מינהל המחקר החקלאי
מרכז וולקני

מדינת ישראל / משרד החקלאות ופיתוח הכפר

משבר המזון העולמי: איום או הזדמנות?

יורם קפולניק
מינהל המחקר החקלאי, מרכז וולקני, בית דגן

נושאי ההרצאה:

1. מגמות בעולם
2. היכן להתחיל?
3. מרכז מצוינות - "חקלאות על סף המדבר"
4. תוכנית לאומית למינוף המו"פ החקלאי - ועדת יוג'ין קנדל והחלטת הממשלה

INCREASING FUTURE FOOD PRODUCTION

CHALLENGES & OPPORTUNITIES FOR THE NEW ERA

2-4.12.2012

90

Agricultural Research Organization
Volcani Center

Within the framework of 90 years of agricultural research the Agricultural Research Organization (ARO) proudly announces the launching of an international workshop to address the Future World Food Crisis.

TOPICS

Session 1. Innovative agro-techniques to improve productivity & yield

Session 2. Reducing losses during production & postharvest periods

Session 3. Breeding genomics & biotechnology for plant & animal improvement

Panel discussion 1. Likelihood that agro-technological means will enhance food production.

Panel discussion 2. [illegible] technologies & solutions for the first & third world that is the middle ground.

Panel discussion 3. Solutions to the food crisis: genetic modification versus classical breeding.

Panel discussion 4. Regulations and policy relating to genetically modified products as a solution for the projected food crisis.

WORKSHOP VISION

The conference will focus on new opportunities to adapt the agricultural research setting to meet the future challenges, enveloping the concept that future agriculture should not compromise the quality of soil and water resources or threaten the ecological integrity of natural ecosystems.

CONFERENCE VENUE

The conference will be held at the Volcani Center campus (Cohen Auditorium). The scientific program will include invited lectures on 3-4 December 2012. The conference will include four panel discussion sessions. There will be live, interactive broadcast coverage of the conference via the web.

LANGUAGE

The official language of the workshop will be English.

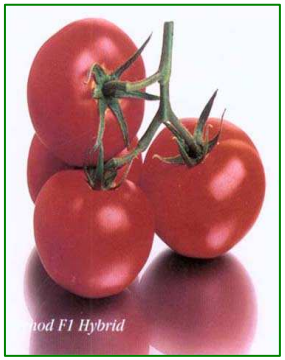
PARTICIPATION

All lectures will be given by renowned invited speakers from overseas and Israel – for full details on the scientific program and for online registration please consult our conference website at:

http://www.agri.gov.il/en/pages/929.aspx

ARO 90

Meeting customer needs



יבול

חיי-מדף

טעם, מרקם ומופע

בריאות ואיכות תזונתית

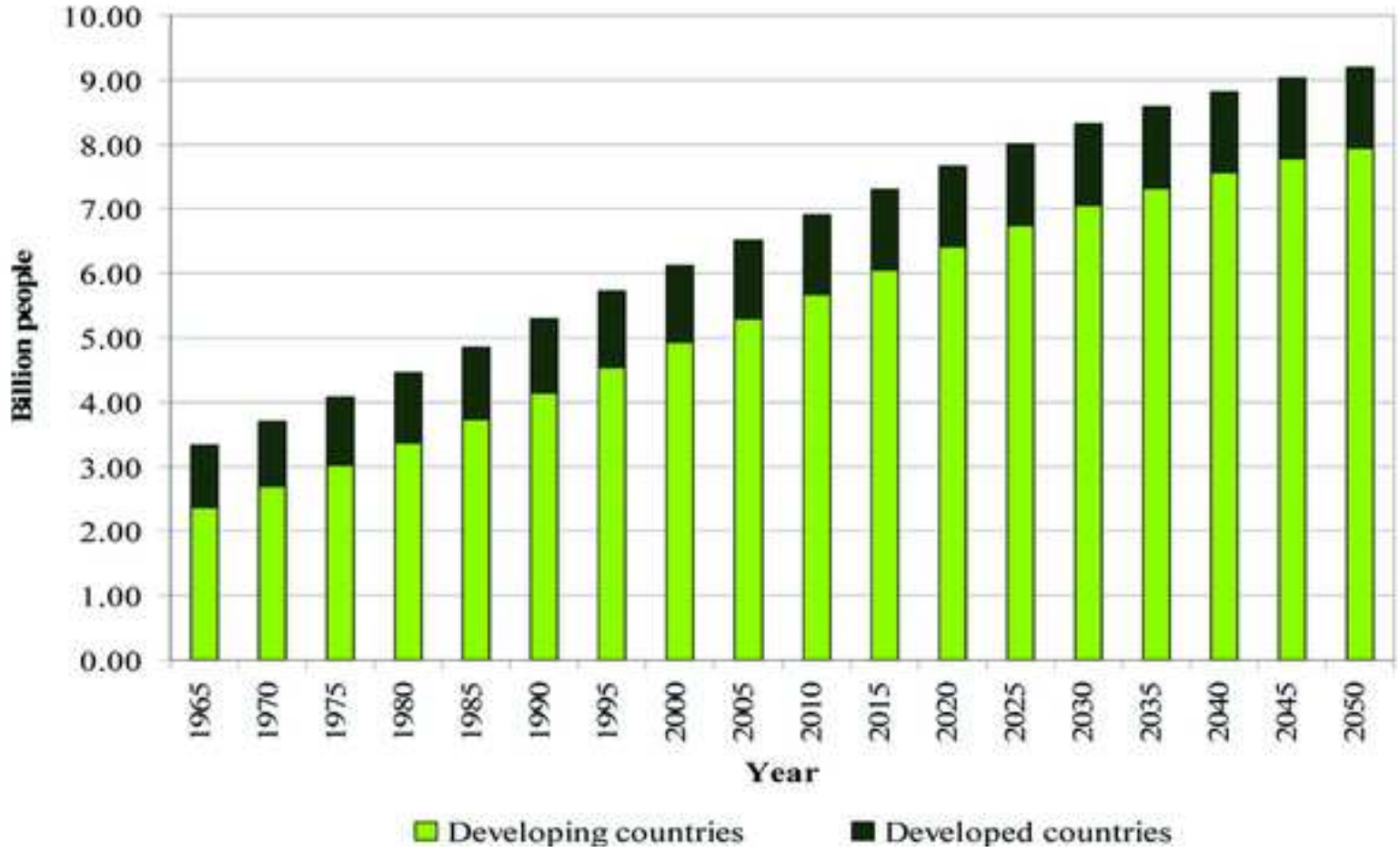
?

1970 → 1980 → 1990 → 2000 → 2010 → →

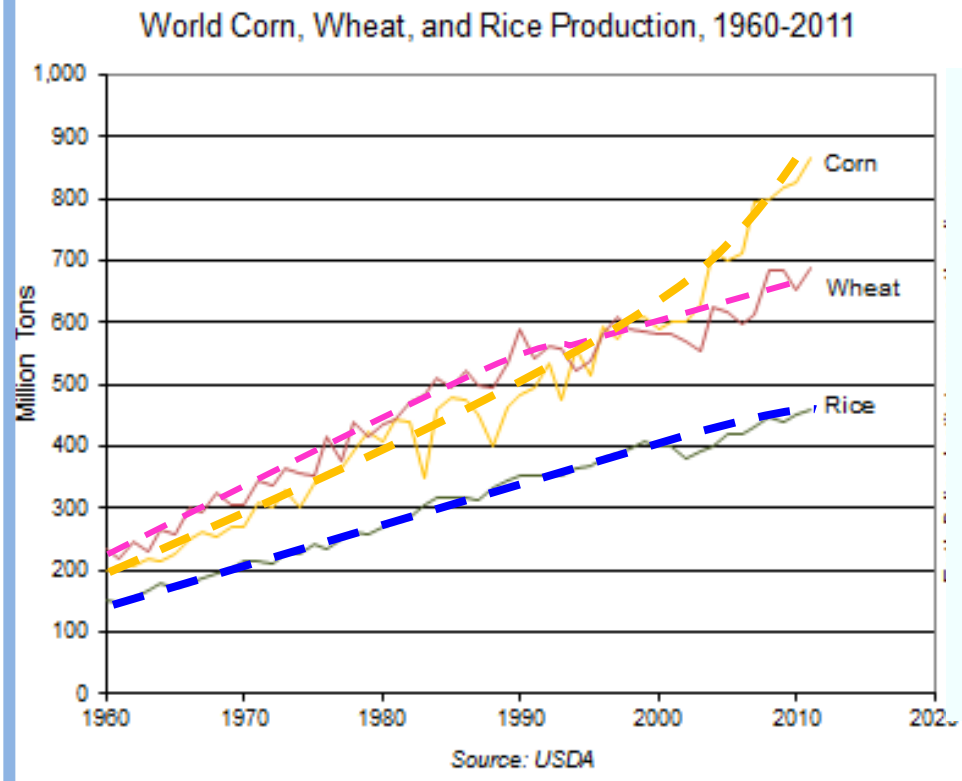
Who is our next costumer?

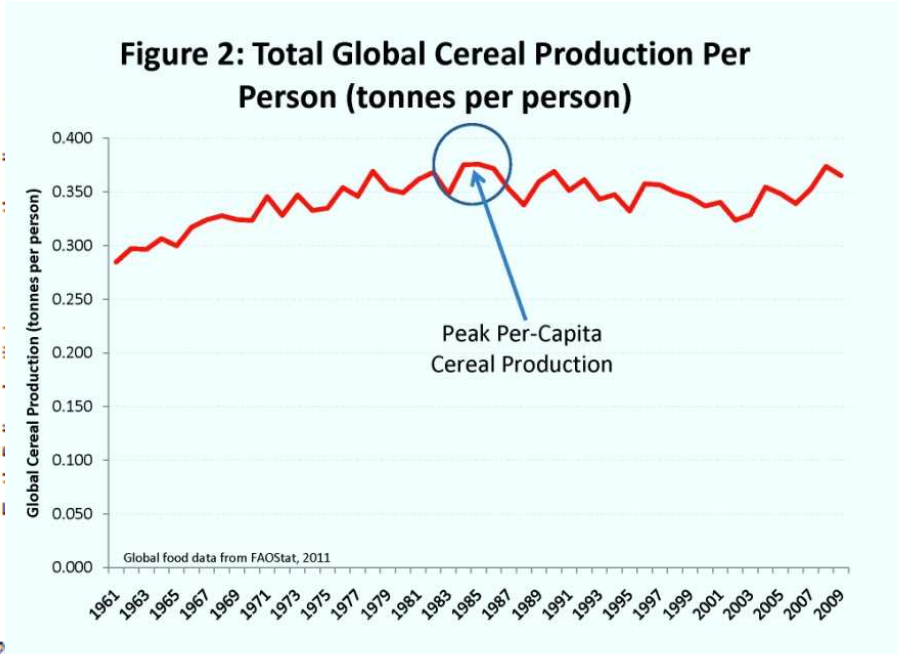
What are the needs?

Increase in world's population



Productive and constructive
But what next?



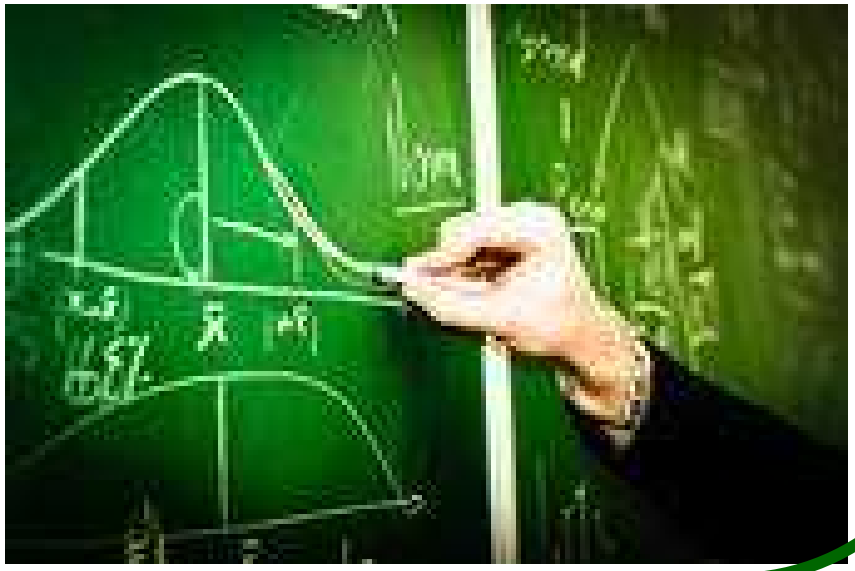


We can not stop the tendency!

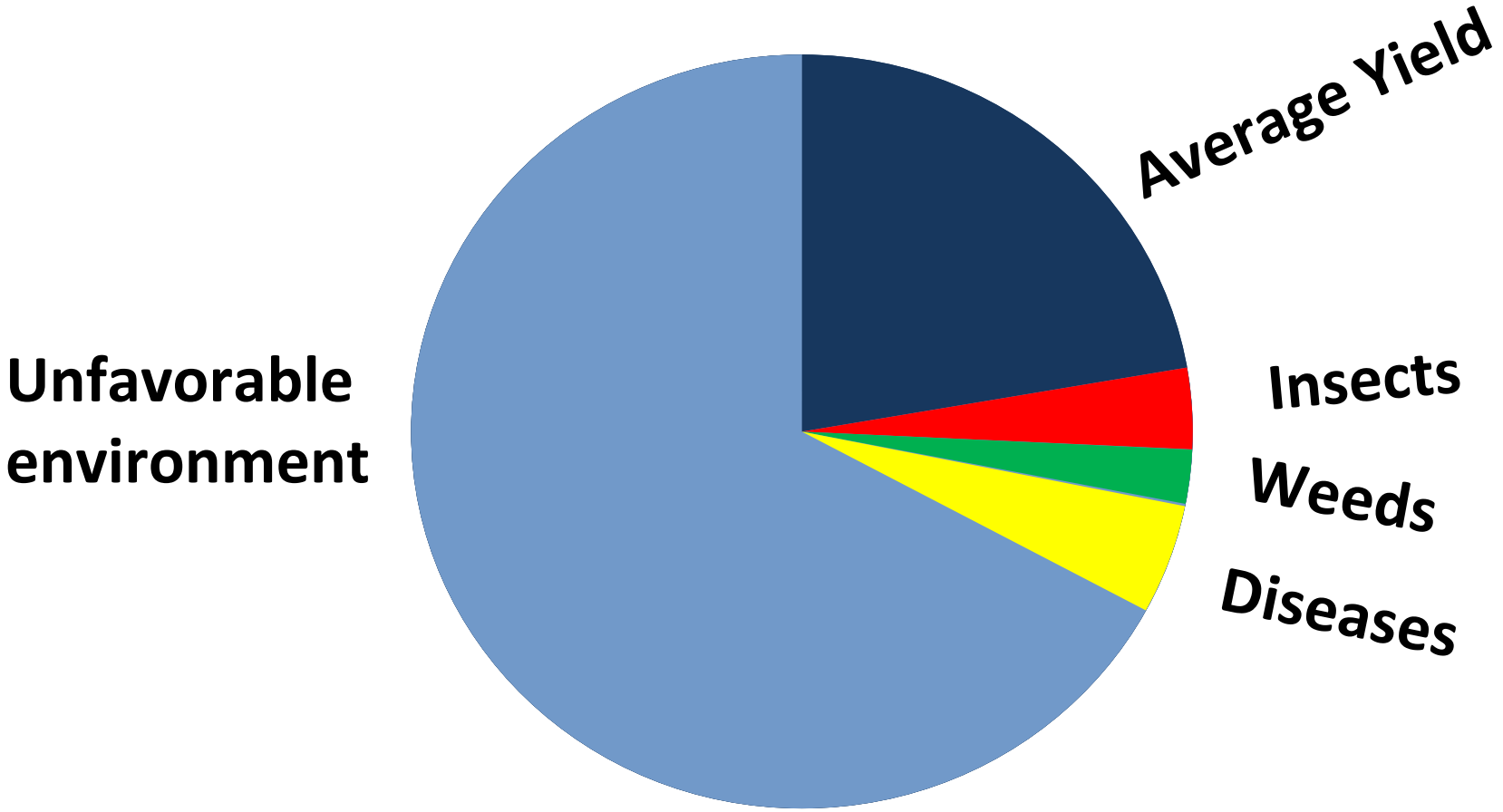
Food shortage: increase in food prices

Where is next?

