

| Sl.No. | Month | Climatic extremes | Measures |
|---|---|---|---|
| 1 | June (2nd week) | Hailstorms affected the germinated pigeon pea | Gap filling done by re-sowing PP (BRG 1) |
| 2 | June -2nd fortnight | Dry spell | 1. Favourable for groundnut for flower bursting |
| | | | 2. Opening of conservation furrow between two rows of Pigeonpea in Groundnut + Pigeonpea (8:2) |
| 3 | July – 2nd Fortnight (shifted from June 1st week) | Delay in the monsoon | Five farmers have taken up finger millet nursery (MR-1 of 130 days) and transplanted after 21days after the receipt of rains. |
| 4 | July -2nd fortnight | Delay in the monsoon | Medium duration varieties of finger millet like GPU-28 were given to 13 farmers. |
| 5 | August -1st fortnight | Delay in the monsoon | Short duration varieties of finger millet like GPU-48 was given to 3 farmers being compared with MR1 |
| | | Dryspell | Thinning, gap filling and weeding was done in the early sown finger millet. |
| 6 | **August-2nd fortnight** | **Excess run off** | **Collected in the farm pond and used for vegetable plants, fruit plants etc.** |

Intervention introduced : 50% of land holding of farmer has been converted into multiple cropping system & 50% of land is used for growing rice traditionally 2011

AFTER INTEREVENTION

FARMER'S PRACTICE



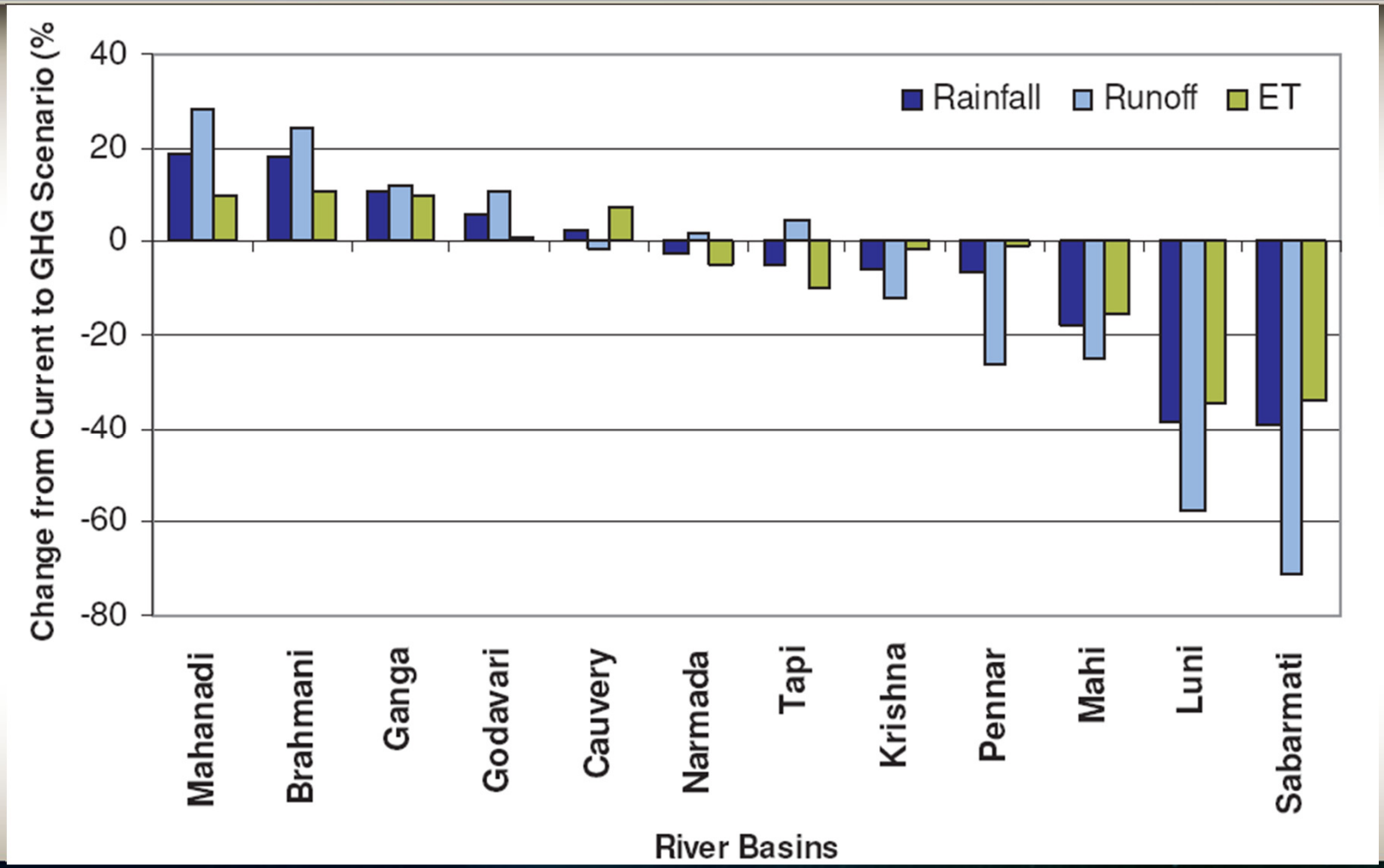
## Crops grown under multiple cropping system

