Ten Commandments For Global Agriculture

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Outline

I. Prologue

II. Revisiting Some Main Themes:
   – Globalization, Trade And Policy
   – Food Security And Production
   – The Role Of Science

III. The Ten Commandments For Global Agriculture
I. Prologue
Why Agriculture?
Why Global?
“We are all on this earth as guests of the green plants and those who tend them.”

-- M.S. Swaminathan
Agriculture is the key to Poverty reduction, environmental stewardship, and food security.
The single biggest issue blocking a new Trade Agreement
Some of this material was kindly provided by Gurdev Khush from his BioVision Lecture and by Per Pinstrup-Anderson from his Wageningen Lectures.
II. Revisiting Some Key Themes
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- Globalization And Trade
- Food Security And Production
- The Role Of Science
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- Globalization And Trade
- Food Security And Production
- The Role Of Science
**Increased Demand for Major Cereals**
(Developing Countries, 1995-2020)

Source: IFPRI IMPACT simulations, July 1999.
Despite Major Production Increases in the Developing Countries, Their Net Cereal Imports Will Double by 2020
Food Prices Will Remain Fairly Stable or Decline Slightly...
World Prices for Major Commodities

Source: IFPRI IMPACT simulations, July 1999.
Except ...
If India and/or China Tip From Net Exporter to Net Importer
Chinese Imports of 10% of Rice Needs, Would Amount to About 30% of Total World Rice Trade
Sub-Saharan Africa Will Remain Net Importer for Many Years, and Vulnerability Will Remain High
African Share of International Agricultural Trade

Source: Mukherjee and Harris (1999)
II. Revisiting Some Key Themes

- Globalization And Trade
- Food Security And Production
- The Role Of Science
Food Security and Production

- Production is a necessary but not sufficient condition for food security.

- Focusing on the small-holder farmer in developing countries is key to environmental protection, poverty reduction and food security.
Responding to the Production Challenge:

• Increasing area under cultivation

• Increasing yields
Meeting the Production Challenge

- Increasing biological yields
- Improving nutrient content
- Intensifying agriculture
- Managing natural resources sustainably
II. Revisiting Some Key Themes

- Globalization And Trade
- Food Security And Production
- The Role Of Science
From the Green Revolution to the Doubly Green Revolution to the Ever Green Revolution
Integrated Soil, Water & Nutrient Management
Recognize The Gender Dimension
Promoting Alternatives to Slash and Burn
Reduce Post-Harvest Losses
Always
Pro-Poor
Pro-Women
Pro-Environment
The Genetic Imperative
Traditional Wisdom and Modern Science
Different Regions Will Need to Address Different Problems... But All Will Require the Best of Science!
Focusing on the problems of the poor
Whole new avenues are opening up at a very fast pace...

It is a wonderful time to be working in the biological sciences.
III. The Ten Commandments For Global Agriculture
The Ten Commandments For Transforming Global Agriculture

1. Reform Policies And Markets
2. Focus On Small-holder Farmers
3. Husband Natural Resources
4. Raise Agricultural Productivity
5. Improve Nutritional Content
6. Address Short-term Vulnerability
7. Empower Women
8. Reach Out To The Ultra-poor
9. Support Science
10. Translate Rhetoric Into Action
The Ten Commandments For Transforming Global Agriculture

1. Reform Policies And Markets
1. Reform Policies And Markets

- **Globally**: Fair trade
- Locally:
  - Remove urban bias
  - Improve access to markets
  - Reduce post harvest losses
Farm Subsidies

• The developed world funnels nearly $1 billion a day in subsidies to its farmers.

• That is about six times total amount of ODA!
Cows Vs. People

• A typical cow in the European Union receives a government subsidy of $2.20 a day –

• more than what 2.5 billion of the world's poorest people live on every day.

• Twice what 1.2 billion of the world's poorest people live on every day.
$2.20 / day

$0.90 / day
LET THE COMPETITION BEGIN!

WTO

1st World

Subsidized

3rd World
1. Reform Policies And Markets

• Globally: Fair trade

• Locally:
  – Remove urban bias (educ., health, etc.)
  – Improve access to markets
  – Reduce post harvest losses
The Ten Commandments For Transforming Global Agriculture

1. Reform Policies And Markets
2. Focus On Small-holder Farmers
2. Focus on Small-holder Farmers

- They are the majority of all farmers in the world
- They are disproportionately poor
- The returns in terms of growth, poverty reduction and improved environmental management is substantial
Rural and Urban Poverty in Developing Countries

Rural poor 70.0%

Urban poor 30.0%

Source: IFPRI estimate from World Bank data.
Why Small-Holders?

