EARLY SEASON FORECASTING OF CROPS BY
FASAL ECONOMETRIC MODEL

Presented at International Workshop on “Operational Mapping/Monitoring of Agricultural Crops in South/Southeast Asian Countries – Research Needs and Priorities”, Organized by jointly GGS Indraprastha University with SARI during May 2-4th, New Delhi, India

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Acknowledgement to all team members past and present who contributed

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Delhi 110007
EARLY SEASON CROP ESTIMATION: LONG TIME HISTORICAL PRACTICE FROM COLONIAL TIME

1. Associated with land revenue system
   - System improved over time
   - Administrative Burden
   - Errors, poor implementation
   - Delays: Not useful for Policy.
   - FASAL: Part of a Comprehensive system for early estimation of crop production using State level estimates (Primary component), Econometric forecast, Met model projections and RS results as inputs in consultation with partners, experts, senior MOA officials
OBJECTIVE AND COVERAGE

Objective: To consider econometric modeling as a method to determine crop outlook before any crisis strikes.


Major growing States only.

Data: Official sources- MOA, IMD, M-Com&Ind.
EVOLUTION OF CROP FORECASTING IN INDIA

- Area- Girdwari, EARAS (sampling), TRS, ICS for checks, validation, speed
- Yield- Annawari system, CCE (sampling across country), GCES
- Globalization, NFSA, Planning transition- information as key tool for planning and administration to avoid hunger, inflation, livelihood crisis, achieve SDG at India and global level
- **FASAL- associated with Space programme, CAPE 1987,**
  - Review 1995 Goel Committee 1996 foresaw need for more ambitious program
    - Comprehensive project, strong mechanism, cohesion of different central and state agencies
  - Creation of NCFC (DES, MOA), CWWG
  - 2006 Central Sector scheme FASAL merging individual schemes
  - MNCFC in 2012, MOA coordinates,
  - IEG in econometric forecast
FASAL AN UMBRELLA PROGRAM

- Spear headed by ISRO-SAC,
- A Systems approach: Vision of J. S. Parihar (SAC) a regular systematic mechanism for generating multiple in-season crop forecasts at intervals (F0 F1 F2 F3 F4) in the year
  - Revised with flow of more and more information
- Multi-discipline and innovative
  - Partners- MOA, IEG, IMD, ISRO, NRSA, SASA, NSSO
  - Final estimate most reliable-RS
  - Timely outlook for policy making, monitoring
- Econometric model – most early, least informed at Sowing time and just after sowing
  - Based on reasonable assumptions and scenarios aided by weather information/forecasts.
USEFULNESS OF EARLY FORECASTS

- Firming up MoA Advance estimates (1AE-Sep, 2AE-Jan, 3AE-Apr, 4AE-Jul and Final-Jan)
  - Provides outlook for India domestic economy and World economy
  - Feeds into GDP estimation, Price outlook
- Helps making timely decision on imports, exports, production incentives, stocking and logistic, credit.

**Benefits**-
- **Government** - Managing food security, price rise, Farmer welfare, poverty
- **Pvt sector** - Transparent and more reliable validated estimates—traders, transporters, processors, Exporter, Food industries, agro-input industries
- **Potentials** - Coordinated (inter-Ministerial) planning, Integration into Global agri-outlook and database, Replication in other developing countries
MODEL
Model in REDUCED FORM and ESTIMATION

- **Two stages- acreage and yield for each crop**
  - Forecast- F-Area X F-Yield, Range based on SE
  - Explanatory variables, Economic, Weather, Irrigation, Technology and Policy,
    - Dummy variables as needed for Policy (NFSM, BGREI, Others)
  - Dynamic Area equation (partial adjustment, price expectations)
  - **OLS or Seemingly Unrelated Regression Equations (SURE)** for Area under different major competing crops in each state
  - Selection-Diagnostics (sign of coefficients, t-stat>1, **Robustness** across specifications and sample sizes. Rbar-Sq, DW)
  
  - Forecast of unknown (data not available) explanatory variables- auto-regressive models,
    - Normal rainfall for future growing months,
    - Scenarios (normal, others)

- **Forecasting**
  - **Regular post sample validation, revision of Model and Sample period made contemporary, Search for more data**
**ECONOMIC VARIABLES, IRRIGATION, WEATHER**