Can we make more?

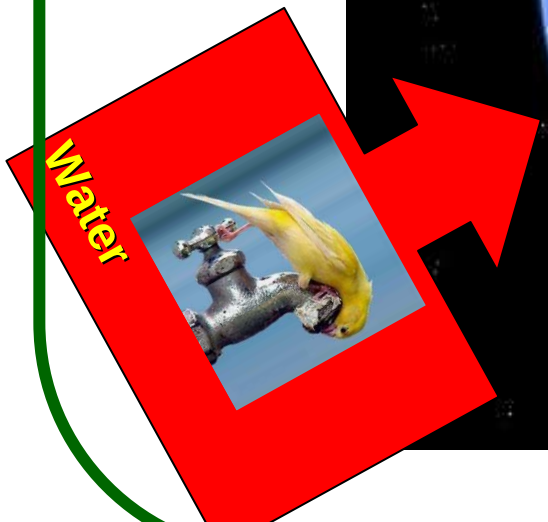


The effect of environment on plant productivity



After: J.S. Boyer (1982)
Science 218: 443-448

Major worlds' threats

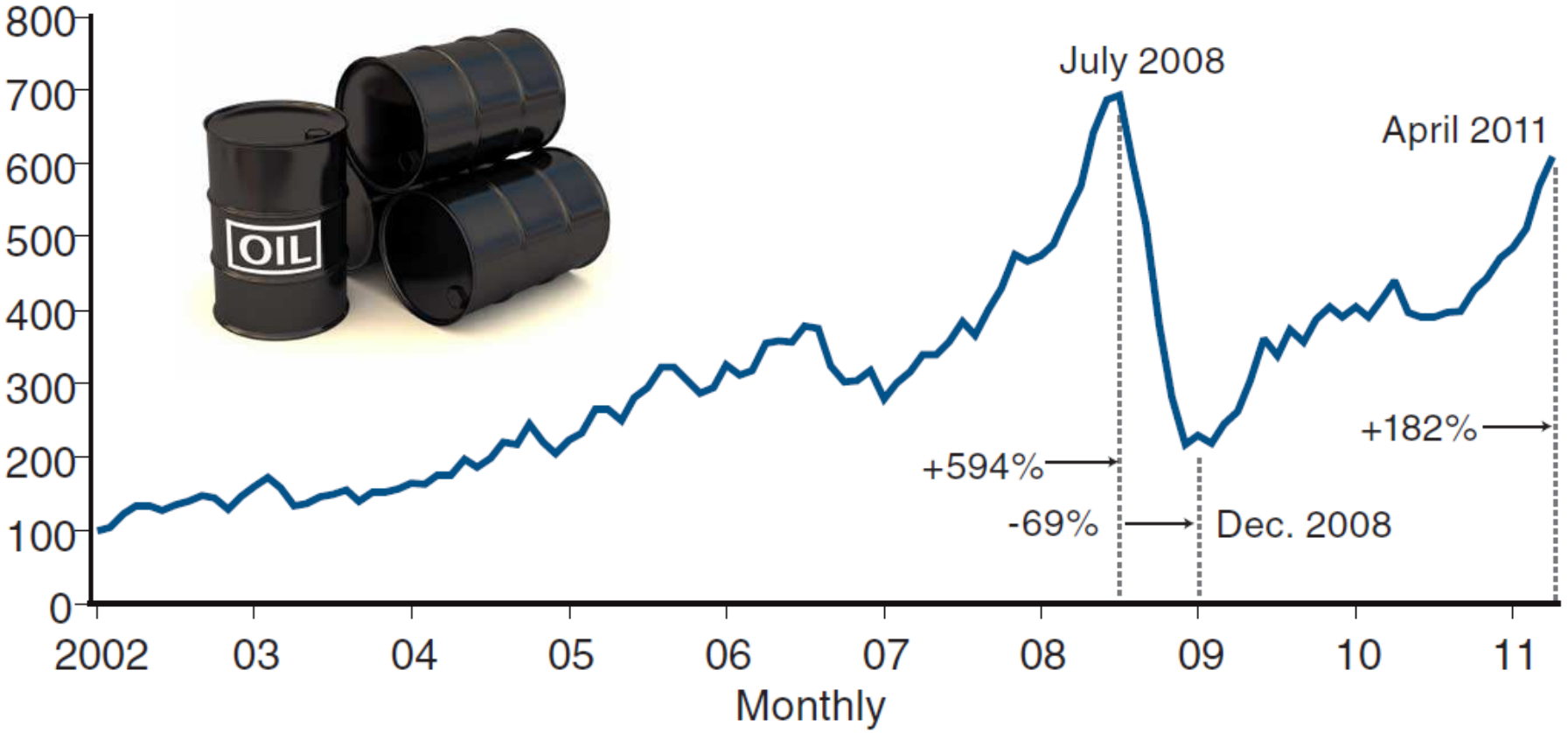


Energy runs modern agriculture

Commodities' value → **Oil price**

Crude oil prices[1]

Index: January 2002 = 100



[1]International Monetary Fund crude oil monthly price index.

מקור: Trostle et al. (2011), Why have food commodity prices risen again? USDA - ERS

Agricultural inputs support Bio-energy production

Technology of developing countries

Increase in rate of "Natural catastrophes"

SO WHAT DO WE NEED TO DO?

WE NEED TO MOVE FORWARD TOGETHER

Source: World Economic Forum,
Realizing a New Vision for Agriculture: A roadmap for stakeholders

WE NEED TO MOVE FORWARD TOGETHER

Set the direction

- Establish and enforce consistent, transparent regulation to attract investors
- Increase funding for agricultural development, especially infrastructure and research
- Open trade policies that facilitate market access for developing countries
- Ensure rural access to education, healthcare, and capital – regardless of gender
- Lead stakeholders in holistic transformations

Innovate and invest

- Develop and scale interventions that are proven to meet the combined objectives of the New Vision
- Increase access to agricultural finance through innovative risk - sharing partnerships
- Step up engagement in holistic transformations

Mobilize the community

- Actively represent the voice of citizens, communities, and the environment in holistic transformations
- Train and organize local producer organizations
- Leverage capital to bridge gaps in the value chain and reduce risk

Source: World Economic Forum,
Realizing a New Vision for Agriculture: A roadmap for stakeholders

21st Century Agricultural Challenges

- **Health**
  - Food safety, nutrition, obesity, type II diabetes, cardiovascular disease, dementia, cancer, hunger, poverty, families/children
- **Ecological Footprint**
  - Water/land use, natural resource and environmental stewardship, greenhouse gas, global climate change, depleted soils
- **Agricultural Competitiveness**
  - Improve crop and animal agriculture; enhance farm productivity and income; policies; supply chain; storage; transportation
- **Bioeconomy**
  - Replacements for petroleum-based products and enhance community economic well being

The Nexus

Biotic Constraints

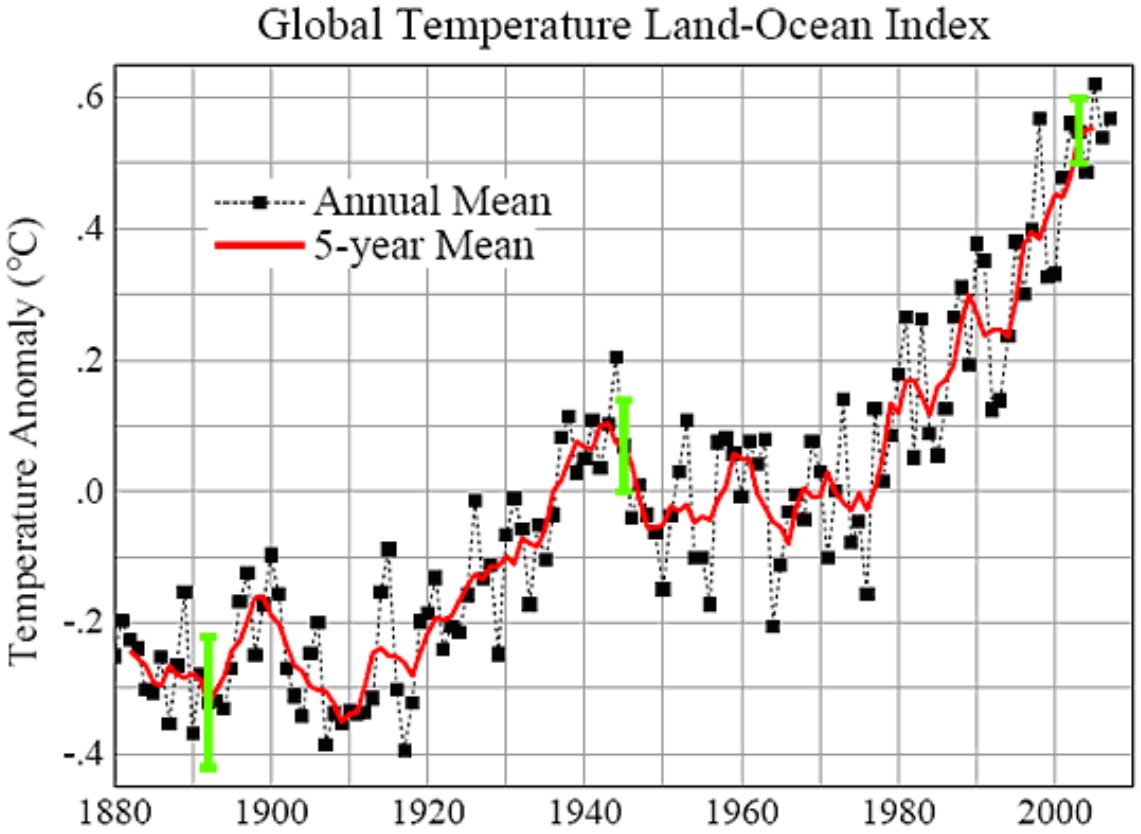
- **Diversity of species**
  - 50,000 edible; 15-50 used
- **Traits**
  - Yield/productivity
  - Yield stabilization:GxExM
  - Pest/disease resistance
- **Efficiencies**
  - Feed-to-yield ratio
  - Heat tolerance
  - Photosynthesis: *C3 to C4*
  - Water-use: *Crop per Drop*
  - Nitrogen-use
- **Pre- and post-harvest losses**
  - Microbes, Invertebrates, Vertebrates

Abiotic Constraints

- Soil depletion
- GHGs and Climate Change
- Correlation between yield and temperature
  - $4^{o}C$ increase: crop failures, malnutrition
  - Livestock/aquatics responses

