Grey side of the Green Revolution
R.B. Singh

24/06/2016

Green, White, Yellow and Blue Revolutions
Between 1951 and 2013

- Foodgrain production 51 to 265 mt, 5.5x
- Horticultural production 268 mt, 7x
- Milk production 17 to 140 mt, >8x (World No. 1)
- Fish production 0.75 to 10 mt, 12x
- Poverty and hunger percentages more than halved
- From Ship-to-mouth and Chronic Energy Deficits to Food Bill – Right to food
<table>
<thead>
<tr>
<th>YEAR</th>
<th>Production (Million Tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965-66</td>
<td>5.37</td>
</tr>
<tr>
<td>1975-76</td>
<td>13.86</td>
</tr>
<tr>
<td>1985-86</td>
<td>25.46</td>
</tr>
<tr>
<td>1995-96</td>
<td>32.00</td>
</tr>
</tbody>
</table>

- In 1995-96 contributed 21% of India’s total foodgrain production
- Contributed 50% of rice and 85% of wheat total procurement

**Grey Effects of Green Revolution**

- Rice productivity growth rate in Punjab during 1965-74 was 9%, but dropped to 1.13% during 1995-96.
- Area under pulses sharply declined
- Summer rice cultivation excessively increased water and energy demands
- Incidences of diseases, pests and weeds (Phalaris minor) increased, biodiversity decreased, aerosols concentration in urban areas increased;
Grey Effects of Green Revolution

- Soil organic carbon declined from 0.5% in 60s to 0.2% in the 90s. Soil with low Phosphorus increased to 73% in 1996 from only 3.5% in 1975 in Haryana; the N:P$_2$O$_5$ ratio came down from 3.3:1 to 4.2:1;
- Harvested more nutrients than being applied, particularly P & K, reducing profitability
- Over exploitation of groundwater led to higher costs of pumping water, thus decreasing profitability and also adding to salinity problems.

Ground Water Status in Punjab

TRENDS OF DECREASING WATER TABLE IN PUNJAB OVER THE YEARS

<table>
<thead>
<tr>
<th>Year</th>
<th>Affected Area</th>
<th>Depth of water level (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973-1974</td>
<td>3%</td>
<td>30</td>
</tr>
<tr>
<td>2005-2006</td>
<td>30%</td>
<td>70</td>
</tr>
<tr>
<td>2023</td>
<td>Whole Punjab</td>
<td>160</td>
</tr>
</tbody>
</table>
### Number of tubewells in Haryana and Punjab

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tubewells</td>
<td>12570</td>
<td>547216</td>
<td>16932</td>
<td>740000</td>
</tr>
</tbody>
</table>

**GROWTH OF TUBEWELLS IS LINKED WITH DECLINE OF TABLE IN PUNJAB**
Irrigated Area (thousand hectors) in Haryana and Punjab

<table>
<thead>
<tr>
<th>State</th>
<th>Net irrigated area 1965-66</th>
<th>1994-95</th>
<th>Gross irrigated area 1965-66</th>
<th>1994-95</th>
</tr>
</thead>
<tbody>
<tr>
<td>Punjab</td>
<td>2263</td>
<td>3944</td>
<td>3136</td>
<td>7315</td>
</tr>
<tr>
<td>Haryana</td>
<td>1293</td>
<td>2663</td>
<td>1736</td>
<td>4515</td>
</tr>
</tbody>
</table>

Ground Water Status in Haryana

Rate of decrease of water table in Haryana
- From 1974 to 2015 depth of water table in Haryana decreased by 8.56m, from an average of 9.19 m in June 1974 it went down to 17.75 m in June 2015
- Hisar is the only district where the water table has risen with more than 7 m per in the last 40 years as the water quality is not good.
Until 1970, canals dominated irrigated agriculture... Since then, tube-wells have emerged as “Engines of Agricultural Growth”...

Water availability: 30% of crop production at risk by 2025

Source: World Economic Forum, 2010
Role of groundwater (GW) in Food Security

Net irrigated area : 58.5 M ha
GW irrigated area : 35.0 M ha

Increase in irrigated area (1951-2007)
Major and medium irrigation projects : 3.5 times
Tank irrigation : 1.9 times
Ground water : 6.3 times

During past 25 years : 75 % increase in GW irrigated area

Ultimate GW potential : 64 M ha with sustainable GW management

Status of groundwater development in North Western Indian states (2008)

<table>
<thead>
<tr>
<th>State</th>
<th>Total blocks</th>
<th>No. of overexploited groundwater blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haryana</td>
<td>113</td>
<td>55</td>
</tr>
<tr>
<td>Punjab</td>
<td>137</td>
<td>103</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>803</td>
<td>37</td>
</tr>
<tr>
<td>Gujarat</td>
<td>223</td>
<td>31</td>
</tr>
<tr>
<td>4 States</td>
<td>1276</td>
<td>226 (27 %)</td>
</tr>
<tr>
<td>India</td>
<td>5723</td>
<td>839 (15 %)</td>
</tr>
</tbody>
</table>
## Groundwater Utilization (BCM) in Eastern Region