**Economic:** Expected prices of crops and substitute crops, MSP (announced), fertilizer price (for cost)
- Prices: Whole Sale Price,
- Substitute crops using state crop calendars and cropping pattern
- Expectation: Previous harvest prices

**Irrigation:** Source wise –Canal, Well, Tank, other, Unirrigated area
- Total available area as the variable (farmer allocates among crops based on own decision)

**Rainfall:** Monthly using sub-division data

**Temperature for states:** Maximum and Minimum monthly averages computed using Zonal data (available in IITM site),
- Sowing and growing seasons identified using state level crop calendars
Rainfall effect in Model

- Rainfall distribution matters: allow pre-season-(also pre-sowing) RF
  - Timely rainfall important
  - Adequate soil moisture - influence crop choice non-water input use for crops, grain filling
  - Interaction with irrigation (source-wise) – temporal and Spatial distribution of rainfall in neighboring states, river upstream states
  - Rainfall and Irrigation Water
    - Complements: Earlier and current Rainfall both can enhance productivity of irrigation (reservoir level, ground water, tank storage, drainage of rainwater etc.)
    - Substitute: Current or recent rainfall can reduce need for irrigation, create water-management problem etc.
  - Quadratic (squared) Rainfall: Excess rainfall (compared to optimum)
AREA EQUATION

\[ A_t = a_0 + a_1 \frac{p^e}{p^e_{Sub}} + a_2 A_{t-1} + a_3 R_m + a_4 R_m I_{SRS}^{(>0 \text{Comlement})} \]
\[ (<1) \]
\[ + a_5 R_m^2 + a_6 I_{SRS} + a_7 T_{max} + a_8 T_{min} \]
\[ (<0) \]

Where

- \( p^e \) = expected price (previous harvest month prices (Kharif/Rabi) and MSP
- \( p^e_{Sub} \) = Substitute crop in that season in the Region
- \( R_m \) = Source wise
- \( I_{SRS} \) = sowing/pre-sowing months
- \( T \) = Temperature
YIELD EQUATION

\[ Y_t = b_0 + b_1 \frac{P^e}{Pf} + b_2 \frac{P_{sub}^e}{Pf} + b_3 R_m + b_4 R_m \frac{I_{SRS}}{est(A_t)} \]

\( (> 0) \quad (< 0) \quad (> 0 \text{Comlement}) \quad (< 0 \text{Substitute}) \)

\[ + b_5 R_m^2 + b_6 \frac{I_{SRS}}{est(A_t)} + b_7 T_{max} + b_8 T_{min} \]

\( (<0) \)

\( P_f \) = Price of fertilizer estimated
\( R_m \) = growing months/ pre-sowing months Rainfall
\( Dum_T \) = Dummy As necessary for Technology programme

