21st Century Agriculture – GMOs, Energy, and Others: Bioethical Concerns, Nels H. Granholm, SDSU, Brookings,SD

Global Perspective; Optimal ways to “carry on” based on ecological realities and ethical analyses

Overview of Discussion

- 21st C very different from the 20th C
- Burgeoning population – 9+/- 1 billion
- Imposing (scary) ecological footprint of 9b. Why so formidable? Ans. Global nr
- Post-peak oil and oil-addicted lifestyles
- Dire need to develop renewable energy – wind, photovoltaic, geothermal, biofuels, tidal, others

Overview of Discussion II

- Issues of food security
- Dwindling natural resources – water, topsoil, fisheries, timber, ocean health (pH), land (for ag), biodiversity, Amazon basin and other biodiversity “hotspots”, health of ecosystems,
- Global Warming and consequences
- Status of U.S. as the global hegemon and other political considerations – rise of other economic powers like EU, BRICs countries, others
- Failed states and other global geopolitical hazards like EU spreading east to Russia

Overview of Discussion III

- Given these challenges, how are we to grow food?
- Thesis: we “ought” to operate in ways that minimize energy inputs, maximize the integrity of the living world (biota), and make maximum use of the world’s natural ecosystems’ capacities to produce food, because it’s the right thing to do ethically and the most practical 21st C approach.

Today's Agenda

- Thought experiment – Organic Farming in the Punjab of India
- Constraints on Feeding 8 b people well- Lester Brown, "Plan B 3.0"
- Energy and "Peak Oil" (our addiction)
- Themes of ecological agriculture
- A bit of environmental ethics
- Case studies – ethical nitty-gritty
- Summary and Conclusions

Thought Experiment – Organic Farming in the Punjab of India – NPR, June 1, 2009

- Profiled Mr. Amarjit Sharma former high intensity farmer turned to organic. Why?
- Grows wheat and other crops
- 1960s and 70s – adopted Green Rev ag; abandoned traditional ag
- Embraced fertilizers, pesticides, hybrid seeds, tillage methods
- 20 years of good productivity and profits.
- Then, things unraveled? What happened?

Mr. Amarjit Sharma II - Punjab

- Not profitable
- Deteriorating soil – need more fertilizer
- More pesticide but not effective
- Realized – “caught in vicious cycle”
- 2005 – “kicked” the chemical habit – went to organic farming
- 1.2 b Indians – 300,000 now organic or transitional farmers (30X more than US)

Mr. Amarjit Sharma III

- HUGE FUNDAMENTAL QUESTION – “What is the most sustainable way to grow food”?
  - Why is this question fundamental?
  - We’re thinking globally – what’s best for world
  - Food-deprived people in Sub-Saharan Africa
  - What will happen to global stability if countries like India and China can’t feed themselves?
  - Partial answer (NHG)– organic, traditional, low E, and make use of the prevailing ecosystems.

Mr. Amarjit Sharma IV

- AS – “requires a more thoughtful farming”
- Mixture of crops in the same field – rice/wheat and types of beans (legumes)
- Rice yields comparable to GR; spend less on inputs except more on labor
- Wheat yields have fallen in half
- Punjab State Farmers Commission Report
  - If all Punjab organic, jeopardize food security
  - But 70% of farms outside Punjab **must** go organic
  - Within Punjab, 20% of farmers **could** go organic and remain productive. A KIND OF MIX OR COMPROMISE

Constraints on Feeding 8 b people well- Lester Brown, “Plan B 3.0”

- HOW TO FEED 8 billion people well
  - China’s Success
  - Rethinking land productivity
  - Raising water productivity
  - Producing protein more efficiently
  - Moving down the food chain
  - Earth’s “carrying capacity”

THE BALANCE

- $6\ CO_2 + 6\ H_2O + sun \rightarrow C_6H_{12}O_6 + 6\ O_2$
- What is this formula? Why is it important?
- What does it have to do with food security? To what extent can it be optimized? **What sets the limit on earth?**
- $C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$
- What can we say about this second reaction? What, where, when, why, how?
- AMAZING SYMMETRY! HERE IT IS!