| | | | | | |
|---|---|---|---|---|---|
| 1 | Ridge gourd | 9 | Turmeric | 16 | Bitter Gourd |
| 2 | Bhindi | 10 | Ginger | 17 | Rapseed |
| 3 | Cow pea | 11 | Napier | 18 | Lentil& Pea |
| 4 | Bitter Gourd | 12 | Arhar | 19 | Pineapple |
| 5 | Cucum Ber | 13 | Black Gram | 20 | Bamboo |
| 6 | Pointed Gourd | 14 | Potato | | |
| 7 | Med duration Rice variety -2 | 15 | French Been | | |
| 8 | Green gram | | | | |

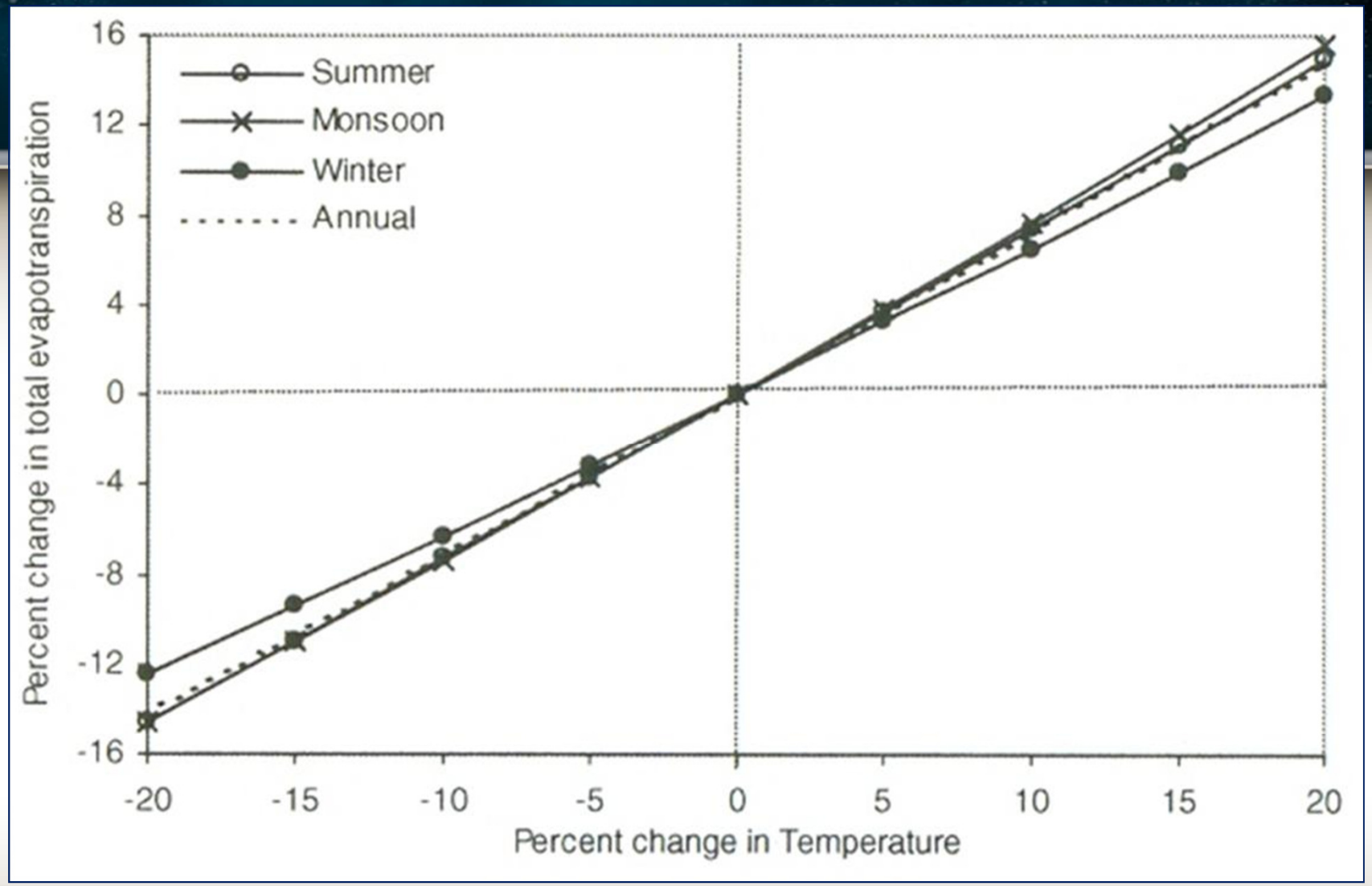
Increase in CI by 200 to 300 %

# Effect of climate change on runoff soil erosion and evapotranspiration

# % change in mean Annual runoff at major river basin of india for GHG scenario (2041-2060)



# Relative change in seasonal and annual $ET_0$ due to relative change in Temperature in Rajasthan




Source: R.K. Goyal *et. al.*, 2004

# Brahmaputra and Ganga River basin

- **By the year 2050, the average annual runoff in the Brahmaputra River will decline by 14 % (Singh, 1998).**

- **It was estimated that in the new climate (2030), the flood peaks will be increased by about 20% for Ganges and by 30% for Brahmaputra as compared with the year 1995 (Jäger and Ferguson, 1991) .**

- **The average annual runoff in Ganges will rise about 12% (Gosain et al., 1996)**

# Rising river flows throughout the twenty-first century in two Himalayan glacierized watersheds

(Ref: Immerzeel et. al., Nature Geosciences, Aug., 2013)

- Results from the latest ensemble of climate models show tha in case of Baltoro and Langtang watersheds that drain into the Indus and Ganges rivers, respectively, strong, but highly variable, increases in future runoff are projected and, despite the different characteristics of the watersheds, their responses are surprisingly similar. In both cases, glaciers will recede but net glacier melt runoff is on a rising limb at least until 2050.
- In combination with a positive change in precipitation, water availability during this century is not likely to decline. River basins that depend on monsoon rains and glacier melt will continue to sustain the increasing water demands.

