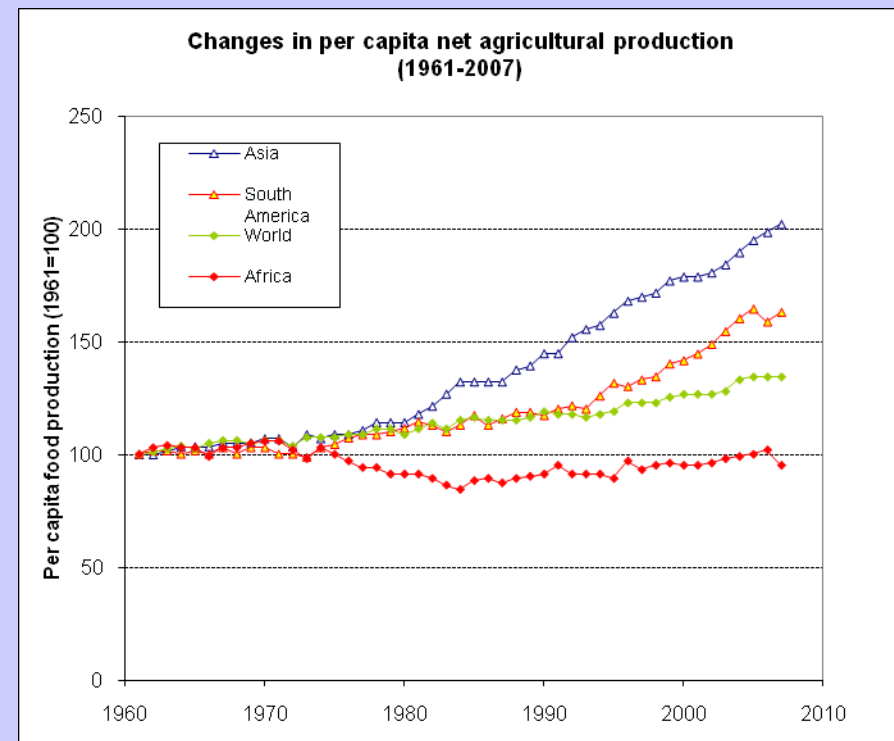
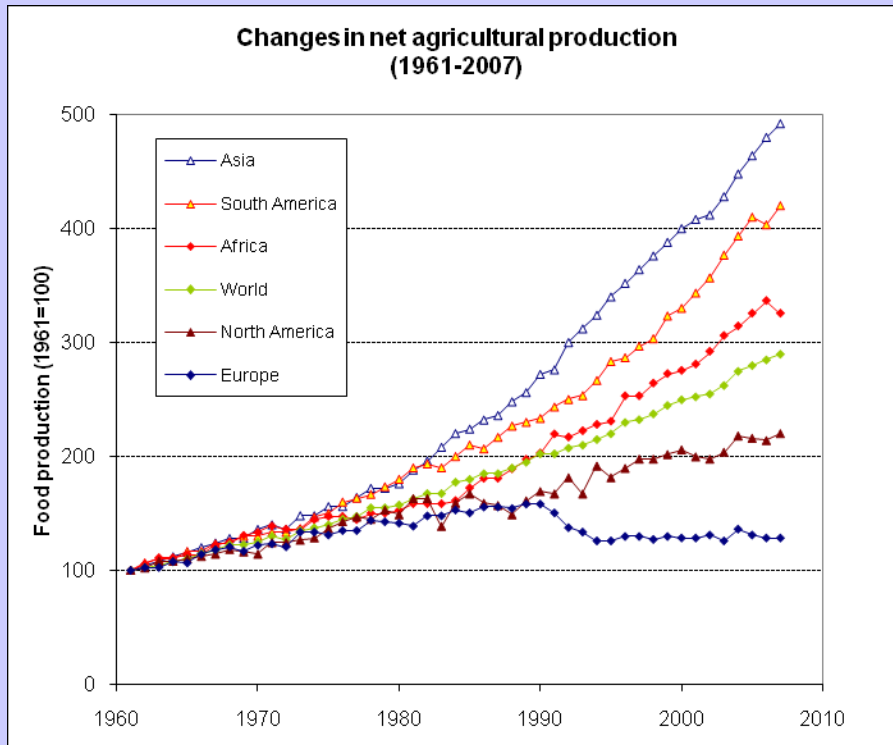