China's Success

- 2005 – food shipments to China ceased
- Now, world's 3rd largest food donor
- The KEY – Economic reforms of 1978
  - Dismantle collective farms ("production teams")
  - Develop family farms
  - Long-term land leases
  - Unleash energy, ingenuity, and incentive
  - NHG – will this productivity continue?

Key to 3X Expansion in Global Grain Harvest since 1950

- High-yielding hybrid wheat, rice, corn
- 3X increase in irrigated land
- 11X increase in fertilizer
- Tripled the world grain harvest
- BUT, what does the future hold for genetic improvement, irrigation, response to fertilizer?

Future Crop Production Outlook Globally: This is a very sobering business

- Shrinking supplies of irrigation water
- Diminishing response to fertilizer
- Rising temperatures (GW)
- Loss of cropland to non-Ag uses
- Rising fuel costs (Elephant in Bed – peak oil – are we near or beyond peak oil-Michael Klare
- Diminishing backlog of yield-raising technologies
- Add 70 million new people per year
- 5 b people “moving up the food chain”
- Crops going to food or fuel?

Not all that Rosy a Picture

- Lester Brown (p176) states, “…world grain production has fallen short of consumption in 7 of the last 8 years dropping world grain stocks to the lowest level since 1974. Farmers and agronomists are now being thoroughly challenged”

Rethinking Land Productivity
Getting more crop from the land

- Breed crops tolerant to drought/cold/stress
- Increase area of double cropped land, i.e., winter wheat with soybeans (U.S.)
- Use fertilizer in high response areas
- Africa – simultaneous planting of grain and leguminous trees
- Effect of land tenure on productivity – political but translates to agricultural
- Think more seriously about stabilizing population, moving “down” the food chain, limiting conversion of food crops to fuels

Raising Water Productivity

- Tons of grain per unit land or per unit water
- Now 1kg grain/ton water; 1,000 tons of water to produce 1 ton of grain
- **70% of world water use – irrigation**
- Thus raising irrigation efficiency is central
  - Drip irrigation; shift to crops that use less water; eliminate water and energy subsidies; encourage local water districts; move down food chain; sustain the yield of aquifers, more water-efficient industrial and household (appliances); recycle urban water supplies.

Producing Protein more Efficiently

- Quiz on Feed Efficiency. In terms of kg grain per kg gain

Animal	kg grain/kg gain
Cattle in feed lot	7
Sus scrofa (pigs)	3
Poultry	2+
Herbivorous fish	2-

- Herbivorous fish – carp, tilapia, catfish

Efficient Protein Production II

- 37% of global grain harvest (740 m tons) used to produce animal protein
- Small increase in efficiency – save grain
- Meat consumption: 44 m tons (1950); 240 m tons (2005) – 5.4 fold increase in 55 yrs
- 70 m more people per year to feed
- 5 billion moving up the food chain
- NHG – huge future challenges

Moving Down Food Chain
Earth's Carrying Capacity

- How many people can the earth support?
- Critical question – at what level of living?

Food consumption (Kg grain/person/yr)	No. people glob. (in billions)	Health (level)
USA 800	2.5	less
Italy 400	5.0	better
India 200	10.0	less

- Demographers tell us about 9 billion in 2050
- At what level of food consumption? A problem?

Energy and Peak Oil

- Civilization tipping points
  - Oceanic fisheries;pH of oceans (phytoplankton)
  - Population growth and natural support systems
  - Falling aquifers, glaciers; GW/CO2 emissions
  - ***Decline in oil production, sooner or later***
  - Food security
  - In addition to the Brown suggestions (Plan B 3.0), here are some themes of “ecological agriculture” – Let Nature do the work!