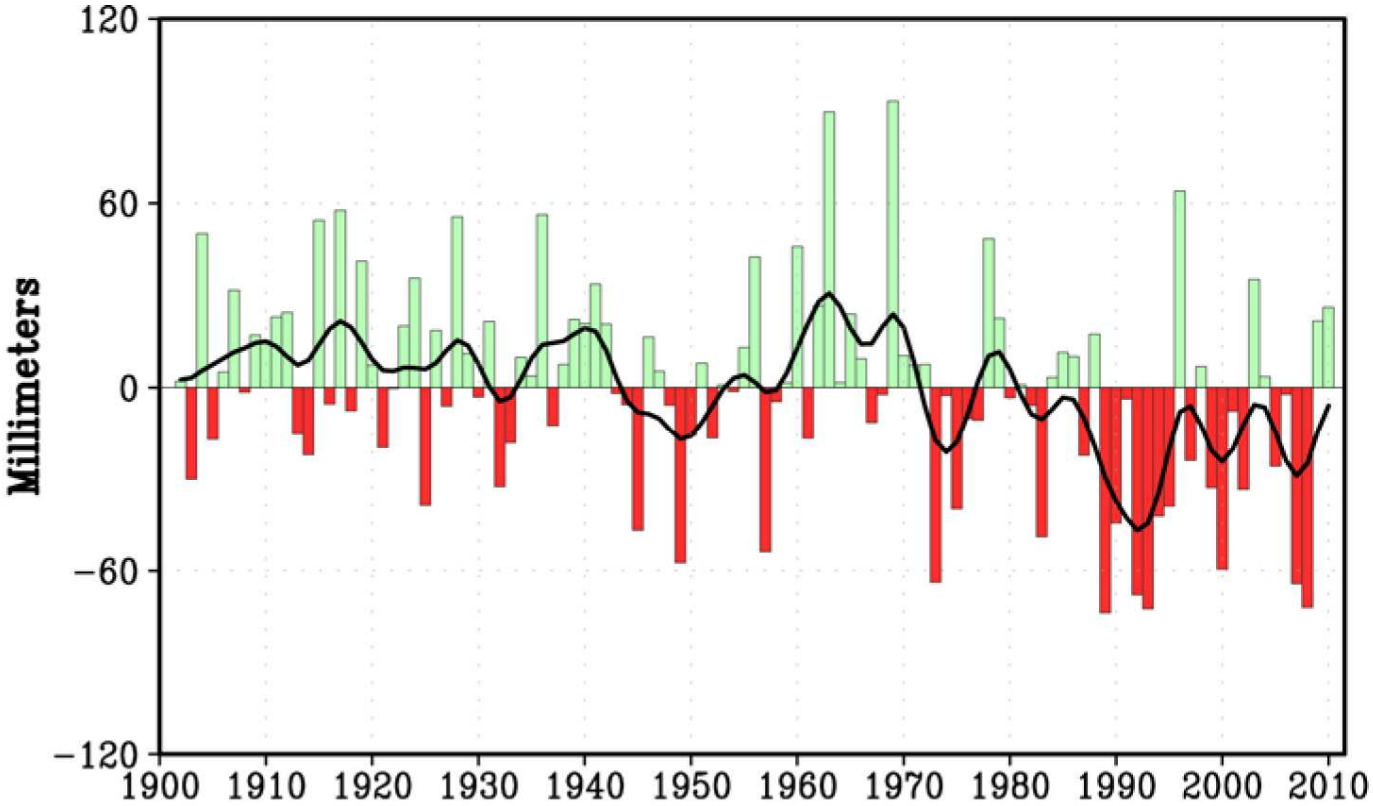
Soil depletion: Soil erosion

A distinguishable trend in temperature rise



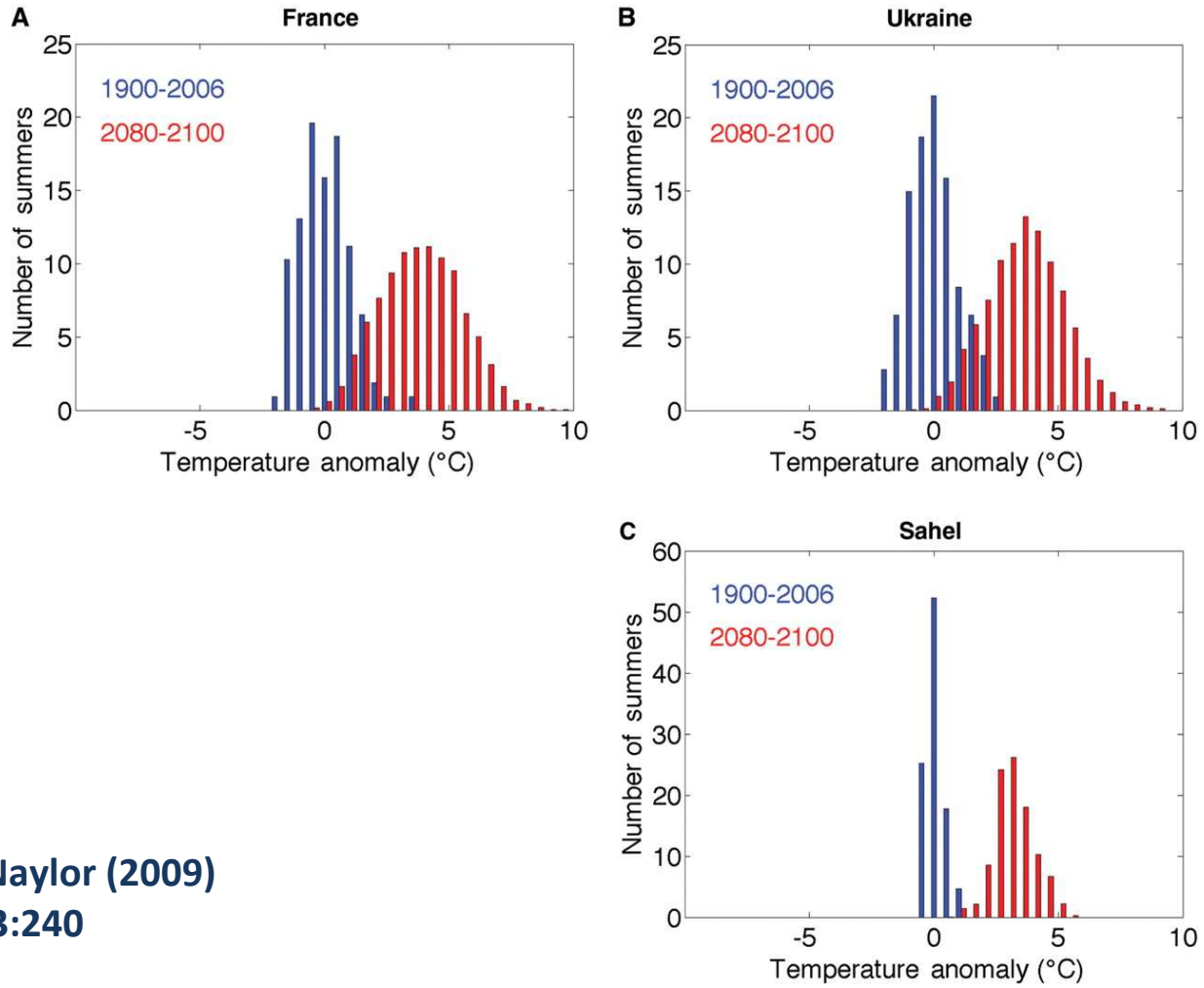
The land-ocean temperature index combines data on air temperatures over land with data on sea surface temperatures. Black line - the annual changes; Red line - 5-year periods. Source: [NASA Goddard institute for Space Studies](). (January 11, 2008)

Unpredictable fluctuation in winter precipitation



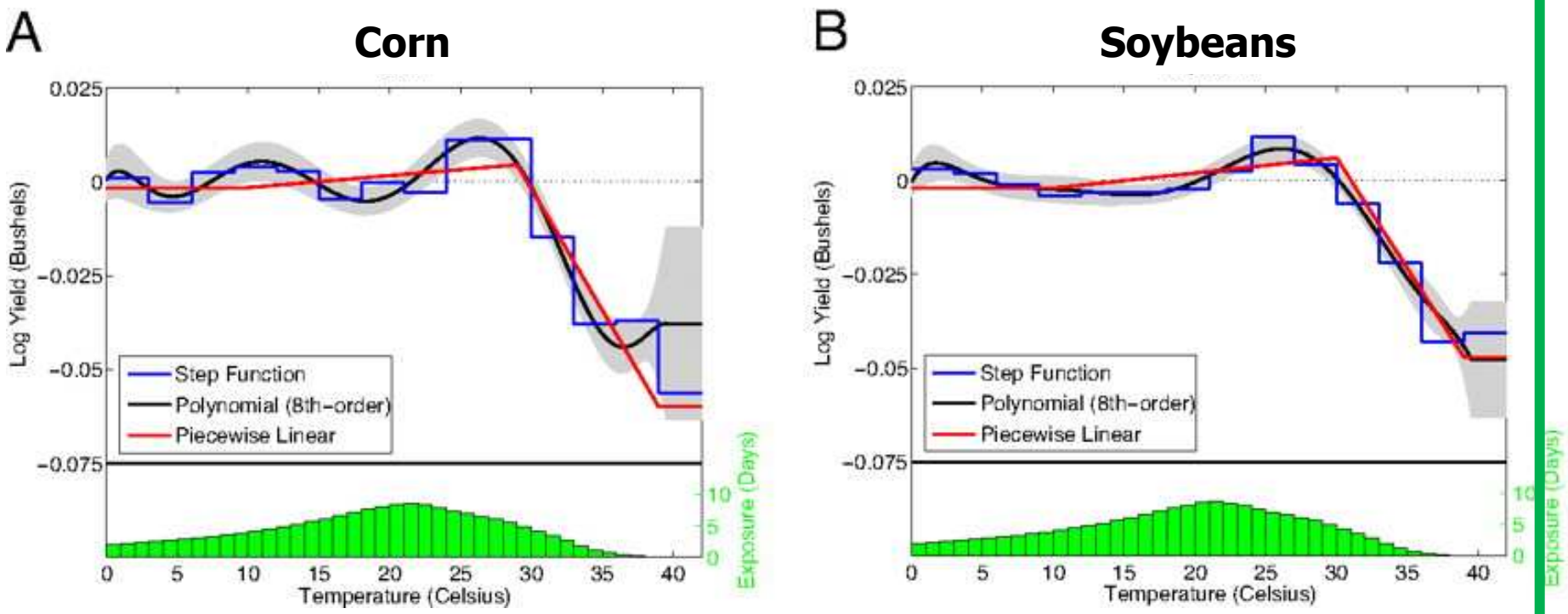
Winter precipitation trends in the East Mediterranean region for the period 1902 – 2010

Projected shifts in extreme climate events
(e.g. rise in extreme temperature events)



Battisti & Naylor (2009)
Science 323:240

Climate Change and Crop Yields

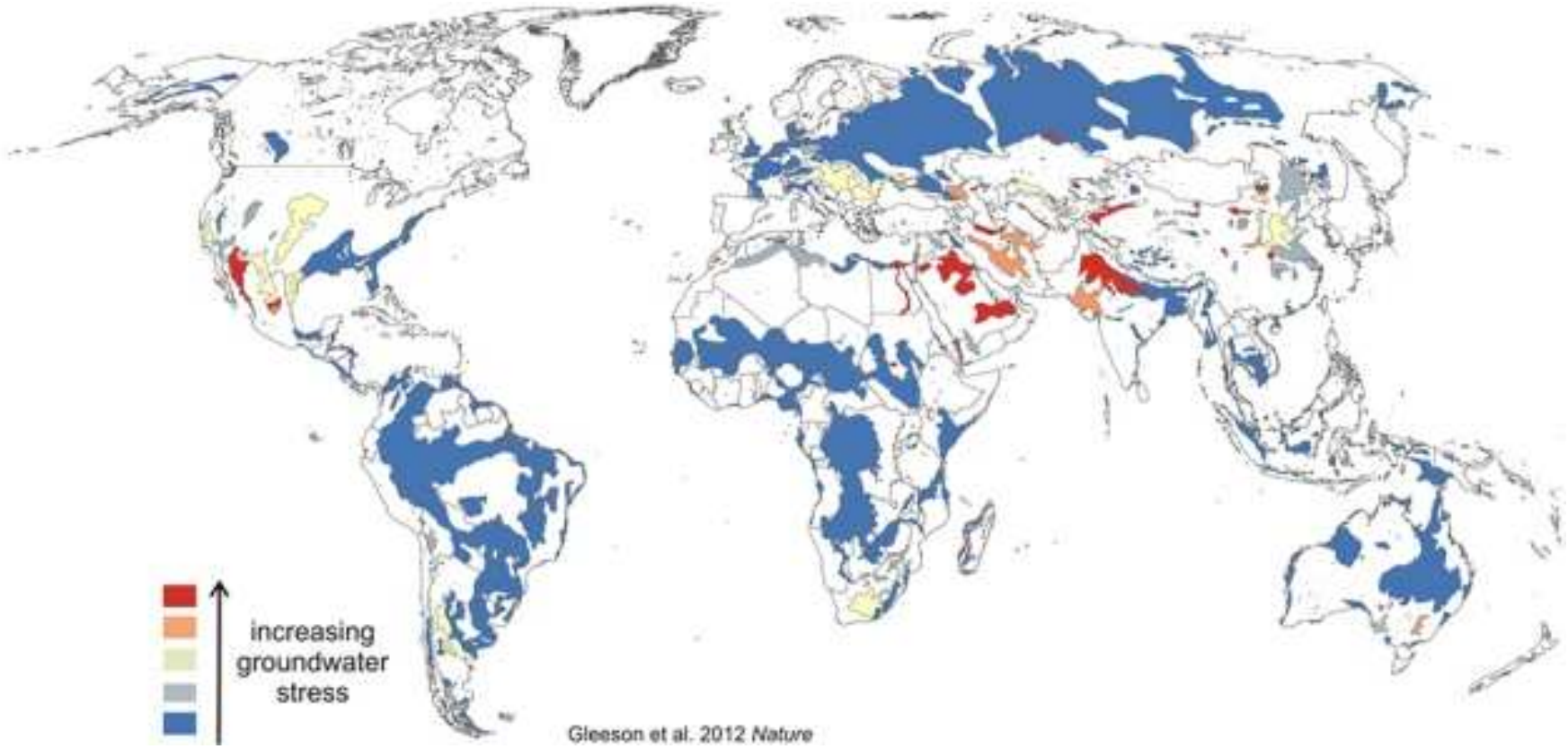


W. Schlenker and M. Roberts (2009)
PNAS, 106:15594-15598

Abiotic Constraints

- Soil depletion
- GHGs and Climate Change
- Correlation between yield and temperature
  - 4°C increase: crop failures, malnutrition
  - Livestock/aquatics responses
- **Water quantity and quality**
  - **Droughts and impacts on yield**
  - **80% of water supply used for food production**

Aquifers under stress



GLEESON, T. ET AL., Nature, August 2012

Abiotic Constraints

- Soil depletion
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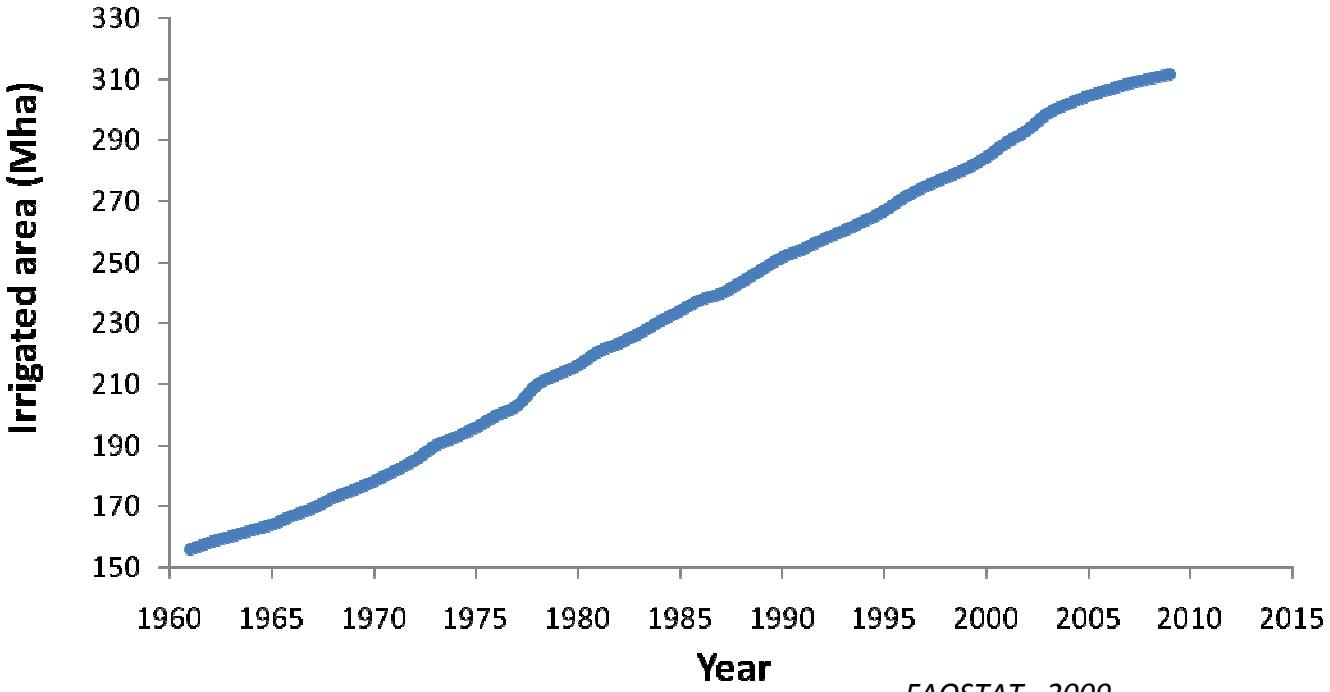
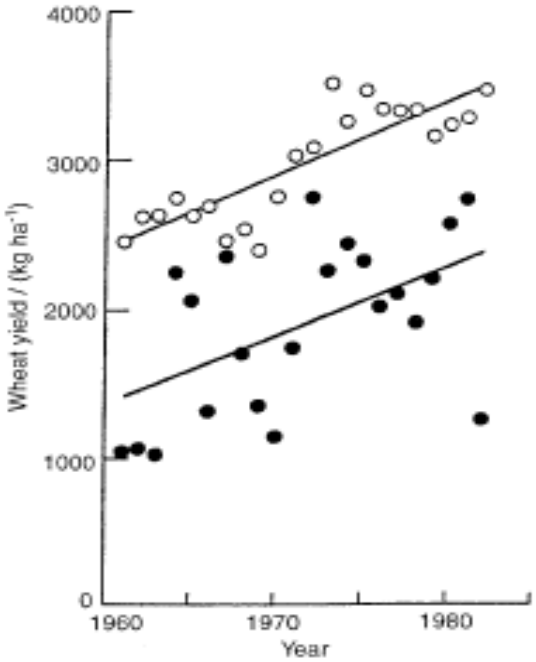
  - $4^{o}C$ increase: crop failures, malnutrition
- Water quantity and quality
  - Droughts and impacts on yield
  - 80% of water supply used for food production
- Nutrient management
  - Nitrogen, phosphorous – Ozone, Eutrophication
- Lifecycle Analysis