Others as in Area slide
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>RICE (K)</td>
<td>92.59</td>
<td>91.41</td>
<td>1.18 [1.3]</td>
<td>93.76</td>
<td>96.02</td>
<td>-2.26 [-2.4]</td>
</tr>
<tr>
<td>RICE (R)</td>
<td>12.25</td>
<td>13.00</td>
<td>-0.75 [-5.8]</td>
<td>13.82</td>
<td>12.84</td>
<td>0.98 [7.6]</td>
</tr>
<tr>
<td>RICE TOTAL</td>
<td>104.84</td>
<td>104.41</td>
<td>0.43 [0.4]</td>
<td>107.58</td>
<td>108.86</td>
<td>-1.28 [-1.2]</td>
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<tr>
<td>WHEAT</td>
<td>88.73</td>
<td>92.29</td>
<td>-3.56 [-3.9]</td>
<td>94.30</td>
<td>96.64</td>
<td>-2.34 [-2.4]</td>
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<tr>
<td>BAJRA</td>
<td>7.77</td>
<td>8.07</td>
<td>-0.3 [-3.7]</td>
<td>9.44</td>
<td>9.42</td>
<td>0.02 [0.2]</td>
</tr>
<tr>
<td>JOWAR (K)</td>
<td>2.12</td>
<td>1.82</td>
<td>0.3 [16.5]</td>
<td>1.99</td>
<td>1.91</td>
<td>0.08 [4.2]</td>
</tr>
<tr>
<td>JOWAR (R)</td>
<td>2.08</td>
<td>2.42</td>
<td>-0.34 [-14]</td>
<td>2.76</td>
<td>2.84</td>
<td>-0.08 [-2.8]</td>
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<tr>
<td>JOWAR TOTAL</td>
<td>4.20</td>
<td>4.24</td>
<td>-0.04 [-0.9]</td>
<td>4.75</td>
<td>4.75</td>
<td>0.00 [0.0]</td>
</tr>
<tr>
<td>MAIZE (K)</td>
<td>15.95</td>
<td>16.05</td>
<td>-0.1 [-0.6]</td>
<td>17.09</td>
<td>19.27</td>
<td>-2.18 [-11.3]</td>
</tr>
<tr>
<td>MAIZE (R)</td>
<td>6.65</td>
<td>6.51</td>
<td>0.14 [2.2]</td>
<td>6.51</td>
<td>6.89</td>
<td>-0.38 [-5.5]</td>
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<tr>
<td>MAIZE TOTAL</td>
<td>22.60</td>
<td>22.56</td>
<td>0.04 [0.2]</td>
<td>23.60</td>
<td>26.16</td>
<td>-2.56 [-9.8]</td>
</tr>
<tr>
<td>ARHAR</td>
<td>2.69</td>
<td>2.56</td>
<td>0.13 [5.1]</td>
<td>2.78</td>
<td>4.23</td>
<td>-1.45 [-34.3]</td>
</tr>
<tr>
<td>MOONG (K)</td>
<td>0.98</td>
<td>1.00</td>
<td>-0.02 [-2]</td>
<td>1.06</td>
<td>1.51</td>
<td>-0.45 [-29.8]</td>
</tr>
<tr>
<td>URAD (K)</td>
<td>1.20</td>
<td>1.25</td>
<td>-0.05 [-4]</td>
<td>1.66</td>
<td>2.11</td>
<td>-0.45 [-21.3]</td>
</tr>
<tr>
<td>GRAM</td>
<td>8.47</td>
<td>7.06</td>
<td>1.41 [20]</td>
<td>9.45</td>
<td>9.12</td>
<td>0.33 [3.6]</td>
</tr>
<tr>
<td>GROUNDNUT (K)</td>
<td>4.91</td>
<td>5.37</td>
<td>-0.46 [-8.6]</td>
<td>6.11</td>
<td>7.05</td>
<td>-0.94 [-13.3]</td>
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<tr>
<td>GROUNDNUT (R)</td>
<td>1.42</td>
<td>1.37</td>
<td>0.05 [3.6]</td>
<td>1.33</td>
<td>1.42</td>
<td>-0.09 [-6.3]</td>
</tr>
<tr>
<td>GROUNDNUT (T)</td>
<td>6.33</td>
<td>6.74</td>
<td>-0.41 [-6.1]</td>
<td>7.44</td>
<td>8.47</td>
<td>-1.03 [-12.2]</td>
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<tr>
<td>SOYBEAN</td>
<td>12.05</td>
<td>8.57</td>
<td>3.48 [40.6]</td>
<td>12.99</td>
<td>14.13</td>
<td>-1.14 [-8.1]</td>
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<tr>
<td>RAPESEED</td>
<td>6.40</td>
<td>6.80</td>
<td>-0.4 [-5.9]</td>
<td>7.90</td>
<td>7.91</td>
<td>-0.01 [-0.1]</td>
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<tr>
<td>COTTON</td>
<td>5.28</td>
<td>5.10</td>
<td>0.18 [3.5]</td>
<td>5.48</td>
<td>5.53</td>
<td>-0.05 [-0.9]</td>
</tr>
<tr>
<td>JUTE</td>
<td>1.96</td>
<td>1.79</td>
<td>0.17 [9.5]</td>
<td>1.89</td>
<td>1.73</td>
<td>0.16 [9.1]</td>
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<tr>
<td>SUGARCANE</td>
<td>366.60</td>
<td>348.45</td>
<td>18.15 [5.2]</td>
<td>376.29</td>
<td>309.98</td>
<td>66.31 [21.4]</td>
</tr>
</tbody>
</table>
### FASAL: Matching with MOA estimates (Production)