The Sustainable Intensification of Agriculture: Options and Challenges

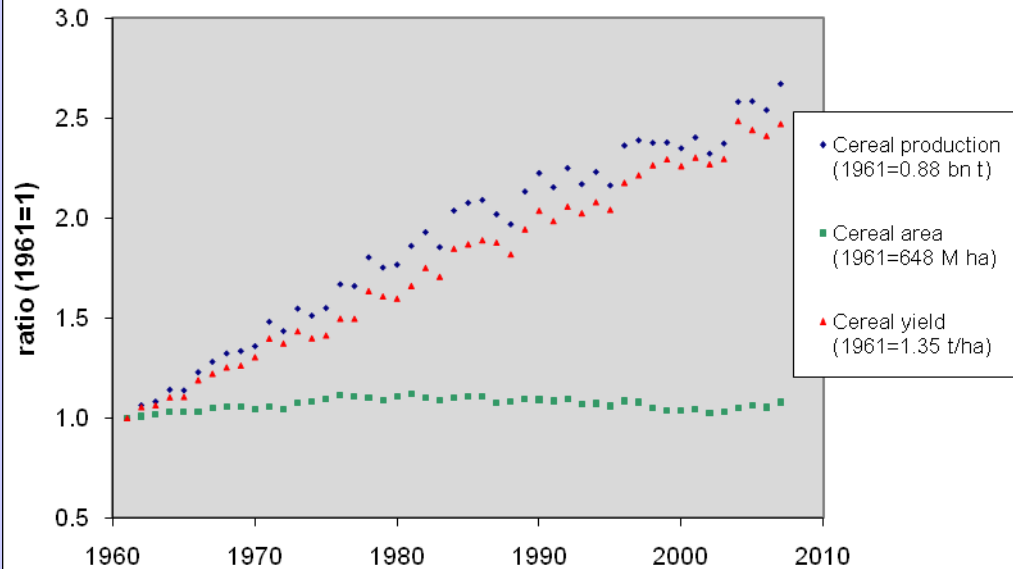
The 35th T B Macaulay Lecture,
James Hutton Institute, Aberdeen
27th September 2012

**Professor Jules Pretty OBE
University of Essex**

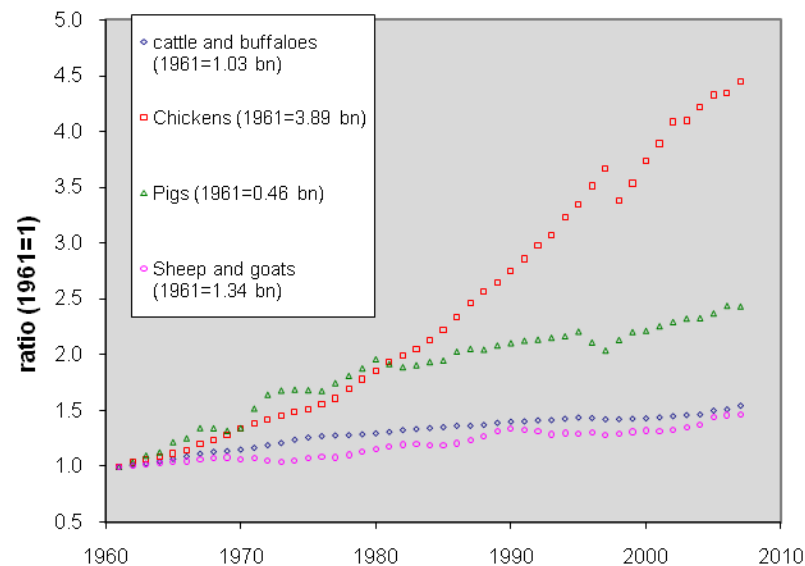
Mixed progress on food: the past 50 years