# Effect on Soil Erosion

- Favis-Mortlock and Boardman (1995), using the Erosion Productivity Impact Calculator (EPIC) model (Williams and Sharpley, 1989), found a 7% increase in precipitation could lead to a 26% increase in erosion in the United Kingdom.
- Lee et al. (1996), also applying EPIC, found that for the U.S. Corn Belt, a 20% precipitation increase gave a predicted 37% increase in erosion and a 40% increase in runoff.
- Schulze (2000), using the CERES-Maize and ACRU models, predicted a 10% increase in precipitation would lead to a 20–40% increase in runoff in South Africa.
- Favis-Mortlock and Guerra (1999) predicted a -9% to +55% change in sediment yield for the year 2050 from three climate models, with the Hadley Centre climate model (HadCM2) showing a 22–33% increase in mean annual sediment yield with a 2% increase in annual precipitation, and monthly sediment yield increasing by up to 103%.

# Precipitation, runoff, and erosion estimated for 1990–1999, and changes estimated for 2040–2059 with changes in crop management ( *After O'neal et al., 2005*) in different regions of USA

## Precipitation Range: 802.9 t0 1106.6 mm in 1990-1999

**Changes (%) Estimated in 2040-2059**

Change in Precipitation: -2.1 to 14.2%

Change in Runoff : 6.3 to 309.5%

Change in soil loss : -3.0 to 273.7%

# Vulnerability reduction through the MGNREGA

Climate change involves action for mitigation and adaptation. The National Rural Employment Guarantee Act (NREGA) contributes towards adaptation. The impact of climate change falls differentially on people, and the poor are the most vulnerable to its adverse impact. NREGA, by encouraging works on water harvesting, flood protection, afforestation and plantation, helps to insulate local communities from adverse effects of climate change. According to the findings of the pilot study conducted in Chitradurga District of Karnataka, there is an increase in groundwater level and in water percolation, and improvement in soil fertility leading to improved land productivity. The findings also suggest a reduction in water vulnerability and livelihood vulnerability in these areas.

*Source: Environmental Services, Vulnerability Reduction and Natural Resource Conservation from NREGA Activities: Case Study of Chitradurga District,* Indian Institute of Science, Bangalore.

# Where do we stand ?

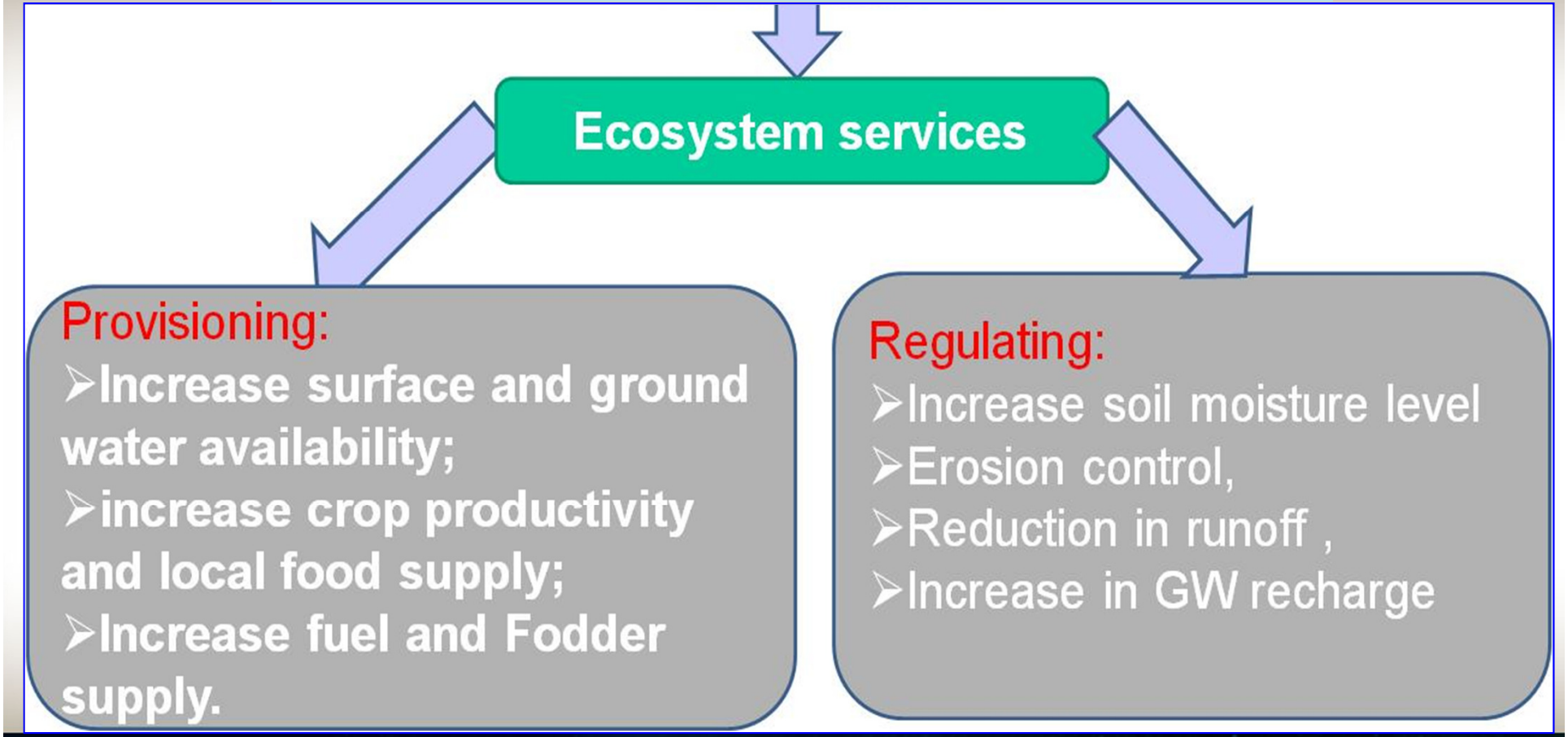
## Soil & Water Conservation in Watershed Domain for Environmental security