THE RECENT EXPANSION OF WORLD IRRIGATED AREA

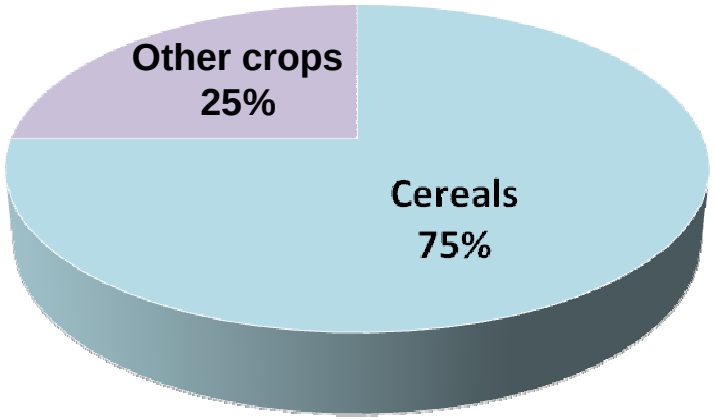


FAOSTAT , 2009

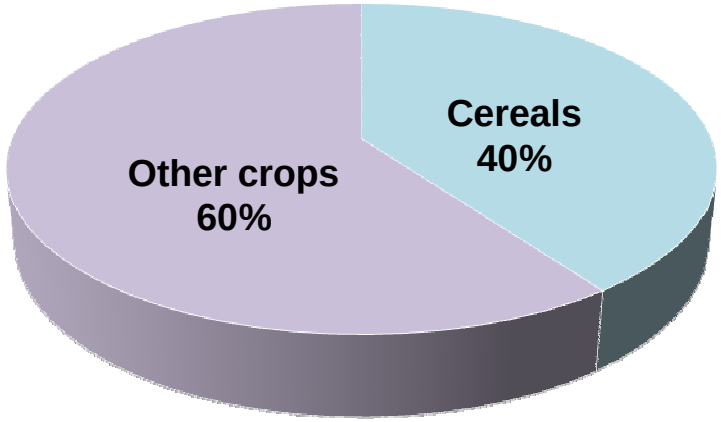


(Stanhill, 1986)

Crops distribution (area)

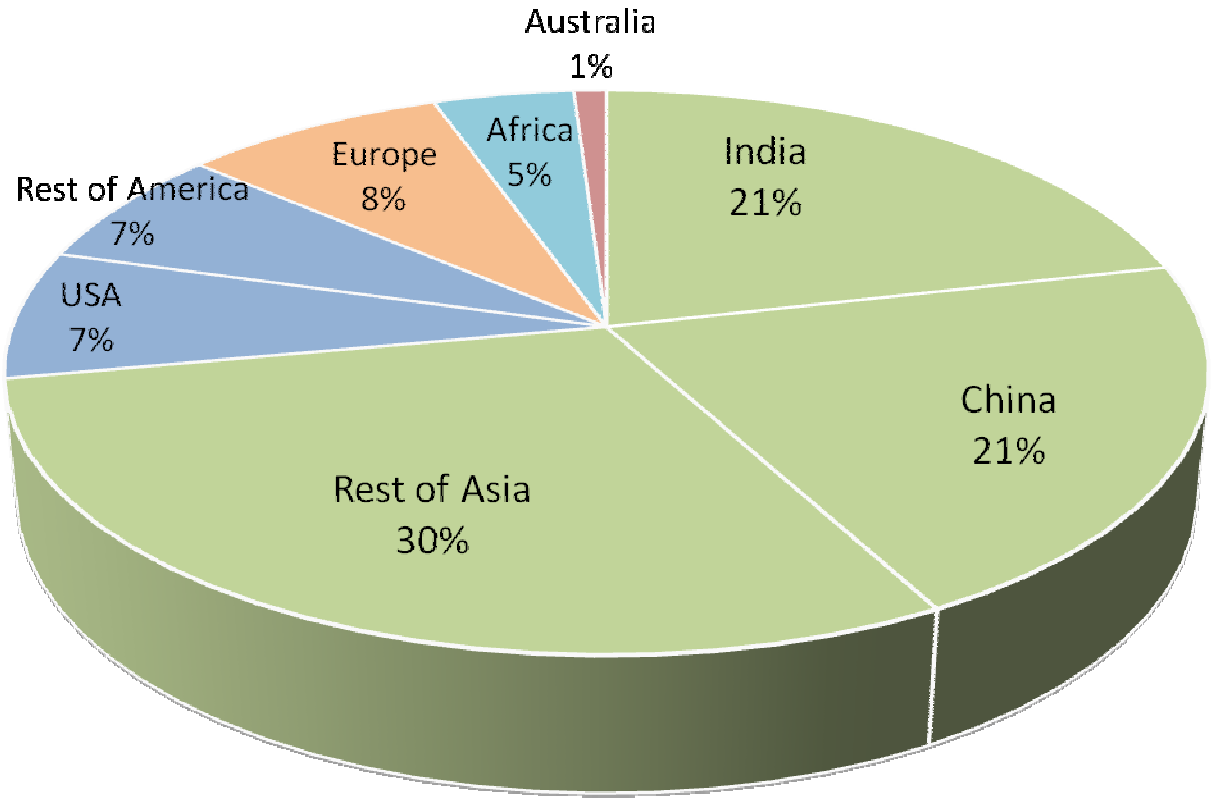


Relative Water Productivity ($/m³)



Agriculture accounts for ~70% of global freshwater withdrawals

(up to 90% in some fast-growing economices).

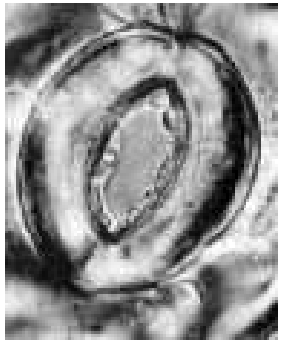


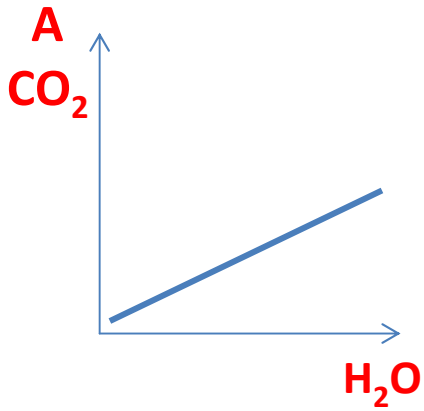
WHERE ARE THE IRRIGATED LANDS LOCATED?

FAOSTAT , 2009

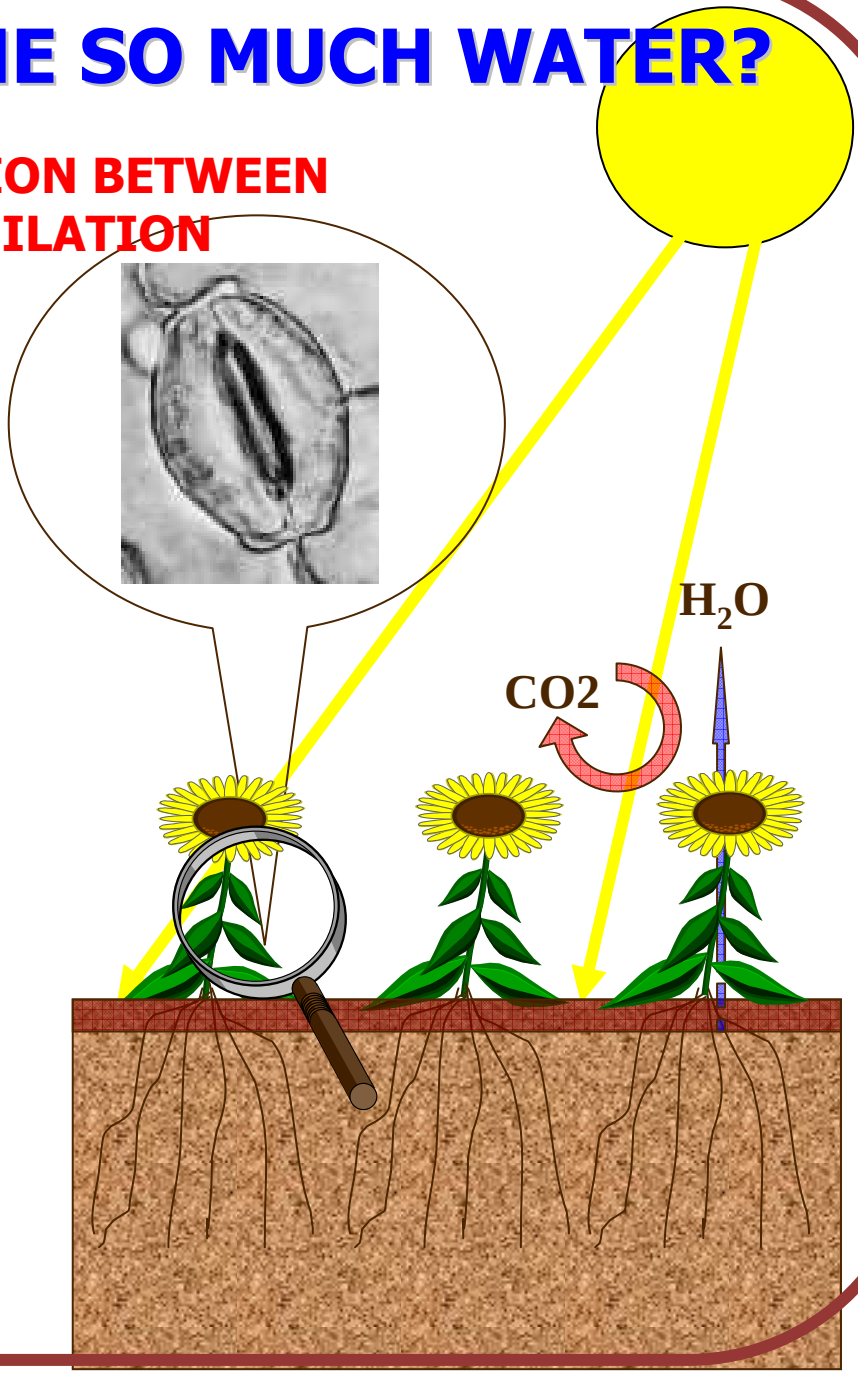
WHY CROPS CONSUME SO MUCH WATER?

THE FUNDAMENTAL CONNECTION BETWEEN H_2O LOSS AND CO_2 ASSIMILATION





$WP = CO_2 / H_2O$

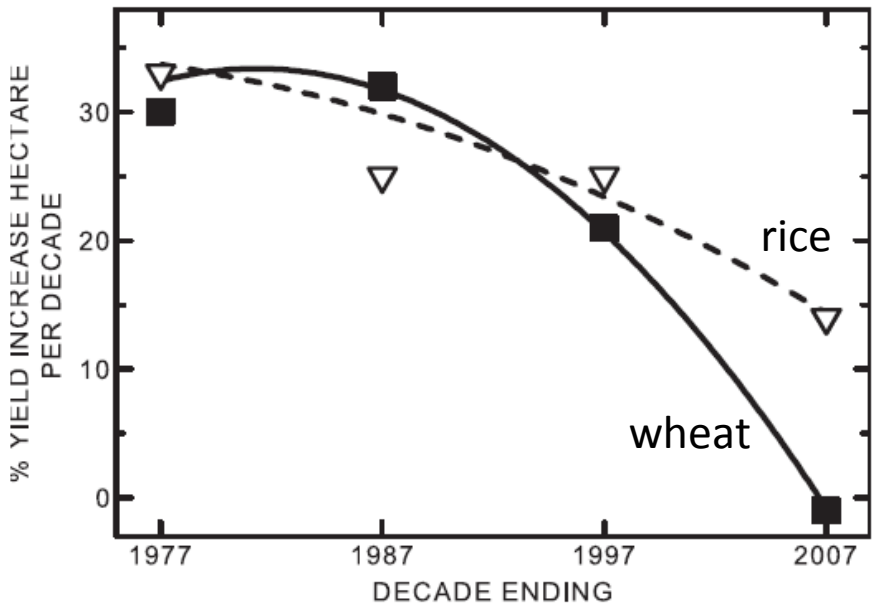


HOW DO WE DEFINE WATER PRODUCTIVITY?

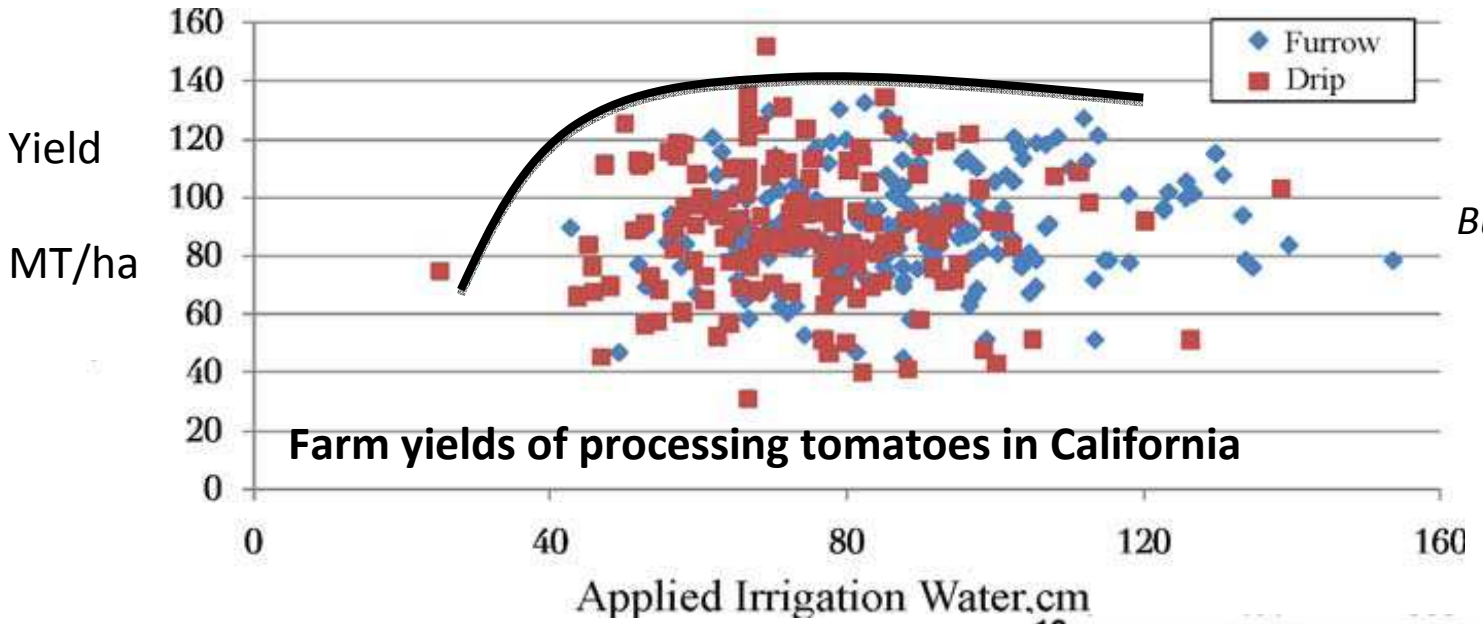
WP = A/T at the leaf scale……..TE, transpiration efficiency
WP = B/T at the plant scale…..Biomass water productivity
WP = Y/ET at the crop scale…..
WP = Y/I at the field and higher scales