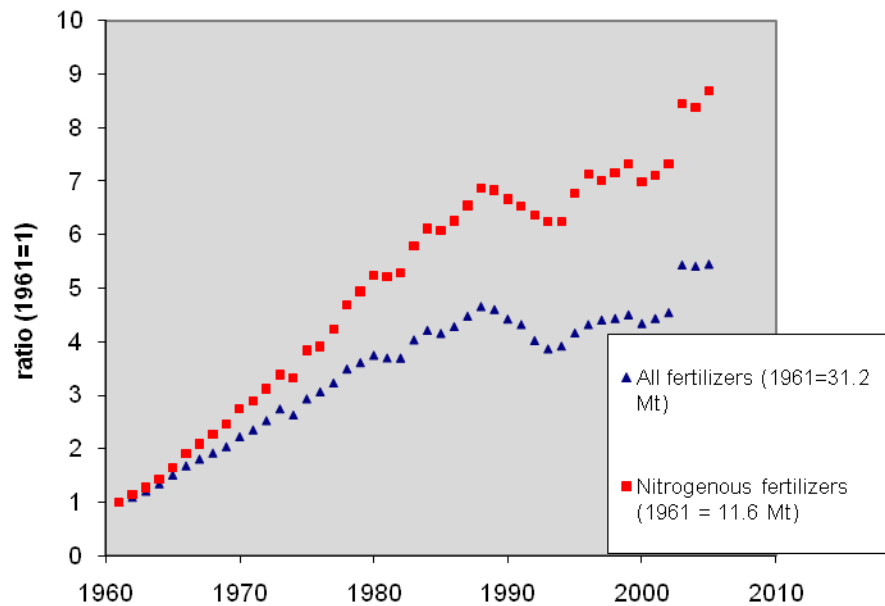
Cereal production, area and yields, world (1961-2007) (FAO, 2009)



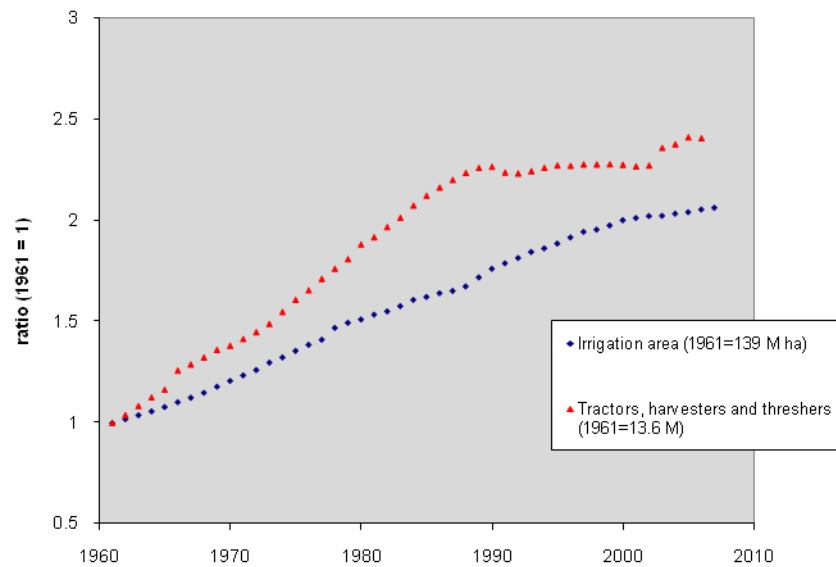
Head of livestock, world (1961-2007) (FAO, 2009)



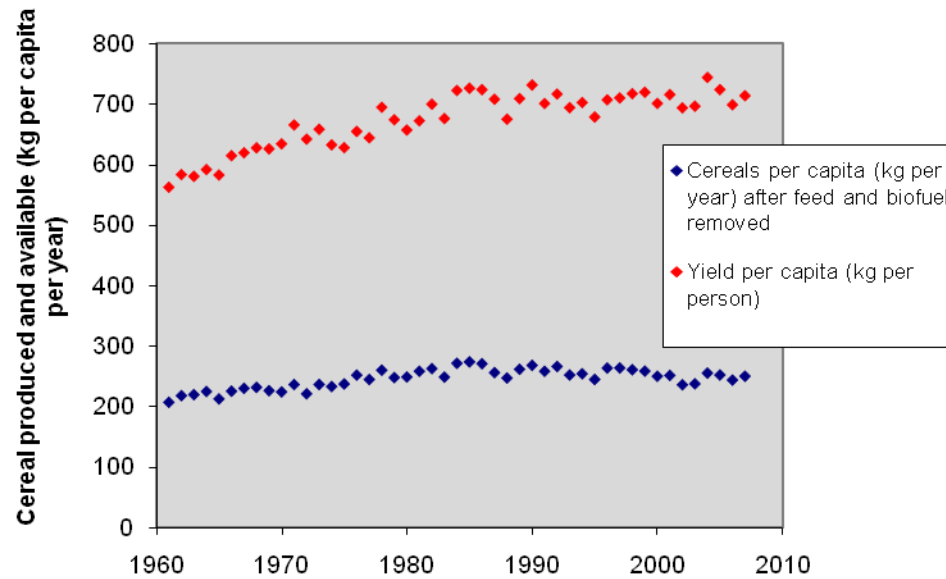
World fertilizer consumption (1961-2005)
(FAO, 2009)