## Policy Needs :
## Operational Watershed Scale

Projections at larger basins ????

Climate change (rainfall intensity), LU change effect on runoff, peak flow and soil loss

# Watershed Management for Climate Resilient Agriculture



# Impact of integrated watershed management practices on runoff (flood moderation) and soil loss (Kerr, *et al.* 2000)

| Watershed | Runoff as % of rainfall | | Soil loss ($tha^{-1}$) | |
|---|---|---|---|---|
| | Pre treatment | Post treatment | Pre treatment | Post treatment |
| Fakot (Uttaranchal) | 42.0 | 14.2 | 11.9 | 2.5 |
| GR Halli (Karnataka) | 14.0 | 1.3 | 3.5 | 1.0 |
| Behdala (Himachal Pradesh) | 30.0 | 15.0 | 12.0 | 8.0 |
| Joladarasi (Karnataka) | 20.0 | 7.0 | 12.0 | 2.3 |
| Una (Himachal Pradesh) | 30.0 | 20.0 | 12.0 | 10.0 |

# Climate Change Through a Farmer's Eyes

Susan Crate, an anthropologist at George Mason University in Fairfax County, Virginia, says there is much to be learned from what she calls "place-based people," who watch the weather closely and know the signs, smell rain in the air, tell the direction of the wind, the way the animals act. These people, she says, "**are incredible experts on their environments**."

# Refinement of Indigenous Technical Knowledge (ITKs) for Promotion of the S& WC Technologies

Prevailing ITKs and local knowledge should invariably be given priority. The stakeholders in the conservation programme who can be partners for promoting the ITKs are:

- Farmers
- NGOs
- Government Agencies
- Research Institutes / Scientists
- Administrators
- Policy makers / people's representatives

# Practical Approaches

1. Evaluate the benefits of building the resilient system to overcome the risk of damage into the conservation planning process from severe changing rainstorms.
2. It is increasingly important to retain water within watersheds with suitable conservation practices for local climate and water regimes.
3. A robust adaption practice locally will sustain the mitigation  strategy globally

# THANK YOU

हर कदम, हर डगर
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भारतीय कृषि अनुसंधान परिषद

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