Climatic Influence on Rice Production: A Panel Data Analysis

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Agriculture & Climate Change (CC)

- Agricultural production preliminary and largely depends on natural resource base and climatic factors (e.g. soil quality, sunshine, temperature and rainfall) and settings
  - Climatic factors plays a crucial role in farm production and farmers’ farming related decisions
  - Randomly affected by natural hazards and other biotic factors (e.g. pest attack)

- CC means generally upward trend in temperature but much more fluctuations in annual, seasonal and spatial variation in rainfall, agriculture likely to be an uncertain prospect – other climate related factors such as salinity intrusion, flood and cyclonic storms put additional burdens unless proper adaptation measure undertaken – BD increasingly becoming a test case of such vulnerabilities in agriculture

- Agriculture not only adversely impacted due to CC, but also a major source of GHG emission
  - Energy use in irrigation, wet paddy cultivation, livestock manure management and enteric fermentation all are sources of GHG emission
CC & Crop Production: BD Scenario and Predictions

• Relationship between weather and yield is often crop and region-specific

• Wheat and maize are found to be more affected due to CC – much less in case of paddy
  • 1-2°C local rise affects wheat & maize adversely, for rice effects more discernible at higher temp rise of 3-5°C

• Predicted wheat yield may fall by 26% on average by 2100. Av Boro rice yield may fall by 12%. For aman rice, yield may decrease by 2050 but remain unchanged in a longer term (2100)

• Rice being water-intensive crop, its productivity largely related to water availability but also sensitive to temperature rise during flowering period

• Negative impact of climatic factors on crop yields may become pronounced from around the 2030s, but become more certain by the 2050s and the end of the 21st century

• For every consecutive decade, the yield reduction is expected to be globally 1% - small but non-trivial fraction of roughly 14% increase in productivity needed to keep pace with rising demand
BD Trends in Annual Max & Min Temperature

y = 0.0002x + 30.234
$R^2 = 0.2235$

y = 0.0107x + 20.677
$R^2 = 0.3356$
Incidence of heavy rainfall and trends in rainfall in met stations

\[ y = 0.0366x + 66.459 \]
\[ R^2 = 0.0789 \]
Salinity changes over time

Note: Salinity classes are - S1 (Very slight): 2-4 ds/M; S2 (Slight): 4.1-8 ds/M; S3+S4 (High): 8.1-16 ds/M; S5 (Severe): 16+ ds/M
Climate Related Physical Events: BD Historical Experience

- Over more than a century, there had been more than 80 instances of flood, seven instances of severe drought, 17 instances of major cold wave and 85 tropical cyclones.

- Flood: in any given year, at least some 20-25% of the area of the country may go under water. In 1988, for example, about two-thirds of the country was under water for an extended period.

- Drought: broadly, in NW
  - 40% of the area is free of drought risk
  - 30% of the area is prone to moderate drought risks
  - The rest (around 31%) is severe to extreme risk of drought

- Cyclone, storm do occur on regular basis
Climate Change Projections for BD

Temperature: Much longer stretch of hotter months than at present.
- The maximum temperatures for all regions will rise substantially during the winter months of Dec, Jan and Feb.
- March, April and May will have little change in maximum temperature.
- Minimum temperature may rise over all the months in general.

Precipitation: Wetter winter and pre-winter months by 2030 and 2050, with some regional variation.
- Some regions will exhibit falling rainfall.
Climate and Rice Production: A Panel Data Exercise

• Production and yield functions for three paddy growing seasons utilizing all the 64 district data for 7 consecutive years (2007-2013)

• Linear and log-log models for each season and also for varieties

• Unlike conventional production and yield functions, no input variables except area in the production function as district and variety-wise input use data unavailable – but a Time variable to adjust for any trend factor in the use of inputs

• Assumed that during the years under consideration, policy level factors that may influence farm level availability and use of inputs have not changed, the production change may be explained through climatic factors like temperature, rainfall, hazards etc.
## Description of Variables Used in the Econometric Analysis