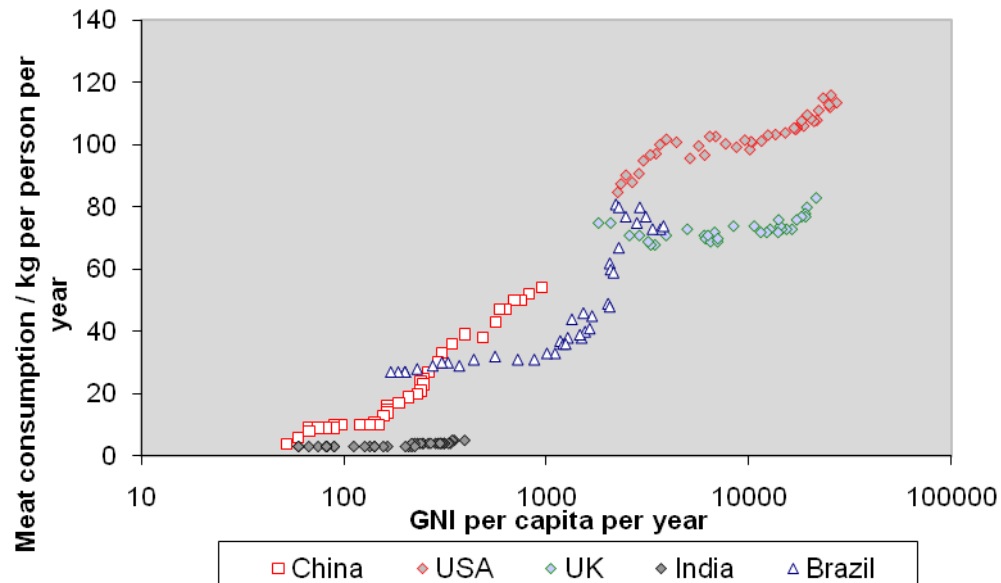
Irrigated area and agricultural machinery, world (1961-2006)
(FAO, 2009)



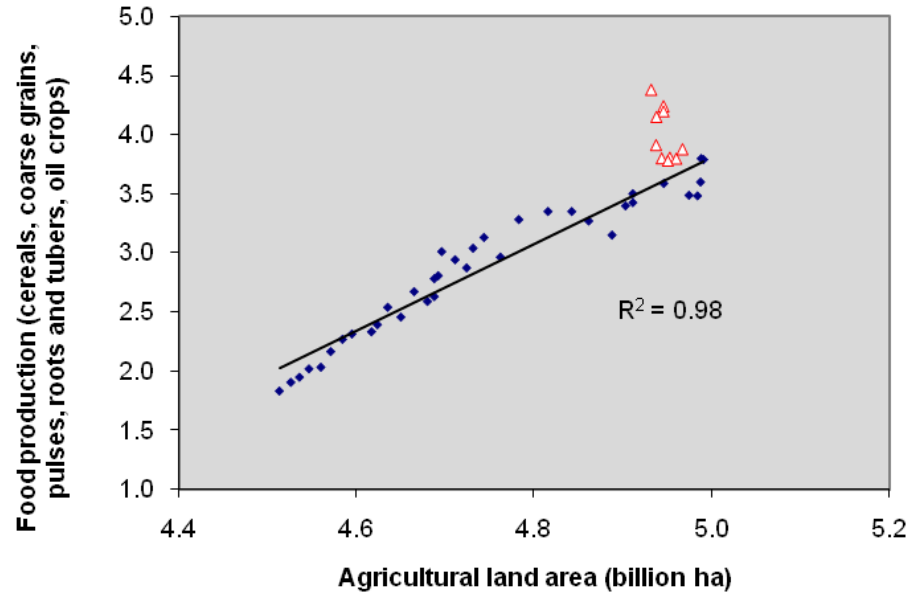
Gross cereals produced and amount available to humans for food (1961-2007)