Improving WP:
1.Increase Yield----via agronomy/breeding
2. Effective use of Irrigation water

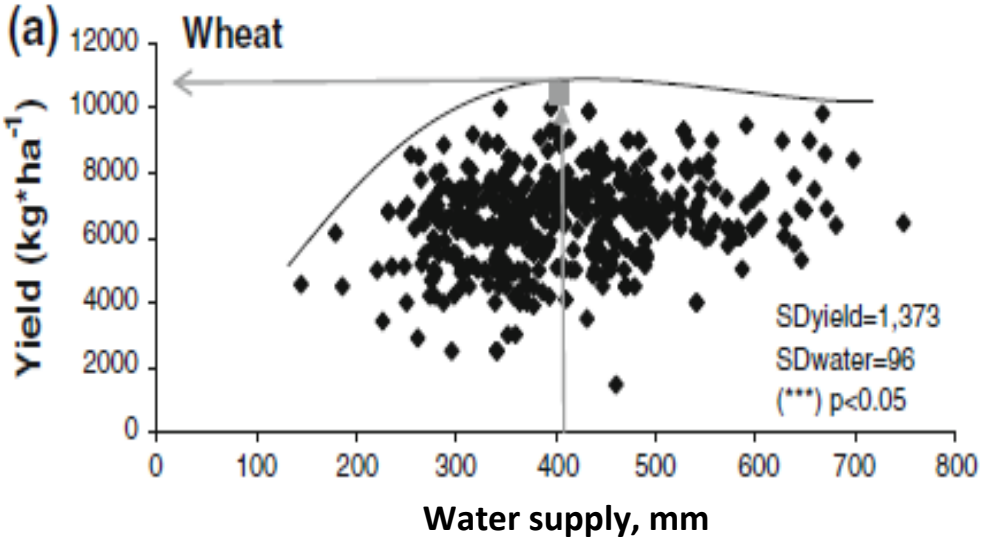
Yield increases are running out of steam ***(S. Long, 2012)***



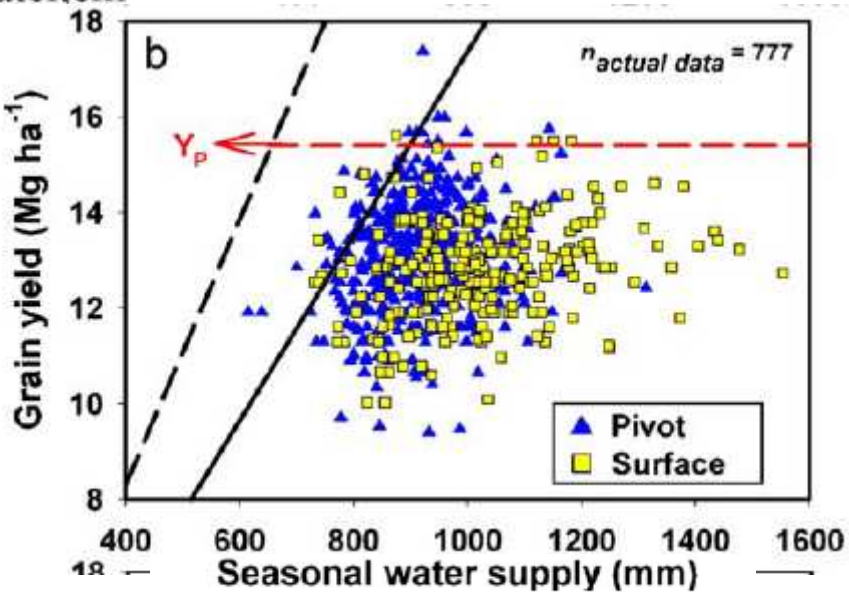
THE YIELD GAP and HOW TO BRIDGE IT



Burt & O'Neill, (2007)



La Mancha, Spain*, Montoro et al., (2011)*



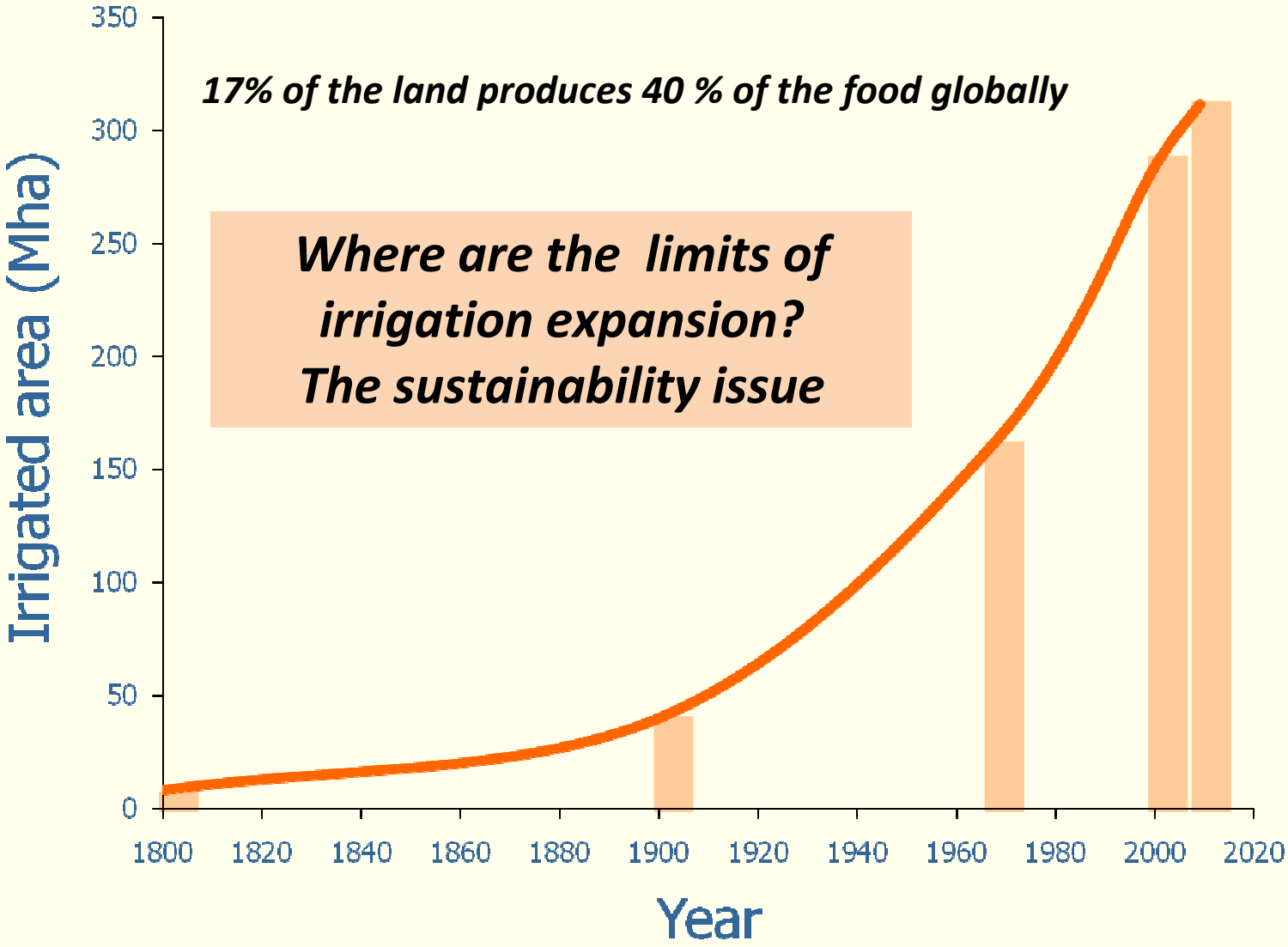
Maize, Nebraska, USA, *Grassini et al.,(2011)*

Key for success

Do we miss the messenger?

Close cooperation and interaction

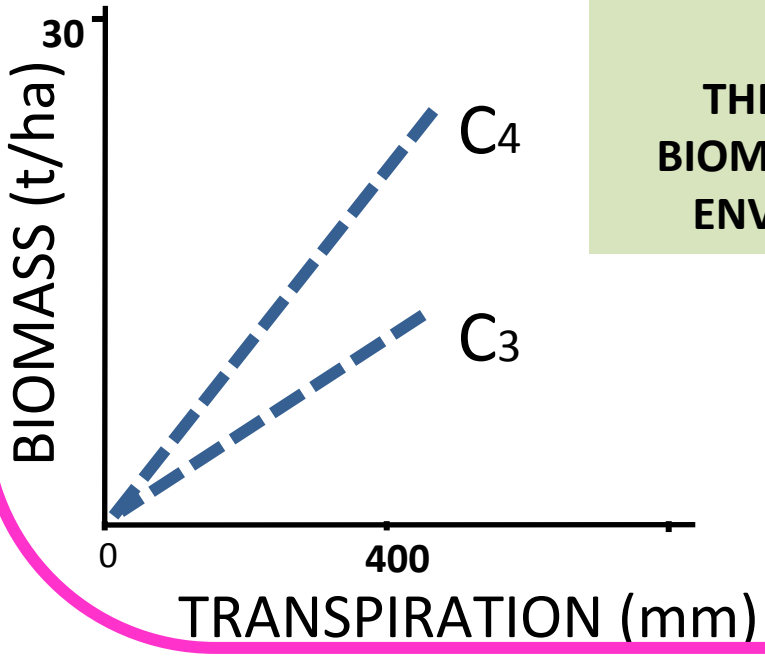
EVOLUTION OF WORLD IRRIGATED AREA



Sources: FAOstats, ICID

CORRECT EMPHASIS ON MORE WATER CAPTURE, ΔT

PHENOMICS: PHYSIOLOGY IN 'NEW CLOTHES'

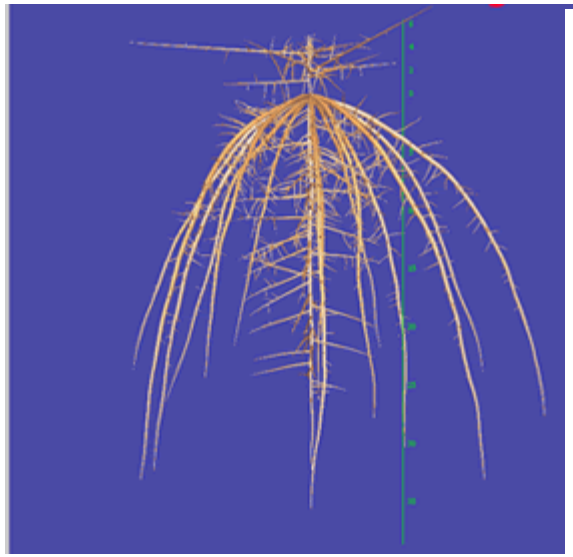


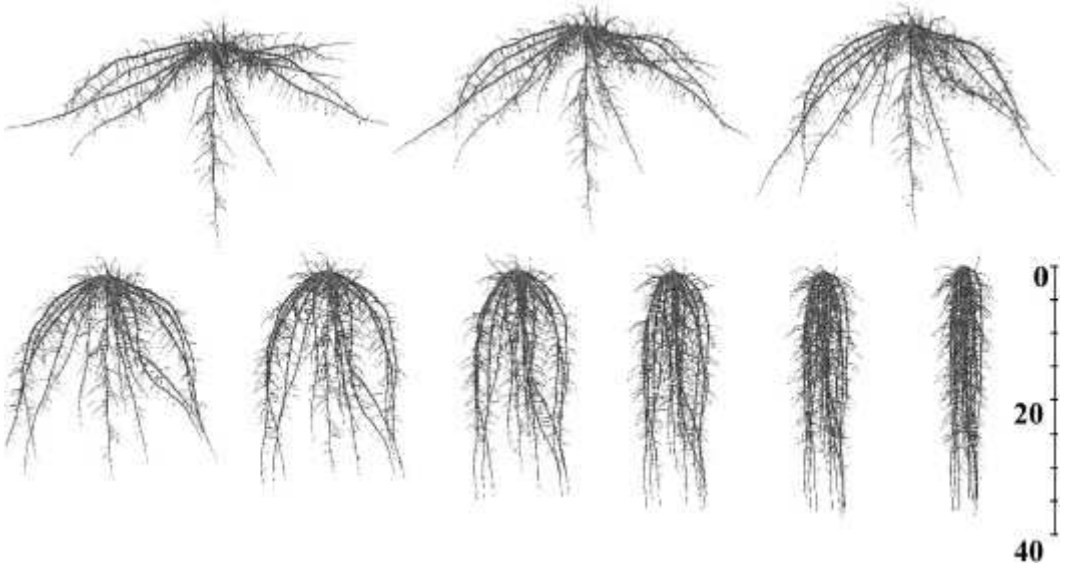
IMPROVING TE

THE CONVERSION OF WATER INTO PLANT BIOMASS, TE, IS MOSTLY DETERMINED BY THE ENVIRONMENT AND PLANT TYPE (C_3 or C_4)

MAINTENANCE OF HARVEST INDEX UNDER WATER STRESS

Roots physiology and function





In conclusion,

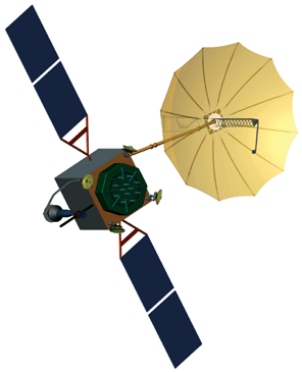
- Engineering advances were largely responsible for past increases in WP

- WP limits have largely been reached, but big gaps remain in most farming systems. Focus on measuring WP gaps and determining their causes
  Water supply limitations will force adoption of deficit irrigation.
  Optimization of limited supplies at scales from field to regions

- Success in breeding for more effective use of water has been limited*, but now there is more hope than ever (and more need in the long-term!!)