<table>
<thead>
<tr>
<th>Crops</th>
<th>IEG-2015-16</th>
<th>Interval</th>
<th>MoA-2015-16 (Final)</th>
<th>Difference (%Error)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rice Kharif</strong></td>
<td>92.59</td>
<td>84.19 - 101.37</td>
<td>91.41</td>
<td>1.18 [1.3]</td>
</tr>
<tr>
<td><strong>Rice Rabi</strong></td>
<td>12.25</td>
<td>10.58 - 14.04</td>
<td>13.00</td>
<td>-0.75 [-5.8]</td>
</tr>
<tr>
<td><strong>Rice Total</strong></td>
<td>104.84</td>
<td>94.77 - 115.41</td>
<td>104.41</td>
<td>0.43 [0.4]</td>
</tr>
<tr>
<td><strong>Wheat</strong></td>
<td>88.73</td>
<td>83.88 - 93.75</td>
<td>92.29</td>
<td>-3.56 [-3.9]</td>
</tr>
<tr>
<td><strong>Bajra</strong></td>
<td>7.77</td>
<td>5.65 - 10.19</td>
<td>8.07</td>
<td>-0.3 [-3.7]</td>
</tr>
<tr>
<td><strong>Jowar Kharif</strong></td>
<td>2.12</td>
<td>1.40 - 2.97</td>
<td>1.82</td>
<td>0.3 [16.5]</td>
</tr>
<tr>
<td><strong>Jowar Rabi</strong></td>
<td>2.08</td>
<td>1.58 - 2.65</td>
<td>2.42</td>
<td>-0.34 [-14]</td>
</tr>
<tr>
<td><strong>Jowar Total</strong></td>
<td>4.20</td>
<td>2.98 - 5.62</td>
<td>4.24</td>
<td>-0.04 [-0.9]</td>
</tr>
<tr>
<td><strong>Maize Kharif</strong></td>
<td>15.95</td>
<td>13.57 - 18.49</td>
<td>16.05</td>
<td>-0.1 [-0.6]</td>
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<tr>
<td><strong>Maize Rabi</strong></td>
<td>6.65</td>
<td>5.87 - 7.47</td>
<td>6.51</td>
<td>0.14 [2.2]</td>
</tr>
<tr>
<td><strong>Maize Total</strong></td>
<td>22.60</td>
<td>19.44 - 25.96</td>
<td>22.56</td>
<td>0.04 [0.2]</td>
</tr>
<tr>
<td><strong>Arhar</strong></td>
<td>2.69</td>
<td>2.19 - 3.22</td>
<td>2.56</td>
<td>0.13 [5.1]</td>
</tr>
<tr>
<td><strong>Moong Kharif</strong></td>
<td>0.98</td>
<td>0.67 - 1.32</td>
<td>1.00</td>
<td>-0.02 [-2]</td>
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<tr>
<td><strong>Urad Kharif</strong></td>
<td>1.20</td>
<td>0.99 - 1.44</td>
<td>1.25</td>
<td>-0.05 [-4]</td>
</tr>
<tr>
<td><strong>Gram</strong></td>
<td>8.47</td>
<td>7.28 - 9.78</td>
<td>7.06</td>
<td>1.41 [20]</td>
</tr>
<tr>
<td><strong>Groundnut Kharif</strong></td>
<td>4.91</td>
<td>3.27 - 6.76</td>
<td>5.37</td>
<td>-0.46 [-8.6]</td>
</tr>
<tr>
<td><strong>Groundnut Rabi</strong></td>
<td>1.42</td>
<td>0.86 - 1.82</td>
<td>1.37</td>
<td>0.05 [3.6]</td>
</tr>
<tr>
<td><strong>Groundnut Total</strong></td>
<td>6.33</td>
<td>4.13 - 8.58</td>
<td>6.74</td>
<td>-0.41 [-6.1]</td>
</tr>
<tr>
<td><strong>Soyabean</strong></td>
<td>12.05</td>
<td>10.21 - 13.97</td>
<td>8.57</td>
<td>3.48 [40.6]</td>
</tr>
<tr>
<td><strong>Rapeseed &amp; Mustard</strong></td>
<td>6.40</td>
<td>5.34 - 7.55</td>
<td>6.80</td>
<td>-0.4 [-5.9]</td>
</tr>
<tr>
<td><strong>Cotton</strong></td>
<td>5.28</td>
<td>4.50 - 6.11</td>
<td>5.10</td>
<td>0.18 [3.5]</td>
</tr>
<tr>
<td><strong>Jute</strong></td>
<td>1.96</td>
<td>1.79 - 2.14</td>
<td>1.79</td>
<td>0.17 [9.5]</td>
</tr>
<tr>
<td><strong>Sugarcane</strong></td>
<td>366.60</td>
<td>340.10 - 394.20</td>
<td>348.45</td>
<td>18.15 [5.2]</td>
</tr>
</tbody>
</table>
RECENT INITIATIVES: SPATIAL EFFECTS