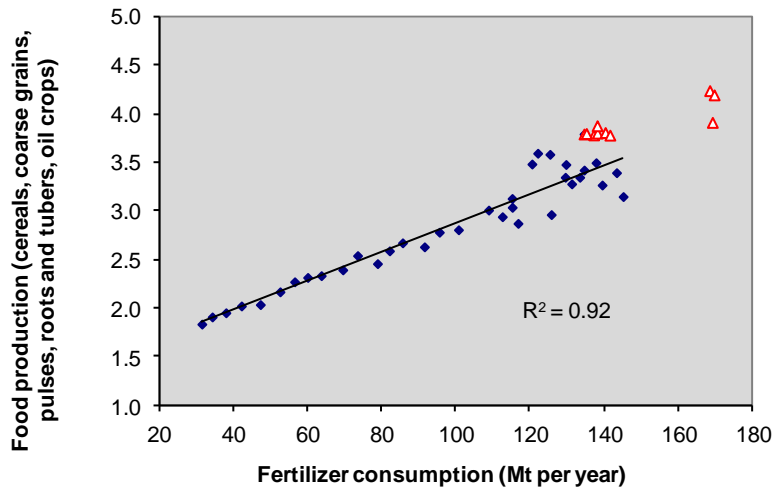
Changing meat consumption with gross national income in China, India, Brazil, UK and USA (1961-2007)



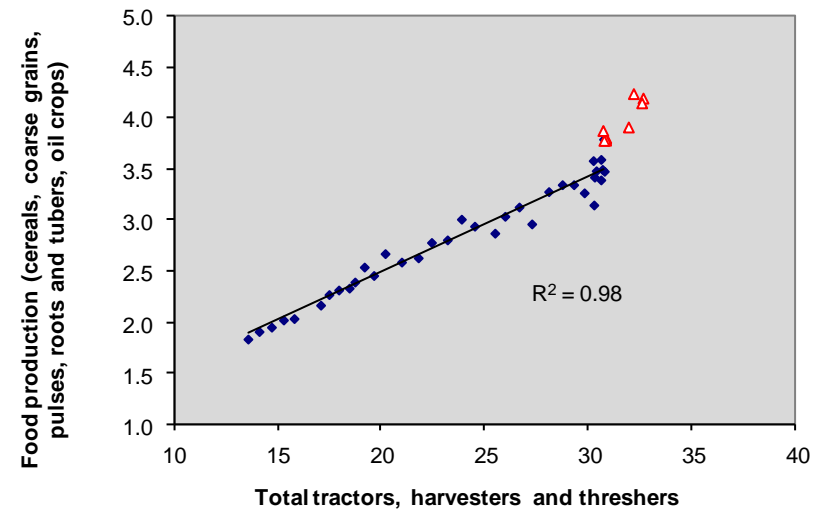
Relationship between world agricultural land area and world plant food production (1961-2007)



Relationship between all fertilizers applied and world plant food production (1961-2007)



Relationship between world agricultural machinery and world plant food production (1961-2007)



New Threats

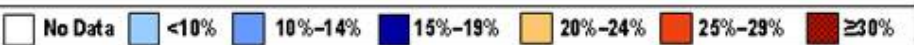
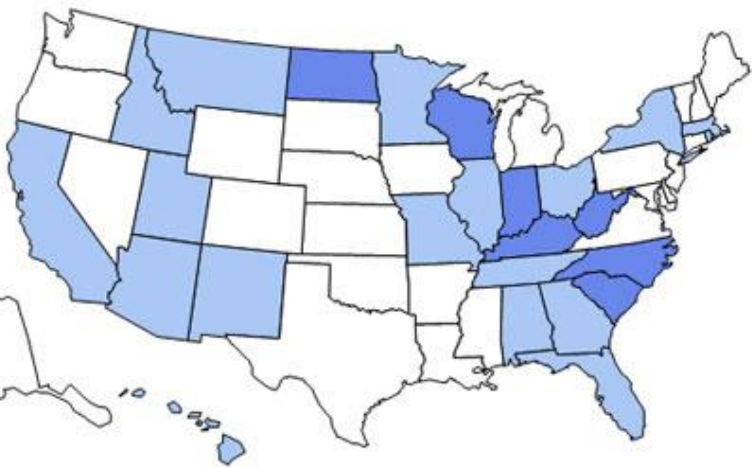