In 2004, they contained over 92 percent of the world's 1.2 billion "dollar-poor" (Dollar-poor = households consuming less than one U.S. dollar's worth of a world average consumption bundle, per person per day, at 1993 purchasing-power-parity values).
Challenges Facing Small Farms

• Globalization, including super-markets even in poor countries.
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• Low world market prices for agriculture.
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• Climate change.
• HIV/AIDS
• Continuing population growth that is making small farms smaller.
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• Climate change.
• HIV/AIDS
• Continuing population growth that is making small farms smaller.
• No political voice.
Challenges Facing Small Farms

• Globalization, including super-markets even in poor countries.
• Low world market prices for agriculture.
• Climate change.
• HIV/AIDS
• Continuing population growth that is making small farms smaller.
• No political voice.
So, dealing with global poverty requires that we address rural poverty…
So, dealing with global poverty requires that we address rural poverty…

AND
So, dealing with global poverty requires that we address rural poverty…

AND

A special focus on small-holder farmers in developing countries in particular to address the problem of food security
The Ten Commandments For Transforming Global Agriculture

1. Reform Policies And Markets
2. Focus On Small-holder Farmers
3. Husband Natural Resources
3. Husband Natural Resources

- Agriculture is the major interface between people and nature
- Sustainable development is beneficial for all
- Resource degradation hits the poor worst
Global Land Use

- World-Wide Natural Vegetation, Croplands And Rangeland

Land Use Transitions

Human Alteration of Major Components of Earth System

- Marine fisheries: 68%
- Bird extinction: 23%
- Plant invasion: 20%
- Nitrogen fixation: 58%
- Water use: 57%
- CO₂ concentration: 22%
- Land transformed: 43%

Source: Vitousek et al (1997)
The Most Important Environmental Action Is to Reduce the Need for More Land Under Cultivation
It Saves Habitats and Biodiversity
Water Is Also a Constraint
10% of World Grain Production Depends on Unsustainable Underground Water Withdrawals.
One Calorie = One Liter
More Crop Per Drop!
Crop yield per unit of water
wheat kg/cu.m

- Rainfed: 0.3
- Irrigated: 0.8
- Supplemental Irrigation: 2.2
New Water Sources
(US cents /cu.m)

• Reduce demand = 10 - 70
• leakage repair = 10 - 70
• Desalination = 20 - 40
  – (brackish water)
• Wastewater reuse = 10 – 50
  – (Only for irrig. & some industry)
• Desalination = 50 – 90
  – (sea water)

Using Treated Wastewater

Sorghum and Topinambur irrigated with Treated Wastewater in Sorbulak area, Kazakhstan – Courtesy ICARDA
And So Much More...
2000 to 4000 tons of water to produce 1 ton of rice
Differences in Growth Duration
Levees for Water Management in Uneven Field
Laser Land Leveling
Laser Leveled Fields
Soil Puddling for Transplanted Rice
Dry Sowing of Rice

Normal Flat Planting

Bed Planted
Reducing Pollution Is Essential.
Reduction in Pesticide Use but Continued Increase in Rice Production in Indonesia
Insecticide use and yields in Long An Province, Vietnam.

- **Av. insecticide sprays/season**
- **Av. yields (t/ha)**

- **Year**
  - 1994
  - 1996
  - 1997

- **Stable yields**

- **Less insecticide spraying**
The Ten Commandments For Transforming Global Agriculture

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4. Raise Agricultural Productivity
4. Raise Agricultural Productivity

- Productivity must rise faster than price declines to generate surpluses for the small-holder farmers and reduce their poverty as their cheaper products help reduce the poverty in the cities.

- Measure in terms of Total Factor Productivity (land, water, labor, energy and chemical inputs)
Trends in world rice production and price adjusted for inflation, 1961-2002
Future Challenges

To Produce More Food

Increasing Population

Less Water
Less Land
Less Labor
Less Chemicals
Transgenic Crop Acreage Growing

Source: Ernst & Young, Beyond Borders, Global Biotechnology Report 2006

Source: Clive Jones, International Service for the Acquisition of Agri-biotech Applications (ISAAA)
Developing Countries Share Of Transgenic Crop Area Growing Fast

Source: Ernst & Young, Beyond Borders, Global Biotechnology Report 2006

Source: Clive Jones, International Service for the Acquisition of Agri-biotech Applications (ISAAA)
Three Themes in Rice Research for Increased Production

- Yield (t/ha)
- Ceiling
- Current

Source: Gurdev Khush, Lecture at BioVision Lyon 2005
Three Themes in Rice Research for Increased Production

- Raise the Yield Ceiling

Source: Gurdev Khush, Lecture at BioVision Lyon 2005
Three Themes in Rice Research for Increased Production