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description of variables</th>
<th>Data sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Endogenous variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield</td>
<td>Yield in mt per acre</td>
<td>Estimated</td>
</tr>
<tr>
<td><strong>Exogenous variables</strong></td>
<td></td>
<td></td>
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<tr>
<td>Share of small farmers</td>
<td>Share of land cultivated by small farmers (&lt;2.50 acres) to total area under that particular variety/season.</td>
<td>Agricultural Census 2010</td>
</tr>
<tr>
<td>Hazard dummy</td>
<td>Dummy for years when flood, excessive rainfall and rush water caused crop damages (1 for years with crop damage, 0=otherwise)</td>
<td>YB of Ag Stat- 2013</td>
</tr>
<tr>
<td>Saline area (acre)</td>
<td>Total saline area in a particular district. Threshold level was 2 dS/m</td>
<td>SRDI 2010</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>Average of maximum temperature during total cultivation period</td>
<td>CEGIS/YB of Ag Stat- 2011, 2012, 2013</td>
</tr>
<tr>
<td>Critical temperature during flowering</td>
<td>Dummy: 1 for districts where temperature crossed 35° C during flowering stage, otherwise 0</td>
<td>CEGIS/YB of Ag Stat- 2011, 2012, 2013</td>
</tr>
<tr>
<td>Rainfall (mm)</td>
<td>Average of monthly rainfall during the cultivation period</td>
<td>CEGIS/YB of Ag Stat- 2011, 2012, 2013</td>
</tr>
<tr>
<td>Area (acre)</td>
<td>Area used to cultivate a specific variety in a specific season.</td>
<td>YB of Ag Stat- 2011, 2012, 2013</td>
</tr>
<tr>
<td>Time</td>
<td>0 for 2007, and higher categorical values for consecutive years.</td>
<td></td>
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</tbody>
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Effects of temperature change

• Both for yield and production function, sign of temperature is generally negative & high & in most cases statistically significant – for aman for example, 1°C rise in temperature reduces yield by 1.8 mt/ha, for aus it is even higher at 2.1 mt/acre

• Exception is LT aman in which case the sign is positive and also significant – it is likely that as LT aman harvest coincides somewhat with cooler period, a slight rise in temperature may help in both flowering and later maturing – but tis needs to be explored more rigorously

• Other major exception is boro for which while sign is generally negative, all are insignificant which may be explained by the use of irrigation which cancels out the effect of temperature – other anomaly is the role of critical period temperature which should have negative effect but are generally positive and significant – note however that it is more the length of higher temperature duration rather than crossing threshold temp (35°C) level which is more important – this we could not model due to lack of data
Effects of rainfall and other factors

• For aus, rainfall changes has limited impact – for aman by and large negative but generally insignificant – for boro, results seem less robust in terms of sign, log-log formulations have positive and significant signs but linear formulations give opposite results – using log-log formulations, one finds 1% rise in rainfall leading to 0.6% rise in yield of hybrid & HYV boro while for output these are 0.7 and 0.8% which are very substantial

• Salinity rise has generally negative impacts in all cases except for aus for which this matters little being cultivated during high rains washing out salinity

• Hazard dummy generally seems to have positive but generally insignificant effect – again the duration/intensity of hazard rather than its incidence is likely to be more important which we could not model due to limited data
Strategies to Move Forward

- Present exercise has basically confirmed several experimental and modelling results globally and in Bangladesh that climatic factors and climate change put stresses on yield of rice – heat and temperature stresses, stresses due to rainfall anomalies, salinity ingress have been by and large reconfirmed although there are still questions regarding some of the observed relationships which in fact is possibly due to limited data.

- Higher temperature and higher rainfall both negatively and substantially affect aman yield and output – while it was not possible to properly model impact of hazards, it is known that these, particularly flood and drought do affect yield and output of aman – all these call for development and popularisation of heat tolerant, drought resistant/less water using and submergence tolerant rice varieties.

- While rising temperature may not affect boro yield/production right now due to availability of irrigation this is likely to be more difficult in future as rainfall anomalies will mean lower availability of water depending on location – thus again heat tolerant and less water using boro varieties need to be developed and popularised while irrigation and water using efficiency have to be increased in general right from now – so far this has received little or no attention in the country.

- A similar situation obtains in case of salinity which has a generally negative effect again calling for not simply development of salinity tolerant varieties or cropping patterns or non-crop agriculture but rather those that can withstand higher level of salinity.
THANK YOU