Ecological Agriculture
Cultural/Historical Agriculture

- Scientifically bolster traditional agriculture in developing countries – bottom up
- Enhance scientifically, traditional methods
- Research and find common denominators for local, traditional farming success
- Keep people of dev'l countries on the land
- Farm more thoughtfully, holistically
- Compromise between scales of ag – not all or none, but the best of both

Ecological Agriculture II, Examples

- National Sun Grant Initiative – revive Amer. farming communities; rural economic development; production of bio-based renewable energy feedstocks
- Two SDSU projects: (two of many nationally and internationally)
  - Dr. Susan Rupp – Wildlife and Fisheries
  - Dr. Arvid Boe – Plant Science

Dr. Susan Rupp, SDSU Wildlife and Fisheries

- Concerned about conversion of marginal land to intensive ag production; increased eutrophication; water quality/quantity
- Experiments on effects of stubble height/season of harvest; max biomass productivity in mixed grass native grasslands; biofuel production from native vegetation (optimal mixes of species)
- Helpful for C sequestration, biodiversity, and overall ecosystem stability

Dr. Arvid Boe, SDSU
Plant Science

- Perennial grass (cellulose) vs. annual crops (starch) for biofuels
- 7 varieties of switchgrass (Dakota, Cave-in-Rock); prairie cordgrass; little bluestem
- Testing input costs, productivity, env issues, wildlife habitat, soil improvement, water quality, C-sequestration, other variables

Dr. Carter Johnson, SDSU Hort., Landscape, Forestry, Parks

- EcoSun Prairie Farm – 640 acres; was corn, soybean, pasture; restore hydrology and wetland grasses to serve as an economic base; working model of ag and ecol. Sustainability
- Experiments on:
  - Grass-fed meat (optimal grass composition)
  - Rates of C sequestration
  - Improvements on surface and ground water quality
  - Marketing of grass products

Dr. Carter Johnson II

- Key theme – capture and make available for human use maximum amt of energy: concept of “grass-based energy farms”
  - Balance wildlife and economic benefits
  - Econ. ways to establish and manage Tall GP
  - Income stream from wetland seed – forbs, sedges, grasses
  - Compare corn, switchgrass, bluestem mix (with forbs) and prairie cordgrass.

Environmental Ethics
Instrumental View

- Two general ways to view the natural world (natural resources)
- **Instrumental valuation** – 99% of our view – for human use (utility) –
  - Recreation and aesthetic values
  - Undiscovered or underdeveloped values
  - Ecosystem stabilization/ecosystem services
  - Survival value/ technical innovation value
  - Utility value – food, fiber, shelter, basic needs
  - Natural World viewed as an instrument for us – H. sapiens
  - POTENTIAL PROBLEMS WITH THIS VIEW?

Environmental Ethics
Intrinsic View

- An argument – ecological ag more approximates the intrinsic view of biota (but a weak argument)
- An exceedingly difficult sell! (Our lenses – totally and necessarily anthropomorphic)
- All biota have value “in and of themselves”
  - Have a claim to do their thing – e.g., “pigdom”
  - Based on species unique genetics (genome)
  - Based on long period of evolutionary history
  - Based on the fact of their very existence; these would seem to provide some evidence of intrinsic value
  - Let’s move on to some bioethics case studies - BREAK

Case Studies – Ethical Analysis

- Organic Faming in the Punjab – Mr. Amarjit Sharma
- Prawn Farms in India
- Expanding global economy and dwindling global resource base (global ecology)
- Large-scale corporate farming in developing countries

Summary
21st Century Agriculture

- Exceedingly complex business – no easy answers – resource and political issues
- Common denominators – E in and E out – annual biomass production/ political use?
- Oil, global warming, renewable non-C fuels, huge & sobering ecological footprint (9b people)
- What is best from a national perspective and a global perspective
- Ethically – “right approach” can sometimes be the most practical approach, simultaneously – stable world.