In the future

Identification of each plants' needs



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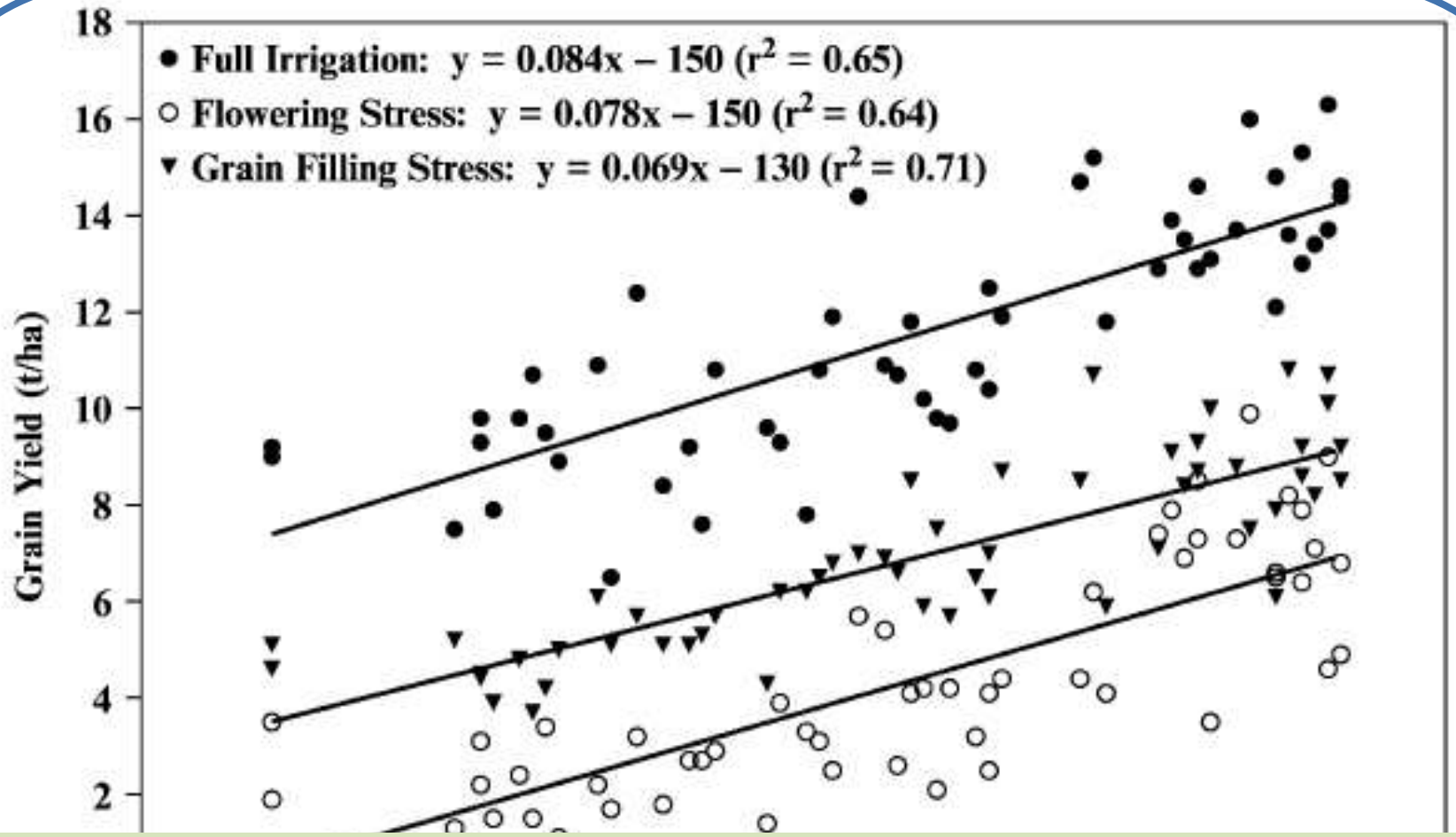


Monsanto to Introduce Genuity Droughtgard Hybrids in the Western Great Plains In 2013 (one year too late)

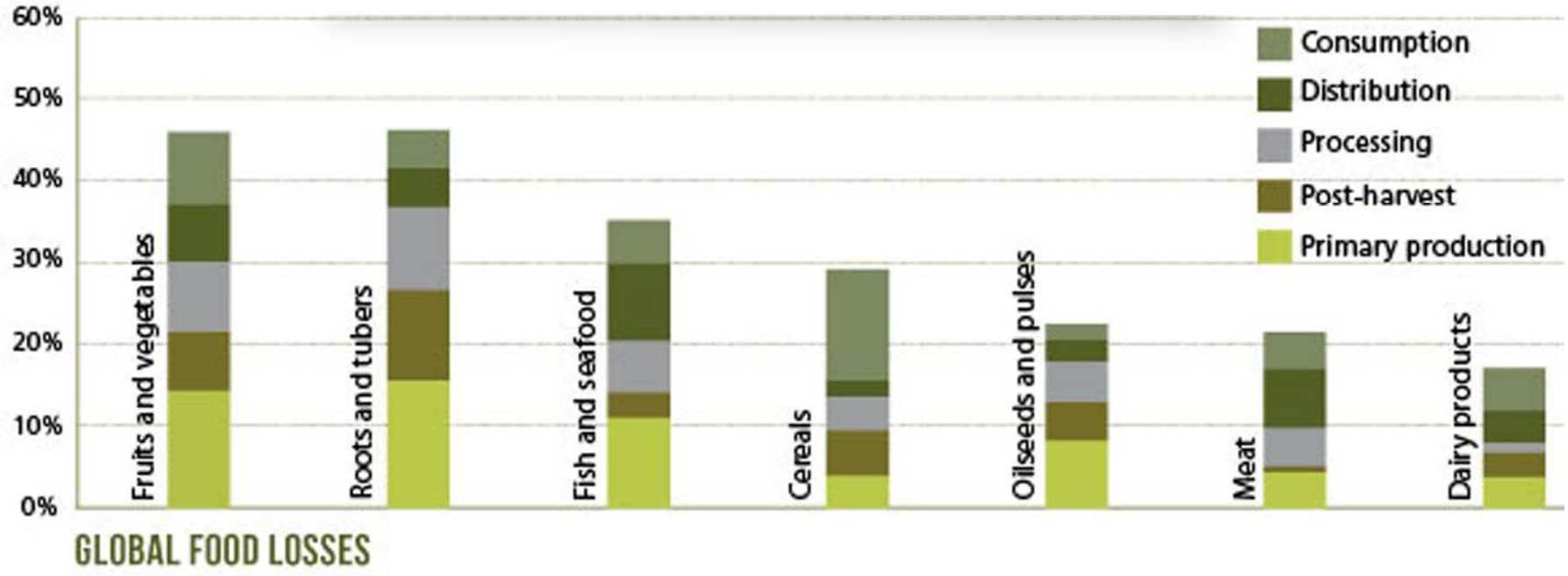
up to 6 bushel advantage over competitor hybrids

were grown in Woodland, California [illegible] three managed stress environments: full irrigation, flowering drou[illegible]g drought stress. Adapted from Barker *et al.* (2005).

(or 360 kg/ha)

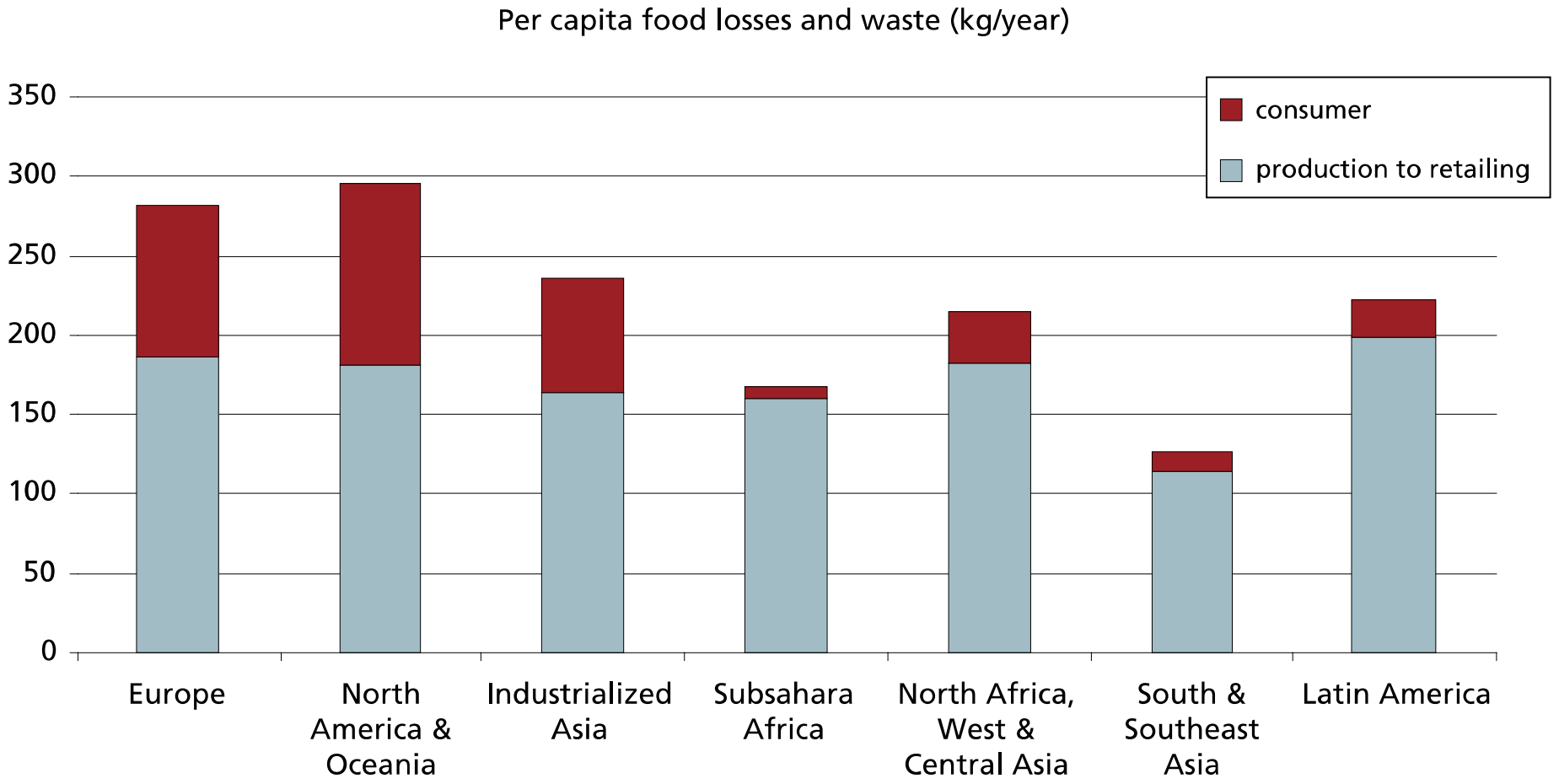
Global food losses and waste

Global food losses and waste estimated at 1.3B tonnes p.a.



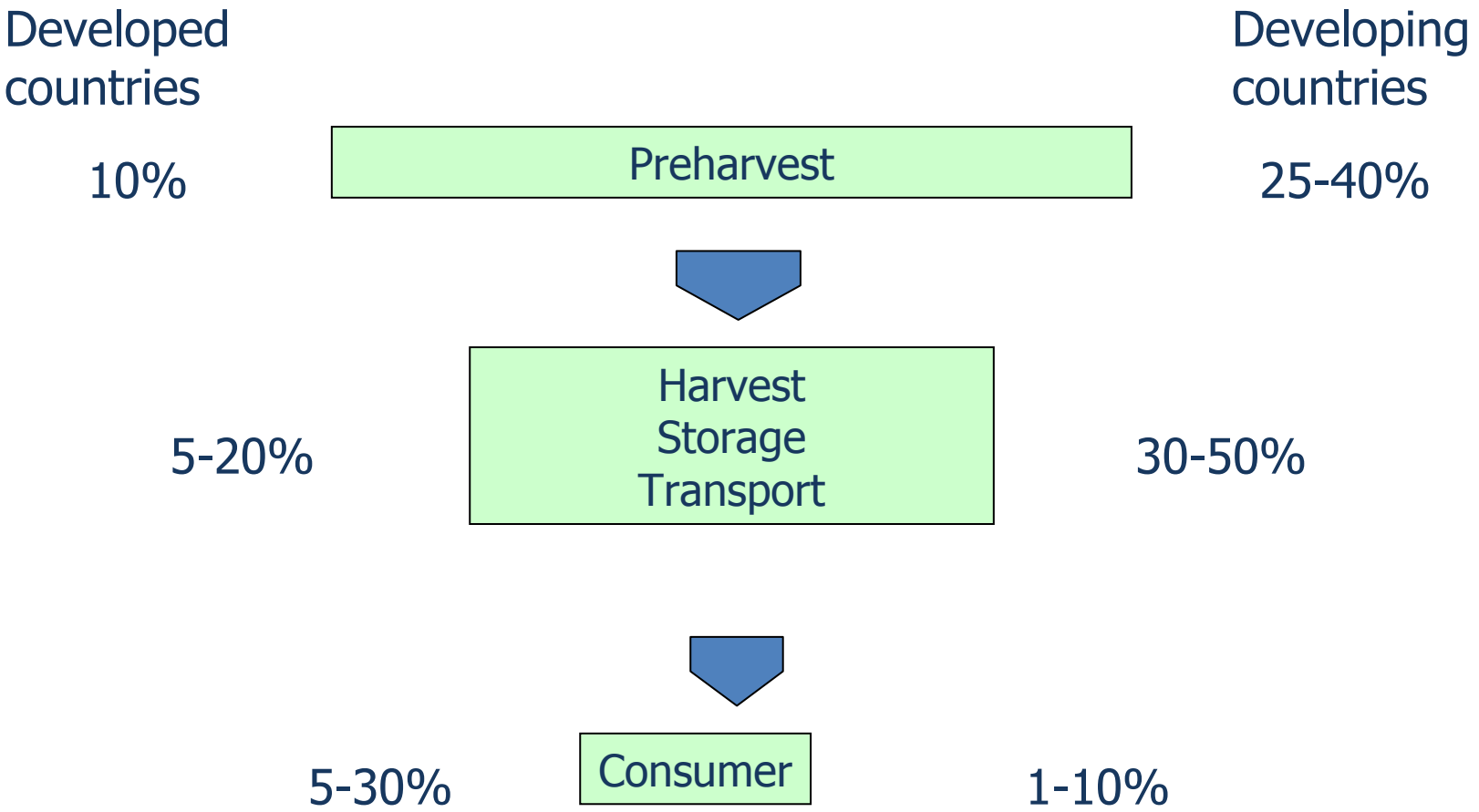
http://www.fao.org/save-food/en/

Per capita food losses and waste, at consumption and pre-consumption stages, in different regions



