HIGH-LEVEL MEETING ON THE INITIATIVE FOR THE ADAPTATION OF AFRICAN AGRICULTURE TO CLIMATE CHANGE "AAA"
C. MADRAMOOTTOO

Honorary President of the International Commission of Irrigation and Drainage (ICID)
Managing Water for Food Security
Under a Changing Climate

Chandra A. Madramootoo
Professor, McGill University
Visiting Professor, MIT
President Honoraire, ICID
Chair, ICRISAT Governing Board
Agriculture in Africa is Primarily Rainfed

Nutrient limited
Nutrient and irrigation limited
75% attainable yields achieved
Table 4: Irrigation potential and actual development in major basins in SSA (2000)

<table>
<thead>
<tr>
<th>Basin</th>
<th>Irrigation potential* (m ha)</th>
<th>Irrigated area** (m ha)</th>
<th>Percentage of potential realized</th>
<th>Depletion in km³**</th>
<th>Percentage of total water resources **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake Chad</td>
<td>1.16</td>
<td>0.15</td>
<td>13%</td>
<td>1.1</td>
<td>12%</td>
</tr>
<tr>
<td>Senegal</td>
<td>0.42</td>
<td>0.13</td>
<td>31%</td>
<td>2.9</td>
<td>19%</td>
</tr>
<tr>
<td>East African Coast</td>
<td></td>
<td>0.23</td>
<td></td>
<td>2.6</td>
<td>1%</td>
</tr>
<tr>
<td>Volta</td>
<td></td>
<td>0.24</td>
<td></td>
<td>5.3</td>
<td>6%</td>
</tr>
<tr>
<td>Zambezi</td>
<td>3.16</td>
<td>0.25</td>
<td>8%</td>
<td>3.8</td>
<td>1%</td>
</tr>
<tr>
<td>Limpopo</td>
<td>0.30</td>
<td>0.27</td>
<td>90%</td>
<td>2.8</td>
<td>53%</td>
</tr>
<tr>
<td>Orange</td>
<td>0.39</td>
<td>0.37</td>
<td>95%</td>
<td>2.5</td>
<td>40%</td>
</tr>
<tr>
<td>Horn of Africa</td>
<td></td>
<td>0.46</td>
<td></td>
<td>9.2</td>
<td>11%</td>
</tr>
<tr>
<td>Niger</td>
<td>1.68</td>
<td>0.64</td>
<td>38%</td>
<td>11.9</td>
<td>5%</td>
</tr>
<tr>
<td>Madagascar</td>
<td>1.50</td>
<td>0.94</td>
<td>63%</td>
<td>7.8</td>
<td>2%</td>
</tr>
<tr>
<td>Total SSA</td>
<td>36</td>
<td>6.2</td>
<td>16%</td>
<td>69</td>
<td>2%</td>
</tr>
</tbody>
</table>

* based on FAO (1997)  ** from Watersim database
Data by country given in annex.
Monthly rainfall amounts are more erratic
- Difficult to predict onset of rains

<table>
<thead>
<tr>
<th>Region/country</th>
<th>Rainfall (mm)*</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Asia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iran</td>
<td>50-1600</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jordan</td>
<td>50-550</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syria</td>
<td>200-600</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td>200-500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Africa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egypt</td>
<td>100-170</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morocco</td>
<td>200-450</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>East Africa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kenya</td>
<td>500-800</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southern Africa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Africa (winter rain)</td>
<td>250-500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Africa (summer rain)</td>
<td>400-900</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zimbabwe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Africa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>300-1200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mali</td>
<td>150-3000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Niger</td>
<td>100-900</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Distribution (% of total):
* variation within country
Projected impacts of climate change

Global temperature increase (relative to pre-industrial)

0°C  +1°C  +2°C  +3°C  +4°C  +5°C  +6°C

Food
Falling crop yields in many areas, particularly developing regions
Possible rising yields in some high latitude regions

Water
Small mountain glaciers disappear, impacts on water supplies
Significant decreases in water availability in many areas, including Mediterranean and Southern Africa
Sea level rise threatens major cities

Ecosystems
Extensive damage to coral reefs
Rising number of species face extinction

Extreme weather events
Rising intensity of storms, forest fires, droughts, flooding and heat waves

Risk of abrupt and major irreversible changes
Increasing risk of dangerous feedbacks and abrupt, large-scale shifts in the climate system

Source: Stern Review (2008)
Influence of extreme weather disasters on global crop production

Corey Leski, Pedram Rowhani & Navin Ramankutty

Extended Data Figure 4 | Time series of the number of extreme heat and drought disasters per year from the EM-DAT database. The EM-DAT database is based on a compilation of disaster reports gathered from various organizations including United Nations agencies, governments and the International Federation of Red Cross and Red Crescent Societies. The time series of reported disasters per year exhibits an increasing trend, probably the result of more complete disaster reporting in more recent decades with a possible contribution from increasing disaster incidence. There is also large inter-annual variability in the number of disasters.
Influence of extreme weather disasters on global crop production

Corey Lesk¹, Pedram Rowhani² & Navin Ramankutty¹,³

1964–2007. We show that droughts and extreme heat significantly reduced national cereal production by 9–10%, whereas our analysis could not identify an effect from floods and extreme cold in the national data. Analysing the underlying processes, we find that production losses due to droughts were associated with a reduction in both harvested area and yields, whereas extreme heat mainly decreased cereal yields. Furthermore, the results highlight ~7% greater production damage from more recent droughts and 8–11% more damage in developed countries than in developing ones. Our
Figure 6: Examples of observed yield gap (for major grains) between farmers' yields and achievable yields (100 per cent denotes achievable yield level, and columns actual observed yield levels). (After Rockström et al., 2007)
Adapting to climate change
Fig. 6. Water productivity in agriculture at various scales: (a) the plant, through the water use efficiency WUE; (b) the irrigated crop at farm scale (Farm WP); (c) the irrigated crop, at system level (Irrig WP); and the crop including rainfall and irrigation water (Total WP).
Manage the soil water reservoir

IRRIG, PRECIP

ET

Leaching Fraction

Surface runoff

Return flows (Q,L)

Active root zone

Soil Water Reservoir

Capillary fluxes

Capillary fringe

Interflow

Percolation

GW accretion

Upward GW movement

Subsurface drainage

Return flows (Q,L)
Improving On-farm Water Management
Less water, Less energy
Re-engineer the canal systems from supply to demand driven based on crop requirements
Application of environmental sensor technology and precision irrigation
Renewable energy and low lift pumps for abstracting shallow ground water from rainfall recharge
Ground Water Exploitation

• Has expanded irrigation
• Boosted local food production
• Increased small holder production systems
• Contributed to inadequate management of the resource
Ground water irrigation:
• on demand
• individual use and not constrained by institutional management and variability in supply
• user flexibility in irrigation scheduling and water management
• overcomes temporal variability in soil moisture in order to stabilize crop production
• drought proofing in times of climate change

An invisible and diminishing resource
• when abstraction exceeds recharge
• depletion
• multiple pumping points – difficult to manage without legal framework
• lack of monitoring and permits
• energy costs – used to be cheap/subsidized
Thank you!