Evidence of climate change: Increase in the Semi-Arid areas of India

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Contents

- Global warming, impacts on climate
- Data and methods
- Changes in Semi-Arid areas in India
- ICRISAT’s Hypothesis of Hope
- Way forward
Natural catastrophes worldwide 1980 – 2010
Number of events with trend

- 2010 is second highest since 1980 with 960 events
- 10 years: 785
- 30 years: 615

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All India: Annual temperature anomalies

Source: IMD, 2010
• Mean annual temperature of India in 2010 was +0.93°C above the 1961-1990 average
• 2010 is the warmest year on record since 1901
• Pre- Monsoon season (March-May) mean temperature was 1.8 °C above normal

Source: IMD, 2011
Effects on extreme temperatures

(a) Increase in mean temperature

(b) Increase in variance of temperature

(c) Increase in mean and variance of temperature

SYR - FIGURE 4-1
Southwest monsoon onset over Kerala

(1871-2012)

Date of onset

Linear (Date of onset)

Normal date of onset: 01 Jun

Data source: IMD
India: Rainfall trends

Data source: IMD
India: Rainfall trends

Long term (>100 years) annual rainfall trends in selected rainfed districts of India

Source: AICRPAM, CRIDA, 2009
Changes in rainfall intensity over Central India

- Significant rising trends in the frequency and the magnitude of extreme rain events
- Significant decreasing trend in the frequency of moderate events
- Contribution from increasing heavy events is offset by decreasing moderate events
- Substantial increase in hazards related to heavy rain is expected over Central India in the future

*Source: Goswami et al., 2006, Science*
Unprecedented rains in AP during 10-11 Jan 2012

- 0.49 million hectares crops have been affected
- Estimated loss is Rs. 7 billion
- On 11 Jan, Kavali in Nellore district 169 mm

Harvested paddy floating in flood water

Flood water affects color of chillies

Wet Blackgram
India: Area changes in different climate types

Data, methods and results
IMD gridded daily climate data

- One degree resolution
- Total 351 pixels
- Pixel data derived from 395 stations for temperature and 1803 stations for rainfall, using spatial interpolation (GIS)
- Data for 34 years (1971-2004)
Climatic Classification of Thornthwaite

Climatic Water Balance

- PET (Hargreaves)
- Soil AWC (NBSS & LUP)
- Modified Water Balance of Thornthwaite and Mather
- Rain
- Humidity Index (IH)
- Aridity Index (IA)
- Moisture Index (Im)

Classification

<table>
<thead>
<tr>
<th>Type</th>
<th>Im (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arid</td>
<td>&lt; -66.6</td>
</tr>
<tr>
<td>Semi-Arid</td>
<td>-66.6 to -33.3</td>
</tr>
<tr>
<td>Dry Sub-humid</td>
<td>-33.3 to 0</td>
</tr>
<tr>
<td>Moist Sub-humid</td>
<td>0 to 20</td>
</tr>
<tr>
<td>Humid</td>
<td>20 to 100</td>
</tr>
<tr>
<td>Per Humid</td>
<td>&gt;100</td>
</tr>
</tbody>
</table>
Climate analysis: 34 years

Period 1

Climate type (1971-1990)
- Arid
- Semi-Arid
- Dry Sub-humid
- Moist Sub-humid
- Perhumid

Period 2

Climate type (1991-2004)
- Arid
- Semi-Arid
- Dry Sub-humid
- Moist Sub-humid
- Humid
- Perhumid
States selected for climate change area analysis

1. Andhra Pradesh
2. Bihar
3. Chhattisgarh
4. Gujarat
5. Haryana
6. Himachal Pradesh
7. Jharkhand
8. Karnataka
9. Kerala
10. Maharashtra
11. Madhya Pradesh
12. Orissa
13. Punjab
14. Rajasthan
15. Tamil Nadu
16. Uttaranchal
17. Uttar Pradesh
18. West Bengal
## Changes in areas under climate types