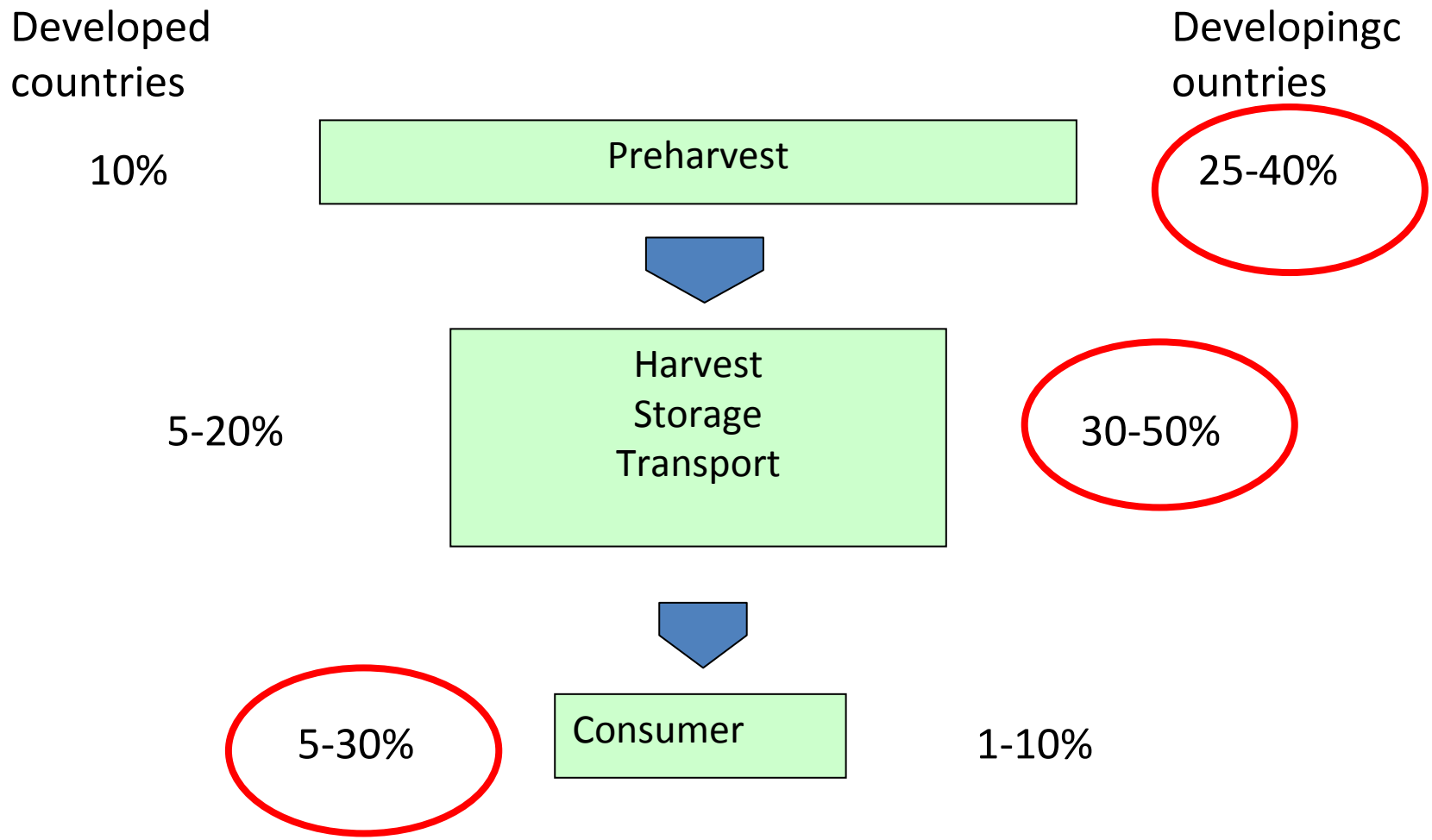
J. Gustavsson et al 2011

Value Chain Food Losses



World Economic Forum, Driving Sustainable Consumption, Value Chain Waste – Overview Briefing 2009

Value Chain Food Losses



Source: World Economic Forum, Driving Sustainable Consumption, Value Chain Waste – Overview Briefing 2009

We may be rich in opportunities from new postharvest technologies,

….but are they going to provide the answers and assurance for future food production?

So what can we do?

4 recommendations

1. Breed new cultivars with better postharvest traits
2. Reform supply chains to minimize physical damage
3. Extend storage life by controlling postharvest metabolism
4. Control postharvest pests and diseases

For the future we will need to:

- **Amplify productivity & sustainability criteria**
- **Adapt to extreme environ. growth conditions:**
  - **-new varieties (Use of genetic diversity, computational genomics and GMO technology)**
  - **-improved Ag technology (irrigation, fertilization and pest management)**
- **Reduce losses (From harvest to the consumer plate)**
- **Distribute "Know how" (Developing markets)**

For the future we will need to:

(continue)

Sustainability

- ✓Producing and maintaining ecological advantages and equilibrium, open spaces, water and natural resources for present and coming generations.
- ✓Protecting the landscape, conserving the soil, using marginal water.
- ✓Encouraging the conservation of the family farm and the rural heritage.

Center for Arid Agriculture at Gilat

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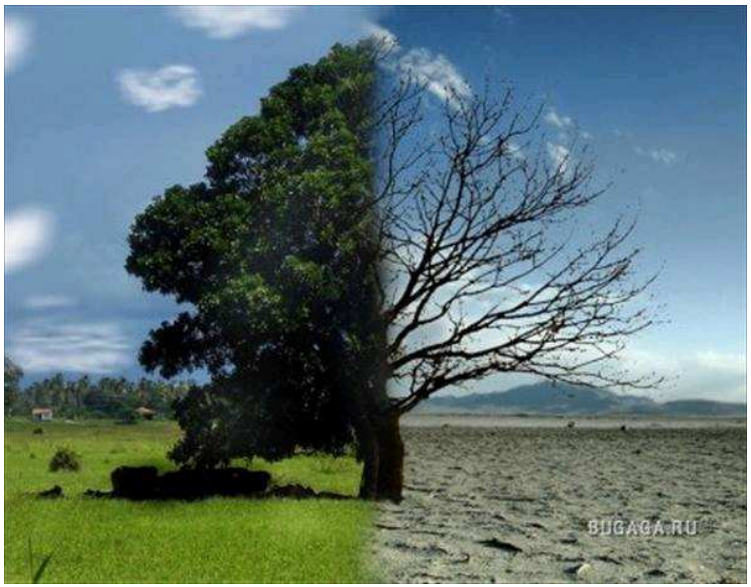
Agricultural Research Organization
Volcani Center

Limitations existing on agriculture under desert conditions

- ✓ Extreme climatic conditions (temperature, radiation)
- ✓ Water limitations (quantity, quality, utilization)
- ✓ Type of soil (sand or clay, poor organic matter levels)



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Focusing activities on arid and semi arid lands

Opportunities

- ✓ **The Negev is a peripheral region of the country with national preference for development**
- ✓ **Most of the land reserves of Israel are concentrated in the region**
- ✓ **Available water resources for agriculture (brackish, recycled)**
- ✓ **Unique climatic conditions most suitable for export crops**
- ✓ **A unique opportunity to utilize the largest waste dump of the country**

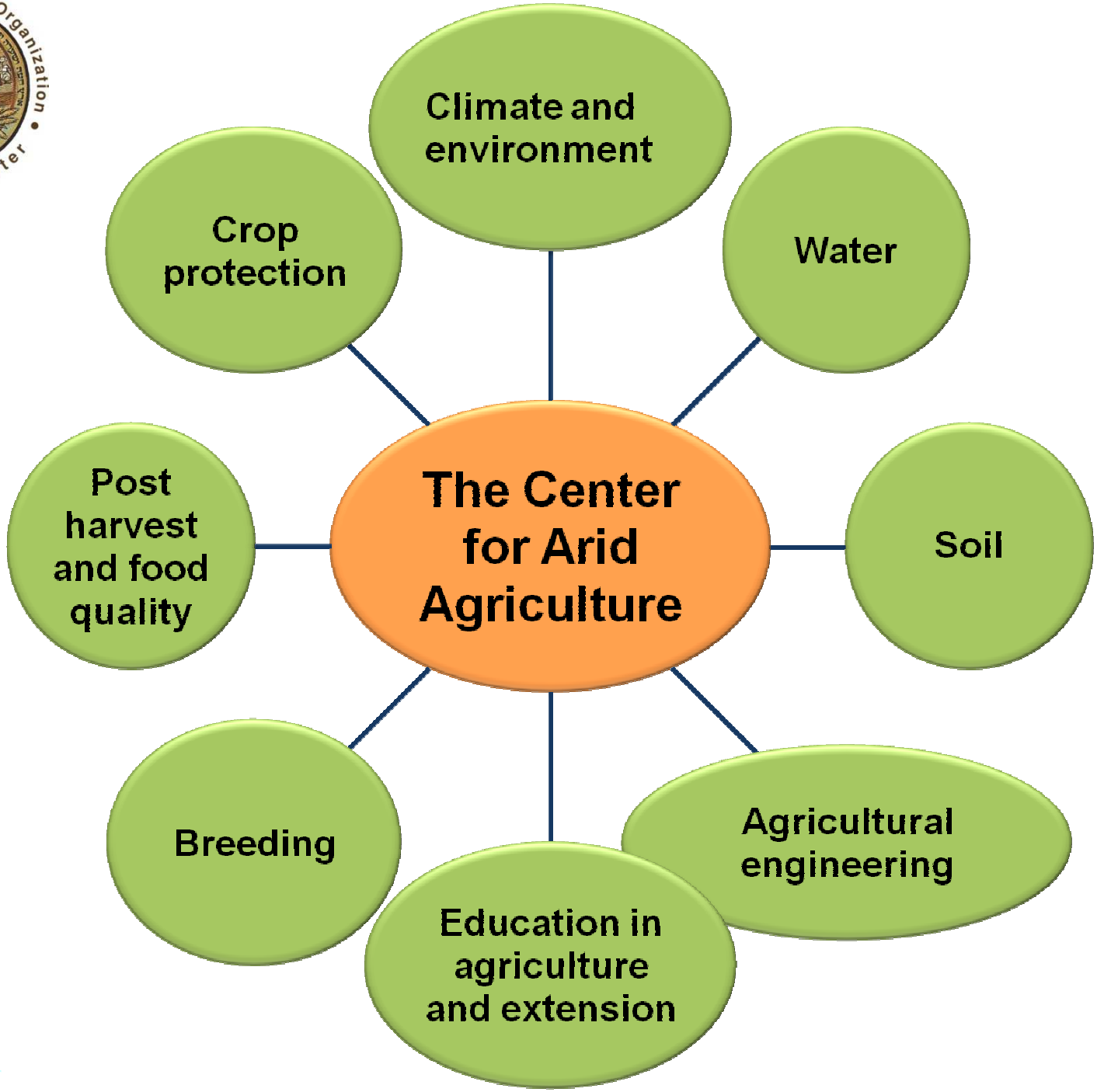
The Gilat Center

Administration and other Services Units

- ✓ Ministry of Agriculture: Negev District Administration;
  Agricultural Extension Services – Negev;
  Plant Protection Inspection Services Negev
- ✓ Gilat field services laboratory
- ✓ Citrus depository
- ✓ Water Authority
- ✓ Green Agricultural Police Unit

Gilat Research Center

The Gilat center maintains close connections with the agricultural sector of the region, the staff of the regional agricultural R&D centers, the agricultural extension services, KKL, higher education institutes such as the Ben-Gurion University, Sde Boker, Sapir and Sami Shamon Colleges as well as agricultural youth high-schools (Eshel Hannasi, Mevoot Hanegev, Merhavim, Sdot Negev, Maaly Habsor)


Climate and environment
Crop protection
Water
Post harvest and food quality
The Center for Arid Agriculture
Soil
Breeding
Agricultural engineering
Education in agriculture and extension

Center for Arid Agriculture

Scientific disciplines (partial list)

- ✓ Root vegetables: production protocols under conditions of stress
- ✓ Field crops: production protocols under conditions of stress
- ✓ Precision agriculture
- ✓ Agro-meteorology

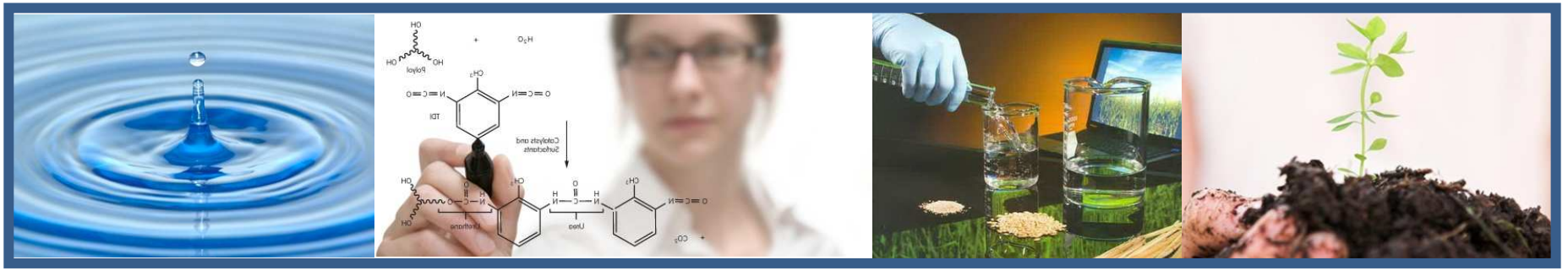
ter for Arid Agriculture

Infrastructure

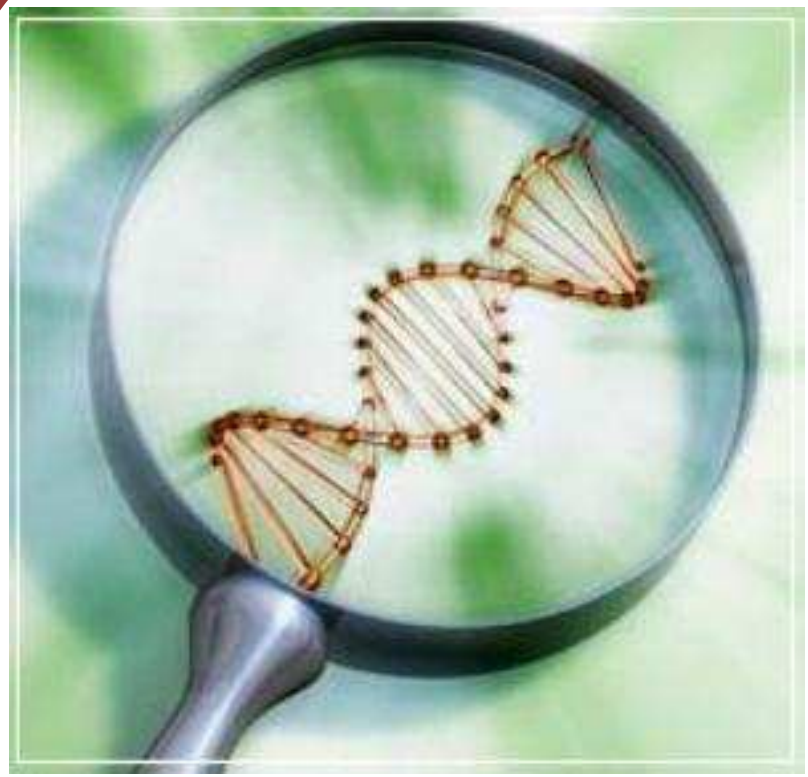
- ✓ Research facilities: new laboratories and scientific equipment
- ✓ Renovation and refurbishing of greenhouses and experimental units
- ✓ Enlargement of the recycled water research facilities