Source: Gurdev Khush, Lecture at BioVision Lyon 2005
Three Themes in Rice Research for Increased Production

- Raise the Yield Ceiling
- Close the Yield Gap

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Three Themes in Rice Research for Increased Production

- Raise the Yield Ceiling
- Close the Yield Gap

Source: Gurdev Khush, Lecture at BioVision Lyon 2005
Three Themes in Rice Research for Increased Production

A: Raise the Yield Ceiling
B: Close the Yield Gap
C: Sustain the Current Yield

Source: Gurdev Khush, Lecture at BioVision Lyon 2005
Three Themes in Rice Research for Increased Production

- **A**: Raise the Yield Ceiling
- **B**: Close the Yield Gap
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Three Themes in Rice Research for Increased Production

- Raise the Yield Ceiling
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- Sustain the Current Yield

Source: Gurdev Khush, Lecture at BioVision Lyon 2005
Let’s take them by turn
Technologies for Increasing the Yield Potential

Source: Guusje Kloos, Lecture at BioVision Lyon 2005
Different Plant Types of Rice

Conventional  Improved  NPT
New Plant Type Rice
New Plant Type

Three of the NPT lines have been released in Yunnan Province of China, with a yield of more than 13 tons/ha in farmers’ fields.

IR64446-7-10-5 ‘Dianchao 1’ (2002)
IR64446-7-10-5 ‘Dianchao 3’ (2000)

Best yield 15.2 t/ha
An Experimental Rice Hybrid
Comparison of Yield of Hybrid and Inbred Rice

Hybrid = 10.8 t/ha
Inbred = 9.9 t/ha

Experiment

Exp I = PhilRice, 96DS
Exp III = IRRI, 97DS
Exp II = PhilRice, 97DS
Exp IV = IRRI, 97DS
C3 and C4

• The Calvin Cycle, discovered in 1958 by Melville Calvin (1911-1997), explains how plants convert CO2 and H2O into sugar during photosynthesis, producing a compound with 3 carbon atoms in its molecule, hence the C3 plants.

• Another pathway, discovered by Australians Slack and Hatch in 1966, shows that plants like Sorghum, sugar cane, and maize, have 4 carbon atoms, hence C4 plants.
C3 and C4

- C4 plants assimilate CO2 at twice or more the rate of C3 plants and grow much faster

- If it were possible to transgenically convert C3 to C4 plants it would have dramatic results
Differences in the Photosynthesis of C3 and C4 Plants

The graph shows the rate of photosynthesis (μmol/m²/s) as a function of atmospheric CO₂ concentration (ppm). C4 plants have a higher rate of photosynthesis at lower CO₂ concentrations compared to C3 plants.
Technologies for Closing the Yield Gap

A
Raise the Yield Ceiling

B
Close the Yield Gap

C
Sustain the Current Yield

Source: Gurdev Khush, Lecture at BioViron Lyon 2005
## Biological cost of weeds, Diseases and Insects

<table>
<thead>
<tr>
<th>Crop</th>
<th>Weeds</th>
<th>Disease</th>
<th>Insects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>10.6</td>
<td>9.0</td>
<td>27.3</td>
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<tr>
<td>Wheat</td>
<td>9.8</td>
<td>9.5</td>
<td>5.4</td>
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<tr>
<td>Maize</td>
<td>13.1</td>
<td>9.6</td>
<td>12.9</td>
</tr>
<tr>
<td>Millets &amp; Sorghum</td>
<td>17.9</td>
<td>10.3</td>
<td>9.5</td>
</tr>
<tr>
<td>Barley</td>
<td>8.8</td>
<td>8.3</td>
<td>3.9</td>
</tr>
</tbody>
</table>
Reaction to Bacterial Blight
Resistant             Susceptible
Bacterial Blight Resistance Genes tagged with molecular markers
Resistance genes effective against bacterial blight

Reaction to a virulent isolate

Karuna

$Xa_4+xa_5$

$Xa_5+Xa_21$

$Xa_4+xa_5+Xa_21$
Rice Plants with White Heads caused by Stem-Borer damage
Stem-Borer Larvae from Transgenic Rice (top) and Control (bottom)
Latest Trend in IPM is to maximize the use of eco-friendly strategies and minimize the use of toxic chemicals for longer lasting benefits to farmers.
Biological Control

The rich and diverse wealth of biological agents such as predators, parasitoids, insect pathogens and their natural *in situ* interactions can be exploited as key components of IPM.
4. Raise Agricultural Productivity

- Productivity must rise faster than price declines to generate surpluses for the small-holder farmers and reduce their poverty as their cheaper products help reduce the poverty in the cities.