### Madhya Pradesh

<table>
<thead>
<tr>
<th>Period</th>
<th>Arid</th>
<th>S-Arid</th>
<th>D-Sub-H</th>
<th>M-Sub-H</th>
<th>Humid</th>
<th>P-Humid</th>
<th>Total (m ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971-90</td>
<td>0</td>
<td>17.96</td>
<td>12.85</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>30.81</td>
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<tr>
<td>1991-04</td>
<td>0</td>
<td>21.78</td>
<td>8.77</td>
<td>0.23</td>
<td>0.03</td>
<td>0.00</td>
<td>30.81</td>
</tr>
<tr>
<td>Difference</td>
<td>0</td>
<td>3.82</td>
<td>-4.08</td>
<td>0.23</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

### Bihar

<table>
<thead>
<tr>
<th>Period</th>
<th>Arid</th>
<th>S-Arid</th>
<th>D-Sub-H</th>
<th>M-Sub-H</th>
<th>Humid</th>
<th>P-Humid</th>
<th>Total (m ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971-90</td>
<td>0</td>
<td>1.82</td>
<td>6.87</td>
<td>0.39</td>
<td>0.32</td>
<td>0.02</td>
<td>9.42</td>
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<tr>
<td>1991-04</td>
<td>0</td>
<td>4.48</td>
<td>3.39</td>
<td>1.04</td>
<td>0.48</td>
<td>0.03</td>
<td>9.42</td>
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<tr>
<td>Difference</td>
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<td>2.66</td>
<td>-3.48</td>
<td>0.65</td>
<td>0.16</td>
<td>0.01</td>
<td>0.00</td>
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</tbody>
</table>
## Changes in areas under climate types contd..

### Orissa

<table>
<thead>
<tr>
<th>Period</th>
<th>Arid</th>
<th>S-Arid</th>
<th>D-Sub-H</th>
<th>M-Sub-H</th>
<th>Humid</th>
<th>P-Humid</th>
<th>Total (m ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971-90</td>
<td>0</td>
<td>0.16</td>
<td>14.45</td>
<td>0.96</td>
<td>0.00</td>
<td>0.00</td>
<td>15.57</td>
</tr>
<tr>
<td>1991-04</td>
<td>0</td>
<td>0.00</td>
<td>13.79</td>
<td>1.71</td>
<td>0.07</td>
<td>0.00</td>
<td>15.57</td>
</tr>
<tr>
<td>Difference</td>
<td>0</td>
<td>-0.16</td>
<td>-0.66</td>
<td>0.75</td>
<td>0.07</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

### Karnataka

<table>
<thead>
<tr>
<th>Period</th>
<th>Arid</th>
<th>S-Arid</th>
<th>D-Sub-H</th>
<th>M-Sub-H</th>
<th>Humid</th>
<th>P-Humid</th>
<th>Total (m ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971-90</td>
<td>1.21</td>
<td>12.05</td>
<td>1.49</td>
<td>0.77</td>
<td>2.44</td>
<td>1.20</td>
<td>19.18</td>
</tr>
<tr>
<td>1991-04</td>
<td>0.93</td>
<td>12.28</td>
<td>1.52</td>
<td>0.87</td>
<td>2.26</td>
<td>1.32</td>
<td>19.18</td>
</tr>
<tr>
<td>Difference</td>
<td>-0.30</td>
<td>0.23</td>
<td>0.03</td>
<td>0.08</td>
<td>-0.20</td>
<td>0.12</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Change in areas between 1971-90 and 1991-2004

(Based on Thornthwaite’s climatic classification and IMD gridded climate data)
India climates: Changes in area

- Arid: 1.60
- Semi-Arid: 3.46
- Dry Sub Humid: -10.71
- Moist Sub Humid: 4.43
- Humid: 1.69
- Per Humid: -0.47
Global warming - Monsoon relationship?

Why is the southwest monsoon rainfall not increasing with increasing temperature due to global warming?