Israel as a Global Lab

Need → **Innovative Solutions** → **Local Testing** → **Global Scale Up**



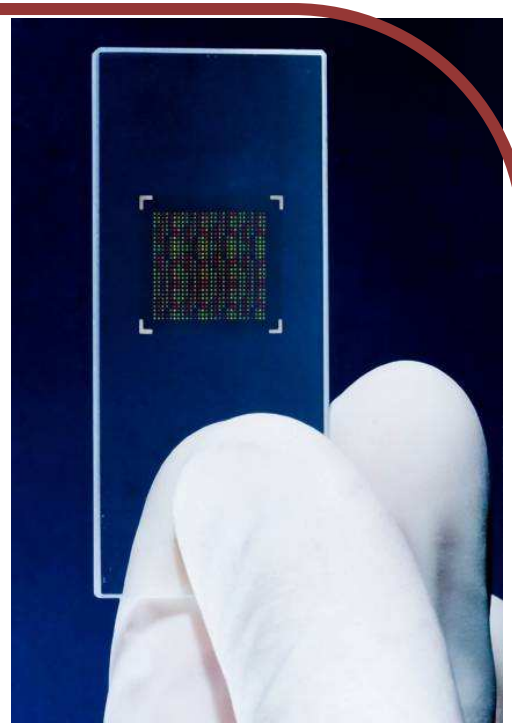
Biotechnology

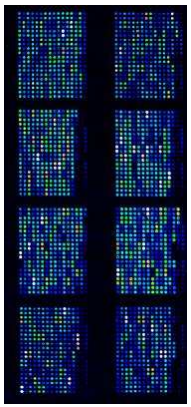


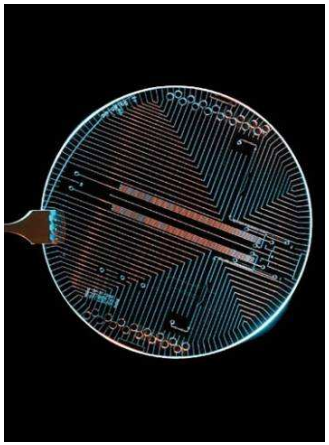
Products that contribute to the environment, to the health of both, men and livestock

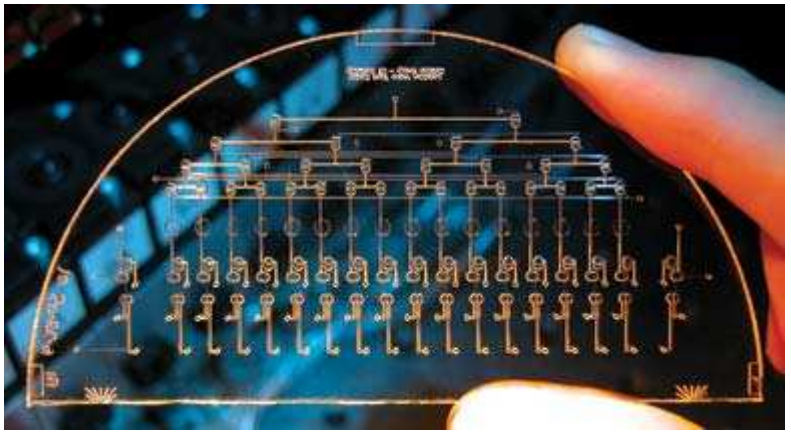
Sensors and nano-lizers

Identification of diseases, luck of nutrients, soil property, contaminations and more

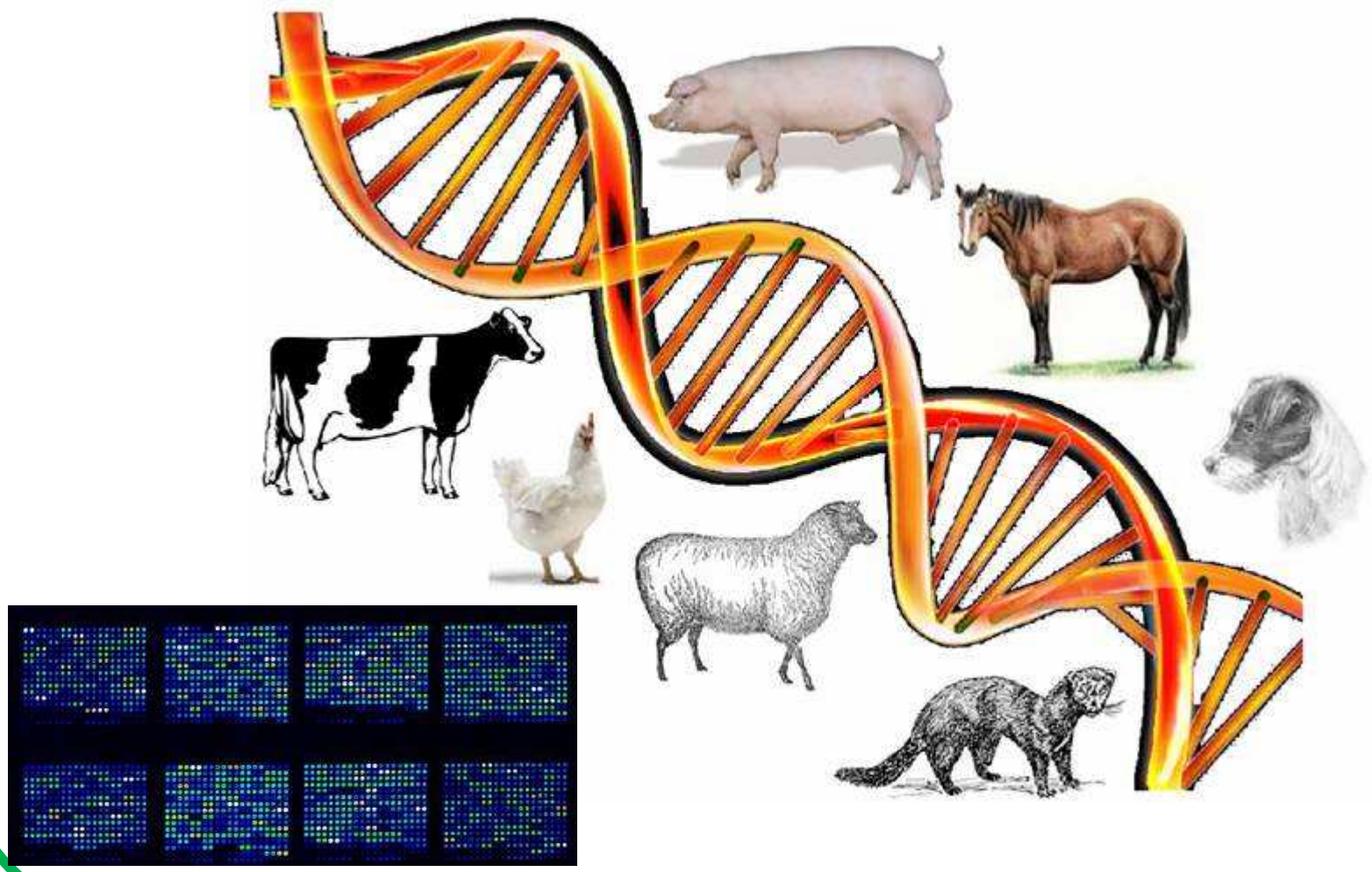






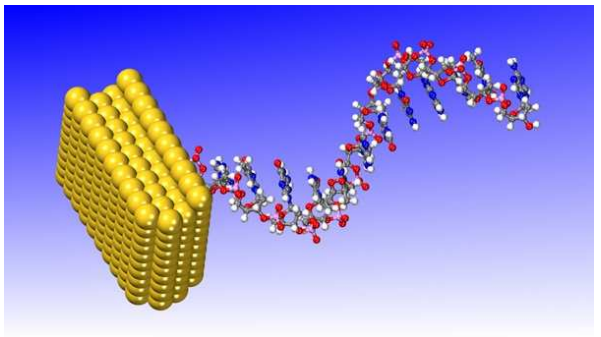


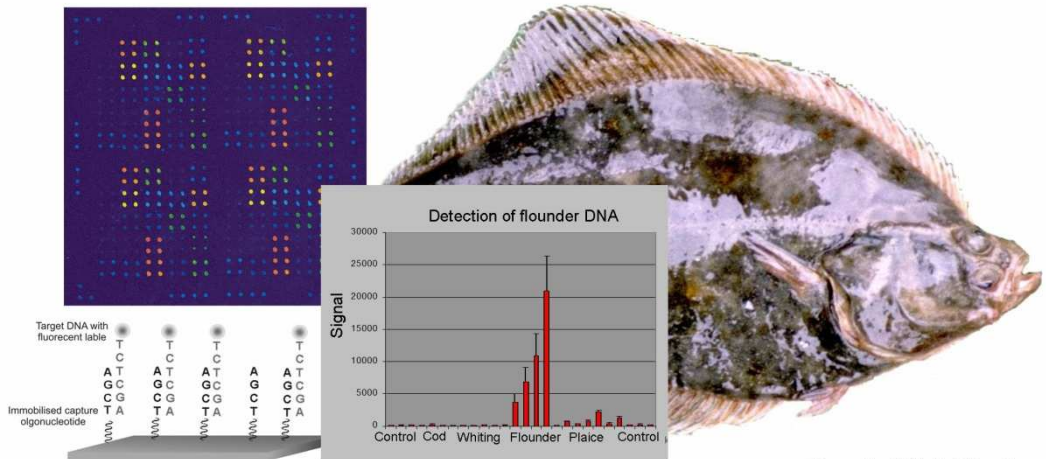
The genome is known and it is ready for array of applications



Biotechnology

Products that contribute to the environment, to the health of both, men and livestock

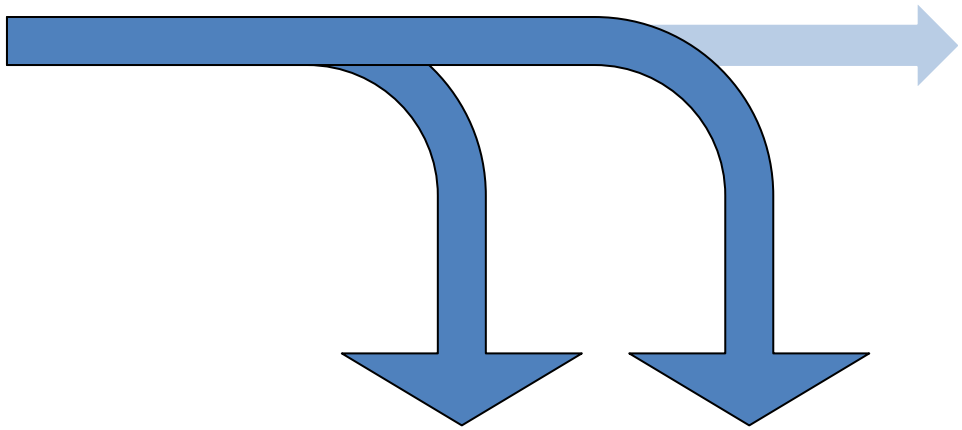





Thank you
for your attention

So what can we do? Rebalance our resources

Research



High tech marginal improvements

Low tech solutions

Translate high tech approaches

Most Significant Abiotic Constraints

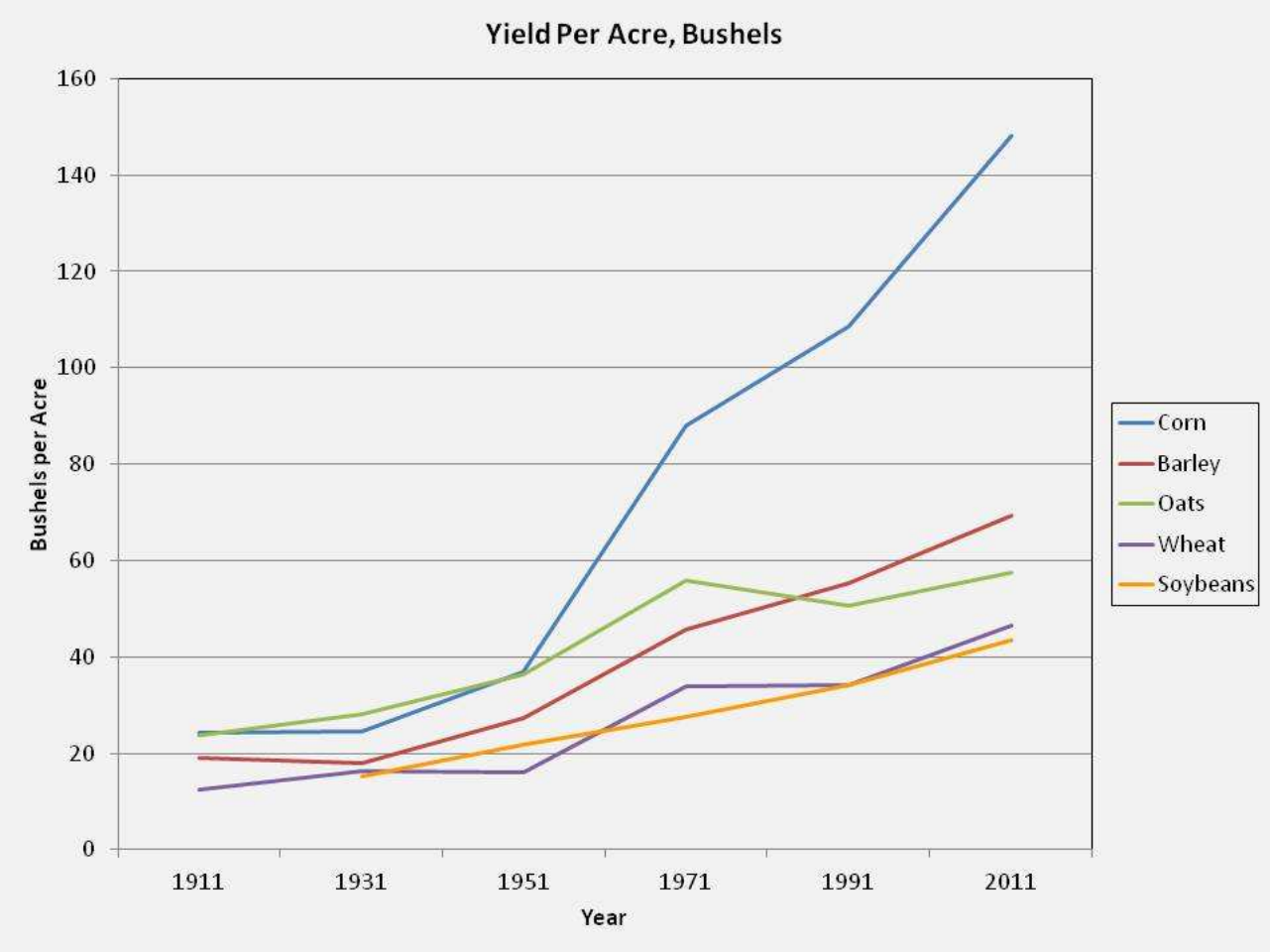
- Arable land
- Water
- Labor
- Climate
- Capital

Food Waste/Food Loss

- Pre-harvest losses in developing countries
- Post-harvest losses in developed countries
  - Need to double food production in 40 years
  - Cut loss/waste by half?

Farming systems

- Improved technologies
  - Productivity gap
- Closed loop systems
- Cooperatives – Kibbutz?
- Integrated/diversified
- Smart farming
- Sustainable intensification
  - Policies and consequences
- Vertical farming
- Hydroponics
- Aquaponics


Yield Per Acre, Bushels
160
140
120
100
80
60
40
20
0
Bushels per Acre
1911
1931
1951
1971
1991
2011
Year
Corn
Barley
Oats
Wheat
Soybeans