- Spatial of rainfall important
  - Crop cultivation may be concentrated/clumped – not grown in all parts of the states
  - Effect on river flows, reservoir storage, water distribution in current season or subsequent season
- Spatial lagged (neighbouring states, highland) and rainfall in previous season can affect agriculture through irrigation
- Rainfall in specific region (i) influential - not necessarily average state rainfall - used map on rivers
  - **Revised Model tried in 2016-17**

  \[ Q_{is} = f(R_{i, s-t}, R_{i-k, s-t}, R_{i, s-t}I_i, R_{i-k, s-t}I_i, Z) \]

Where, s-Season, t – seasonal lag, k-spatial lag, Z-other variables
Actual and Estimated Area Graph

**Gram (MP) - Revised**

- **Actual**: Black line
- **Fitted**: Blue line

**Wheat (Haryana) - Revised**

- **Actual**: Black line
- **Fitted**: Blue line
ACTUAL ESTIMATED YIELD GRAPH

Wheat (MP)-Revised

2700
2500
2300
2100
1900
1700
1500


•••••的实际•••••的拟合

GN (MH)- Revised

1600
1550
1500
1450
1400
1350
1300


•••••的实际•••••的拟合
TOWARDS A REFORMED POLICY PARADIGM

- Significance of reliable information based on rigorous transparent, simple methods and error ranges—Early outlook- becoming increasingly important
- Need for coordinated, well deliberated policy making at inter-Ministerial level based on outlook formed by multiple alternate agencies and rational methodologies
- Need for improved communication between Centre and States to understand reality and reconcile
- **Transitions in statistical system** – technology enabled, transparent, more reliable, timely data
- Vast developments
THANK YOU
**Arhar-Andhra Pradesh**

\[ A = -452.3 + 0.08A(-1) + 1211 (9.3)P + 6.03 (15.0) \text{RF(Jun, Jul)} + 0.12 (3.4) \text{Irr(Well)} - 0.003 (-14.0) \text{RF(Jun, Jul)}^{*}\text{Irr(canal)} - 0.39 (-8.8) \text{RF(Oct-lag)} \]

\[ = \text{Adj R}^2 = 67.67 \text{ Sub-crops= GN, COT, BJ} \]

\[ Y = -121.7 + 87.2 (2.1) P - 1.4 (-2.6) \text{RF(Mar)} - 0.5 (-3.1) \text{RF(Oct-lag)} + 0.7 (4.6) \text{RF(Sep, Oct)} + 0.97 (2.3) \text{RF(Jun)} + 69.5 (2.4) \text{Irr(Well)} - 2.3 (-3.0) \text{RF(Apr)} - 54.8 (-1.9) \text{Temp(Jul-max)} \]

\[ = \text{Adj R}^2 = 0.87 \text{ Sub-crop= URD} \]

**GRAM-MP**

\[ A = 1488.45 - 0.35 (-2.5) A(-1) + 244 (2.3) P + 0.62 (7.9) \text{Irr(Canal+Well)} - 144 (-2.2) \text{Temp(Nov-min)} \]

\[ = \text{Adj R}^2 = 0.89 \text{ Sub-crop= WHT} \]

\[ Y = 201 + 23.8 (6.1) P + 0.6 (3.5) \text{RF(Jul)} + 2.8 (4.2) \text{RF(Nov)} + 0.13 (2.2) \text{RF(Aug, Sep)}^{*}\text{Irr(Well)} + 5.3 (3.2) \text{RF(Jan)}^{*}\text{Irr(Canal)} + 126 (3.6) \text{temp(Nov-max)} \]

\[ = \text{Adj R}^2 = 0.8 \]