*Higher level of saturation of errors in the high frequency events would cascade larger errors to weather scale and could decrease predictability of monsoon weather*

The monsoon weather forecasting could become almost twice as difficult

## Southwest monsoon rainfall situation as on 31 July 2012

<table>
<thead>
<tr>
<th>Region</th>
<th>Actual (mm)</th>
<th>Normal (mm)</th>
<th>Percentage departure deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>East and NE India</td>
<td>708</td>
<td>787</td>
<td>-10%</td>
</tr>
<tr>
<td>Northwest India</td>
<td>184</td>
<td>288</td>
<td>-36%</td>
</tr>
<tr>
<td>Central India</td>
<td>414</td>
<td>488</td>
<td>-15%</td>
</tr>
<tr>
<td>South Peninsula</td>
<td>282</td>
<td>378</td>
<td>-23%</td>
</tr>
<tr>
<td>Country as a whole</td>
<td>366</td>
<td>452</td>
<td>-19%</td>
</tr>
</tbody>
</table>

*Source: IMD, 2012*
Many people who have contributed least to climate change may suffer the greatest livelihood consequences.
Climate Change: ICRISAT’s Hypothesis of Hope

Climate Change Adaptation in the Drylands
“Hypothesis of Hope” Schematic Framework

- **Current Climate Yield Gap**
- **Yield Gap 1**
- **Yield Gap 2**

Management and Climate Scenarios

1. Low Input Practices + Current Climate
2. Low Input Practices + Climate Change
3. Improved Practices + Adapted Germplasm + Climate Change
4. Improved Practices + Improved Germplasm + Current Climate
5. Improved Practices + Improved Germplasm + Current Climate

Average Crop Yields
Resilient crop for the poor

Short-duration chickpea cultivars that can withstand high temperatures

- **Super-early**: ICC 96029, 75-80 days
- **Extra-early**: ICCV 2, 85-90 days
- **Early maturing**: KAK 2, 90-95 days
ICPH 2671: World’s first pigeonpea hybrid

- Developed through cytoplasmic male sterility (CMS) system
- Wilt resistant and high yielding with farmers earning 80% higher than those growing traditional varieties

Short-duration groundnut cultivar ICGV 91114 escapes terminal drought
Integrated Watershed Management to Build Resilience of Natural Resources and Communities
Vermicomposting

Pigeonpea dall mill

Vegetables

Vermicomposting
Sharing of agroclimatic information – Wall writings

<table>
<thead>
<tr>
<th>Week</th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thu</th>
<th>Fri</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

Legend:
- Red: Rainfall
- Yellow: Normal
- Green: Above normal
- Blue: Below normal

Note: For detailed information, refer to ICRISAT's official resources.
Weather awareness at watersheds

- Training to the farmers to operate and maintain raingauges
- Farmers themselves measure rainfall and document. Datalogger nevertheless records rainfall automatically, which will be downloaded at regular intervals
Weather awareness at watersheds

- Training to the students to operate and maintain the Automatic Weather Station
- Students collect the weather parameters daily and display at the school
Equity and Efficiency to Protect Economy and Environment

Adaptation & Mitigation Strategies

Efficiency
Equity
Economy
Environment
Climate change impacts: Way forward

Climate Change has no respect for borders and affects all:
Ban-Ki-Moon, Secretary General, UNO

“Hypothesis of Hope” validated in bridging the yield gaps, needs to be strengthened / operationalized

Harness potential of IWM through holistic approach to enhance crop productivity by 2-3 folds

Diversification of livelihood options, a good adaptation strategy

Improved agromet advisory services at local level along with associated weather insurance packages

Enabling policies and institutions for the rural poor and women

Agriculture must play a key-role in climate solutions

Rigorous climate analysis using high-resolution data
We have no time to lose

- Global warming tolerance thresholds not too far
- Adaptation + mitigation approach is crucial

*Time to take off*