- Measure in terms of Total Factor Productivity (land, water, labor, energy and and chemical inputs)
Technologies Needed For:

- increasing the yield potential
- closing the yield gap, including pest management
- Soil, water & nutrient management
- Labor & capital input management
- developing nutritious crops (more later)
The Ten Commandments For Transforming Global Agriculture

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5. Improve Nutritional Content
5. Improve Nutritional Content

- Enormous health benefits
- Bio-fortification is just the beginning
- Edible vaccines?
Better Nutrition
Golden Rice

1. The genes that give golden rice its ability to make beta-carotene in its endosperm (the interior of the kernel) come from daffodils and a bacterium called Erwinia uredovora.

2. These genes, along with promoters (segments of DNA that activate genes), are inserted into plasmids (small loops of DNA) that occur inside a species of bacterium known as Agrobacterium tumefaciens.

3. These agrobacteria are then added to a Petri dish containing rice embryos. As they “infect” the embryos, they also transfer the genes that encode the instructions for making beta-carotene.

4. The transgenic rice plants must now be crossed with strains of rice that are grown locally and are suited to a particular region’s climate and growing conditions.
White and Golden Rice
Sweet Potatoes with and Without Beta-Carotene
High Iron Rice

16ha production of the High iron rice in Mindanao
Longer, More Productive Lives
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6. Address Short-term Vulnerability
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• Most farmers live precariously

• Downside is devastating

• Climate change is increasing vulnerability
Desertification

In one year (1984-1985), Sahara’s boundary shifted 110 km decreasing an area 724,000 sq. km (21.3 times the Netherlands)
Extreme Variability: Africa’s Burden

Kenya: Annual Rainfall Variation about the Average
Climate Variability (Change?)
Index of Rainfall in Sahel 1941-1990

Source: Departure from standard deviation; Climate Prediction Center 1991, Presentation by South Africa at Camdessus Panel meetings.
Climate Variability (Change?)
Index of Rainfall in Sahel 1941-1990

Source: Departure from standard deviation; Climate Prediction Center 1991, Presentation by South Africa at Camdessus Panel meetings
Climate Change and Food Security:

Changes in Length of growing period 2000-2005

Thronton, et.al., cited in Greg Mock and Paul Steele, “Power to the poor: tapping the wealth of ecosystems”, in Environment, vol 48: 1; Jan/Feb 2006, p. 15
The Ten Commandments For Transforming Global Agriculture

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7. Empower Women
7. Empower Women

- Essential to recognize the gender dimension of agriculture

- Empowering Women results in major improvements in infant mortality, school enrolments, child morbidity
7. Empower Women

- Women have unequal opportunity in:
  - Education
  - Health care
  - Income
  - Credit
  - Employment
  - Assets
  - Decision-making
And We Must Never Forget the Gender Dimension...
Educate Girls and Empower Women...
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8. Reach Out To The Ultra-poor
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• Market incentives do not work for the ultra-poor

• Trickle-down does not work

• Special Programs will be needed
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8. Reach Out To The Ultra-poor
9. Support Science
9. Support Science

• We need more support for science in developing countries
• Not just technology
Rich Countries Vs. Poor Countries

Income: 40 Times

Research: 220 times
The Divide in S&T Capacity

The mystery of economic growth
R&D expenditures as percent of GDP

Source: Ernst & Young, Beyond Borders, Global Biotechnology Report 2006
Inventing a better future
A strategy for building worldwide capacities in science and technology

InterAcademy Council
Inventing a better future
A strategy for building worldwide capacities in science and technology

InterAcademy Council

www.interacademycouncil.net/streport
Launch of the InterAcademy Council report

Inventing a Better Future

United Nations, New York, 5 February 2004
9. Support Science

• Science and Society
• Human resources (including Brain drain)
• Institutions of excellence
• Public/Private interface
• Financing mechanisms
African Biotechnology Panel

Presenting our report later this year for consideration by AU summit in early 2007
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10. Translate Rhetoric Into Action
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- Many past declarations
- Many government announcements
- Will the Millennium Development Goals be different?
“We have the capacity to eliminate hunger from the face of the earth in our lifetime. We need only the will.”

President John F. Kennedy
World Food Congress 1963
The Per Pinstrup-Andersen Equation (Wageningen Lecture March 2005)
WE'RE STILL MISSING A KEY TRANSLATOR...

A.U. LAUNCH
The Ten Commandments For Transforming Global Agriculture

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10. Translate Rhetoric Into Action
Envoi
Working All Together
There is so much we can do for a whole generation
For The Whole World...
Thank You
Thank You
Important notice

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