Agricultural Engineering & Farm Mechanization Options Under Climate Change Scenarios in Pakistan

Dr. Rakhshan Roohi
WRRI, NARC, Islamabad, Pakistan
Contents

• Country’s background
• Climate change and agriculture
• National policy initiatives
• Farm mechanization and needs for adjustments
• Recommendations
AGROCLIMATIC ZONES

LEGEND
- Humid (K*, R**)
- Humid (K), Sub-Humid (R)
- Humid (K), Semi-arid (R)
- Sub-Humid (K), Humid (R)
- Sub-Humid (K), Semi-arid (R)
- Sub-Humid (K), and (R)
- Sub-Humid (K), Hyper-arid (R)
- Semi-arid (K), Humid (R)
- Semi-arid (K, R)
- Semi-arid (K), Arid (R)
- Semi-arid (K), Hyper-arid (R)
- Arid (K), Semi-arid (R)
- Arid (K,R)
- Arid (K), Hyper-arid (R)
- Hyper-arid (K), Semi-arid (R)
- Hyper-arid (K), and (R)
- Hyper-arid (K,R)

Data Source: Pakistan Meteorological Department & WRRI, NARC, Islamabad.

* Kharif ** Rabi
PAKISTAN
CROPPING PATTERN
(2004-05)

LEGEND
- Course Grain - Chickpea (mix for K)
- Course Grain - Wheat
- Course Grain - Wheat (mix for K and R)
- Course Grain - Wheat (mix for K)
- Course Grain - Rice - Wheat
- Cotton - Wheat
- Cotton - Wheat (mix for K)
- Cotton - Wheat - Chickpea (mix for K)
- Groundnut - Wheat (mix for K & R)
- Groundnut - Wheat (mix for K)

Data Source: Agriculture Statistics Division (Economic Wing), MINFAL, Govt. of Pakistan.
Per Capita Water Availability (ft³/year)

Population (millions)

Source: PMD; National Institute of Population Studies
<table>
<thead>
<tr>
<th>Land utilization statistics (million ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographical area</td>
</tr>
<tr>
<td>Forest area</td>
</tr>
<tr>
<td>Not available cultivations</td>
</tr>
<tr>
<td>Culturable waste</td>
</tr>
<tr>
<td>Cultivated area</td>
</tr>
<tr>
<td>Current fallow</td>
</tr>
<tr>
<td>Net area sown</td>
</tr>
<tr>
<td>Area sown more than once</td>
</tr>
<tr>
<td>Total cropped area</td>
</tr>
</tbody>
</table>

Source: GOP, 2005
Figure 3. Share of Agriculture in GDP

<table>
<thead>
<tr>
<th>Year</th>
<th>Percent Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969-70</td>
<td>38</td>
</tr>
<tr>
<td>1998-99</td>
<td>25</td>
</tr>
<tr>
<td>2000-01</td>
<td>23</td>
</tr>
<tr>
<td>2001-02</td>
<td>22</td>
</tr>
<tr>
<td>2002-03</td>
<td>21</td>
</tr>
</tbody>
</table>

Legend:
- Agriculture
- Major crops
- Minor crops
- Livestock
- Fishing
- Forestry
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm area cultivated</td>
<td>76</td>
<td>83</td>
<td>83</td>
<td>82</td>
<td>81</td>
</tr>
<tr>
<td>Area net sown</td>
<td>86</td>
<td>92</td>
<td>95</td>
<td>96</td>
<td>94</td>
</tr>
<tr>
<td>Intensity of land use</td>
<td>84</td>
<td>89</td>
<td>89</td>
<td>87</td>
<td>85</td>
</tr>
<tr>
<td>Cropping intensity</td>
<td>103</td>
<td>111</td>
<td>122</td>
<td>137</td>
<td>142</td>
</tr>
</tbody>
</table>

Source: GOP, 2005
Climatic Trends

- Increasing concentration of CO₂ in the atmosphere
  - Pre-industrial revolution (1789) 280 ppm
  - Present (2004) 383 ppm
  - Expected level (2050) 550 ppm
- Rising surface temperatures
  - Global Av. Temp. rise 0.6 °C (20th century)
  - Projections for 2100 1.4 to 5.8 °C
- Changing rainfall patterns
  - Increase in monsoon rainfall in sub-humid and humid areas
  - Decrease in winter and summer rainfall in coastal belt and hyper arid plains

Source: IPCC, 2001
Change in Mean Temperature during 1961-90 from that of 1931-60

Legend
- Increase
- Decrease
MAXIMUM TEMPERATURE PATTERN IN NORTHERN AREAS DURING (1961-2000)

MINIMUM TEMPERATURE PATTERN IN NORTHERN AREAS DURING (1961-2000)

RAINFALL PATTERN IN NORTHERN AREAS DURING (1961-2000)

Pakistan Meteorological Department
## Annual Water Availability (Western Rivers)