<table>
<thead>
<tr>
<th>States</th>
<th>Annual Repleni-shable GW</th>
<th>Net annual GW availability</th>
<th>Annual GW draft</th>
<th>Stage of GW development (%)</th>
<th>GW availability for future irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assam</td>
<td>28.52</td>
<td>25.79</td>
<td>3.49</td>
<td>14</td>
<td>22.14</td>
</tr>
<tr>
<td>Bihar</td>
<td>29.34</td>
<td>26.86</td>
<td>11.95</td>
<td>44</td>
<td>14.10</td>
</tr>
<tr>
<td>Chhattisgarh</td>
<td>12.42</td>
<td>11.63</td>
<td>4.05</td>
<td>35</td>
<td>7.44</td>
</tr>
<tr>
<td>Eastern UP</td>
<td>27.29</td>
<td>25.47</td>
<td>17.68</td>
<td>69</td>
<td>7.58</td>
</tr>
<tr>
<td>Jharkhand</td>
<td>6.31</td>
<td>5.76</td>
<td>1.86</td>
<td>32</td>
<td>3.69</td>
</tr>
<tr>
<td>Odisha</td>
<td>17.78</td>
<td>16.69</td>
<td>4.73</td>
<td>28</td>
<td>11.64</td>
</tr>
<tr>
<td>West Bengal</td>
<td>29.25</td>
<td>26.58</td>
<td>10.69</td>
<td>40</td>
<td>15.38</td>
</tr>
<tr>
<td><strong>Eastern Region</strong></td>
<td><strong>150.91</strong></td>
<td><strong>138.78</strong></td>
<td><strong>54.45</strong></td>
<td><strong>39</strong></td>
<td><strong>81.97</strong></td>
</tr>
<tr>
<td>India</td>
<td>432.72</td>
<td>398.16</td>
<td>245.10</td>
<td>62</td>
<td>154.71</td>
</tr>
</tbody>
</table>

Source: Dynamic Ground Water Resources of India (2014)

## Per capita water availability in India

![Graph showing per capita water availability in India](image)
### Groundwater Challenges

- **Uncontrolled Groundwater exploitation both in hard rocks and alluvial areas** is the threatening sustainability of this resource, mostly in the states of Rajasthan, Gujarat, Tamil Nadu, Punjab, Delhi, and Haryana.

- **Dependence on groundwater for irrigation** will increase due to global warming. Quality issues will increase.

- **Excessive withdrawal of ground water** is worsened further due to free/subsidized power in some States. (Water-Energy nexus)

- **Groundwater pollution due to excess application of fertilizers and pesticides, indiscriminate disposal of effluents from industries and urban sewerage.**

- **Arsenic, Fluoride and Iron in groundwater in excess of permissible limits** in several states of India prohibits its use for drinking purposes.

- **Seawater Ingress in Coastal Aquifers**- Groundwater in coastal aquifers exists in a fragile dynamic equilibrium with seawater. Indiscriminate exploitation of ground water from such aquifers leads to seawater intrusion into the fresh water aquifers.

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<table>
<thead>
<tr>
<th>Country</th>
<th>Abstraction (km²/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>251</td>
</tr>
<tr>
<td>China</td>
<td>112</td>
</tr>
<tr>
<td>United States of America</td>
<td>112</td>
</tr>
<tr>
<td>Pakistan</td>
<td>64</td>
</tr>
<tr>
<td>Iran</td>
<td>60</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>35</td>
</tr>
<tr>
<td>Mexico</td>
<td>29</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>23</td>
</tr>
<tr>
<td>Indonesia</td>
<td>14</td>
</tr>
<tr>
<td>Italy</td>
<td>14</td>
</tr>
</tbody>
</table>

Groundwater-Abstracting Countries as of 2010
India: A Gene Rich Center

Science must ensure judicious harnessing of this Treasure, Know your treasure-
Evaluation and Conservation through use

Second Generation Problems of Green Revolution

- Decline in quantity and quality of soil organic matter
- Multi-nutrient deficiencies in soils and crops
- Deterioration of soil physical health
- Nutrient withdrawals in excess of replenishment
- Factor productivity decline
- Stagnation/decline in production/productivity growth rates
- Increased incidence of diseases and pests
- Reduced farm profits
Temporal changes in fertilizer consumption, foodgrain production and land use

Fertilizer N Use Efficiency
Trend for Cereals in India

Calculated using IFA and FAO data under the assumption that two-thirds of fertilizer N is applied to cereals
Progressive expansion in the occurrence of nutrient deficiencies

Causes of soil health deterioration

- Inadequate and unbalanced fertilizer use
- Incomplete fertilizer prescriptions
- Poor soil testing services
- Low use of organics
- Clean cultivation – residue removed/burnt
- Excessive tillage; poor land leveling
- Ignoring principles of crop rotation – monoculture
- Lack of awareness among farmers
- Fertilizer policies ????
Consequences of soil nutrient mining

- Depletion of native nutrient reserves
- More widespread and more acute nutrient deficiencies
- Low nutrient use efficiencies
- Lower returns from investment in fertilizers and other inputs
- Very high remedial cost of improving depleted soils
- Jeopardizing the sustainability of agriculture sector as a whole