<table>
<thead>
<tr>
<th>Probability (%)</th>
<th>Rim Station Inflows (billion m$^3$)</th>
<th>1937-67</th>
<th>1968-96</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>134.5</td>
<td>114.9</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>143.9</td>
<td>135.5</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>163.1</td>
<td>153.2</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>173.0</td>
<td>162.1</td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>184.9</td>
<td>180.9</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>198.2</td>
<td>189.6</td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>231.7</td>
<td>206.0</td>
<td></td>
</tr>
</tbody>
</table>
Climate-Water-Agriculture Linkages

Climate

Temperature
Rainfall
Wind, Sunshine, Solar Radiation
CO2 level

GDD and Corresponding GSL

Evapo-transpiration (ET)

Crop Water Demand
Water Availability
Agriculture (Crop Yield)

Canal/ground water

Photosynthetic Activity

Source: Dr. Mohsin Iqbal, GCISC
Climate change research in Pakistan

• *Physical Indicators*
  Water Resources
  • Glaciers & glacial lakes
  • GLOFs
  • River flows
  • Climate

• *Biological Indicators*
  • Agriculture
  • Natural Ecosystems
If only Temperature Changes
(Semi-Arid Areas)

(CO₂ Level = 360 ppm)

Yield (kg/ha)
Baseline Yield

Change in Temperature (°C)

Source: Dr. Mohsin Iqbal, GCISC
If both CO₂ and Temperature Change
(Semi-Arid Areas)

Yield (kg/ha)

Change in Temperature (°C)

Baseline Yield

Source: Dr. Mohsin Iqbal, GCISC
If both Water Availability and Temperature Change

\((\text{CO}_2 \text{ Level} = 360 \text{ ppm})\)

![Graph showing the impact of temperature change on yield](image_url)

- **Baseline Yield**
- **Change in Temperature (°C)**: 0, 1, 2, 3, 4, 5
- **Yield (kg/ha)**: 0, 1000, 2000, 3000, 4000, 5000

**Legend:**
- 4 Irrigations
- 2 Irrigations

*Source: Dr. Mohsin Iqbal, GCISC*
If both Water Availability and Temperature Change
(Semi-Arid Areas)

(CO$_2$ Level = 550 ppm)

Source: Dr. Mohsin Iqbal, GCISC
National Policy Initiatives
• Pakistan Environment Protection Act-1997
• Pakistan Environmental Protection Ordinance - 1983
• Enactment of National Conservation Strategy - 1992
• Forestry Sector Master Plan and NCS plan of Action and the finalization of a National Environmental Action Plan (NEAP) -February 2001
• Establishment of Global Change Impact Studies Centre-2002
• Establishment of Alternate Energy Board
Climate Change & Clean Development Mechanism (CDM)
Institutional Set-up for CDM

- **PM Committee on Climate Change**
- **CDM Steering Committee**
- **Project Proponent**
- **CDM Cell**
- **National and International Stakeholders**
- **Technical Committees**

Policy Formulation and Implementation

Operational

Facilitation and Promotion
Farm Machinery Institute  
NARC

Promotion of agricultural mechanization in the country through designing, performance evaluation and commercialization of appropriate farm machinery

- crop establishment engineering
- harvesting and threshing engineering
- post harvest engineering
- industrial and mechanization research
- farm machinery testing and standardization.
Developed and commercialized

- paddy transplanter
- zero-till drill

Working on

- pneumatic row crop planter
- hold-on paddy thresher
- solar dryer for fruits and vegetables
- dual mode drill
Needs for Adjustment in AE & FM

• **Energy**
  – Improvement in fuel efficiency in agricultural machinery
  – Commercialization of wind/Solar power potential
  – Development and commercialization of cost effective solar panels
  – Biofuel
  – Biogas production units

• **Farm Operations**
  – Low cost laser leveler
  – Minimum/zero tillage
  – Furrow-Bed plantation to save water

Continued…
• Water Resources

• Better techniques for determining crop water requirements or irrigation demand preferably using RS/GIS techniques

• Efficient Irrigation systems like sprinkler, trickle or Central Pivot systems

• The water injection cum fertilizer drill can be one of the solutions for timely sowing, particularly rainfed crops

• To address the low Irrigation efficiency
  Development and commercialization of low-cost geo-membrane liners for lining of canals and watercourses

• On-farm rainwater harvesting and storage structures

Continued…
• Livestock
  – Environmental management systems and preventing pollution for intensive animal production units
  – Animal housing and storage structures with ventilation systems, temperature and humidity controls, and on-farm waste management

• Nursery & Greenhouse Engineering
  – For off season vegetables and nursery development cost effective greenhouse/plastic tunnel structures need to be developed
  – Equipment for hydro-ponic cultivation??
Recommendations

- Strengthen international partnerships to address the expected threats of climate change
- The regional information/data sharing should be encouraged
- Education in climate change
- System approach is required to integrate the entire farm activities

• Continued....
• Water management and cost effective efficient irrigation systems
• Tapping renewable energy sources and improving fuel efficiency in agricultural machinery
• Use of new tools and techniques like GIS, RS & simulation modeling for characterization and system analysis under changing climate
• Facilitate greater adoption of scientific and economic pricing policies, especially for water
• CDM Projects for small scale enterprise
Thank you

drroohi_gis@yahoo.com