Food Demand Compared to Agricultural Output from TFP Growth in India

Intensify science-led high efficiency and productivity
The Indian Enigma

- Despite rapid economic growth trajectory of 7-8%, 1/4th of World’s hungry and poor, 200 m, have homes in India
- 40% of world’s malnourished Children are our own; high epigenetic & economic costs
- 1/4th of world’s smallholder farmers in India, they comprise 50% of rural poor and hungry, F:NF income 1:4
- A nation of youth, largest bulge of unemployed/poorly employed youth, a demographic disaster
- Agriculture 2-3 times more effective than other sectors in alleviating agrarian crisis, yet investment in Agr low

Big Picture

- No where in the world Food and Agriculture System (FAS) is as important as in India – 14% of national GDP, 50% of employment (650 m directly dependent on agriculture)
- Structural transformation during past 65 years failed to bridge farmer-non-farmer income gaps (1:4); small and declining farm size
- Agriculture is best bet for alleviating stubbornly high poverty, undernutrition, inequity, unemployment and livelihood insecurity.
- New Agriculture stipulates high efficiency, save and grow, competitive, resilient, sustainable, remunerative, modern, bio-based, healthy, safe and nutritious, vibrant and fast-growing FAS.
From MDGs to SDGs

In number terms, India will not meet the MDG1. Extra efforts needed to meet SDGs, especially the first 3 of the 17

• “End poverty in all its forms everywhere
• End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.
• Ensure healthy lives and promote well-being for all at all ages – a life cycle approach”

The 9.6 Billion Person Question

2050
Pusa Basmati 1509, $5 billion annual export

- Reduced height
- Earliness
- Non-lodging
- Non-shattering

Pusa Basmati 1509

Pusa Basmati 1121

Drip irrigation system
## Small Farmers: Huge Contributions

<table>
<thead>
<tr>
<th></th>
<th>Cereals</th>
<th>Fruits</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2ha</td>
<td>48%</td>
<td>45%</td>
</tr>
<tr>
<td>&gt; 2ha</td>
<td>52%</td>
<td>55%</td>
</tr>
</tbody>
</table>

### Milk

<table>
<thead>
<tr>
<th></th>
<th>&lt; 2ha</th>
<th>&gt; 2ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>49%</td>
<td>61%</td>
</tr>
</tbody>
</table>

### Vegetables

<table>
<thead>
<tr>
<th></th>
<th>&lt; 2ha</th>
<th>&gt; 2ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30%</td>
<td>70%</td>
</tr>
</tbody>
</table>

## Farmers’ Challenges

- Will I ever get C II + 50% C III for my produce?
- Whether inflation or deflation, I am always the looser.
- Soil has lost its physical, chemical, biological character; my seeds are not germination.
- When will I reap fruits of new science? What if the new seed fails?
- I am indebted & distressed.
- Can my welfare be built on solid ground, not on quicksand.
- Where are my traditional seeds?
- Where is the Ground Water, my Well is dried up, Jan Jal?
Can We Impose a BAN on Hunger?

Yes We Can

100%  Zero  All  100%  Zero
access to adequate food all year round
stunted children less than 2 years
food systems are sustainable
increase in smallholder productivity and income
loss or waste of food

“Hunger can be eliminated in our life times”.

Ban Ki-moon, 2012

President Lula in Brazil did it in 10 years, 2003-2012

The Challenges for Agricultural Researchers and Educationists are to Develop Innovations that Offer:

• **Sustainable Intensification** of production to meet global demand for food quantity and quality.

• **Profitability and Social Attractiveness** to agriculture as a profession.

• **Ecosystem Services** that improve water quality, soil health, carbon capture, biodiversity and wildlife habitat.

• **Predict differentiated** future demands and food and agriculture systems, and **match** them.

ASA Science Frontiers, 2015
STRATEGIES

• Diversification (Livestock, Horticulture, Aquaculture, Pulses, Oilseeds, MAC)
• Bridging Yield Gaps & Accelerated Productivity Growth
• Natural Resources Management – More from less for more, Efficiency
• Value Chain, Prevention of Post-harvest losses, Market Linkage
• Climate Smart Agriculture- the triple win
• Genetic Alchemy, Biotechnology Safe Food, Biosecurity
• Equity, Inclusiveness & Social Protection
• Right to Food - the Food Bill, implementation
• Agri Res, Education, Extension and demand-driven disruptive innovation
• Business Unusual, Monitoring, Evaluation and Impact Pathways

Paradigm Shift
Main Policy Options

- “New Normal” - Integrated outlook and action for food, nutrition, income, livelihood, education, sanitation, hygiene and health securities
- Connect Jan Dhan, Digital India, Skill India, Swachh Bharat, Make –in- India, Start-up India, Innovate India, RKVY, MNREGA etc.
- Nutrition at centre stage of Government Development Plans and seen as a major development indicator; Implementation of the Food Bill
- Strong AREE4D for comprehensive livelihood security
- Big data, monitoring, evaluation, assessment and accountability, impact pathways, effective & transparent Social Protection Floors

Let this not be a glimpse of our future ..