- Consensus: world food system in **new danger**
 - Consumers expect to be able to buy food anywhere, anytime
 - But also now disconnected from food production
 - Nature of shortages forgotten by many
 - Emergence of obesity pandemic
 - Biofuels
 - Cereals into ethanol
 - Climate change
 - IPCC predicts 50% yields cut in much of Africa (by 2020-30) and other threats
 - Agriculture also important contributor to GHGs
 - Converging consumption patterns
 - Food price uncertainty (doubled 2005-2008; fell back, spiked again late 2010, then 2012)

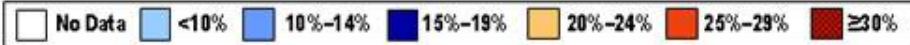
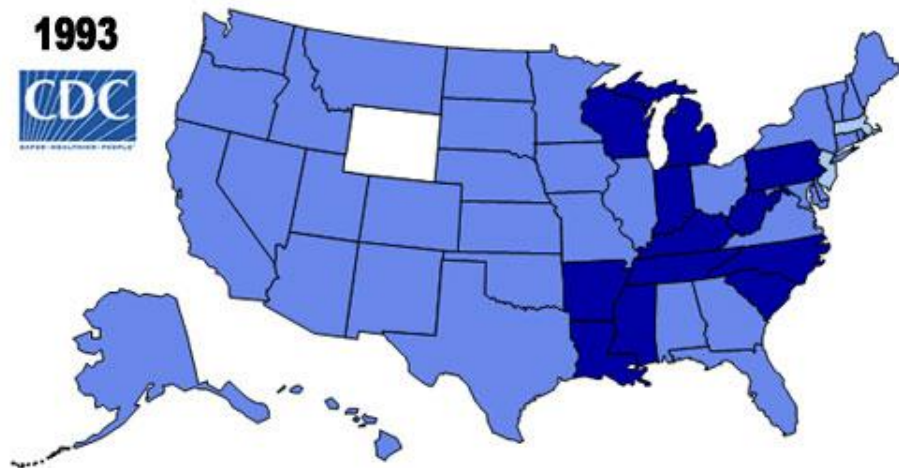


Change in Adult Obesity, US (BMI ≥ 30), 1986-2008

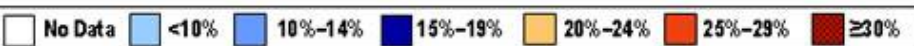
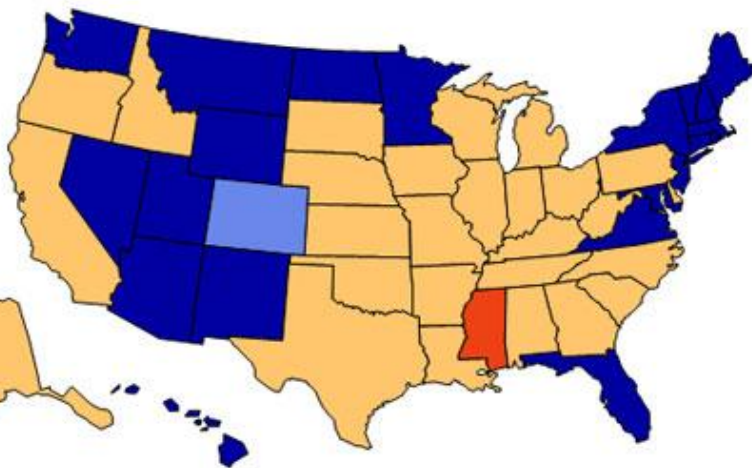
1986



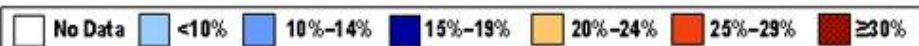
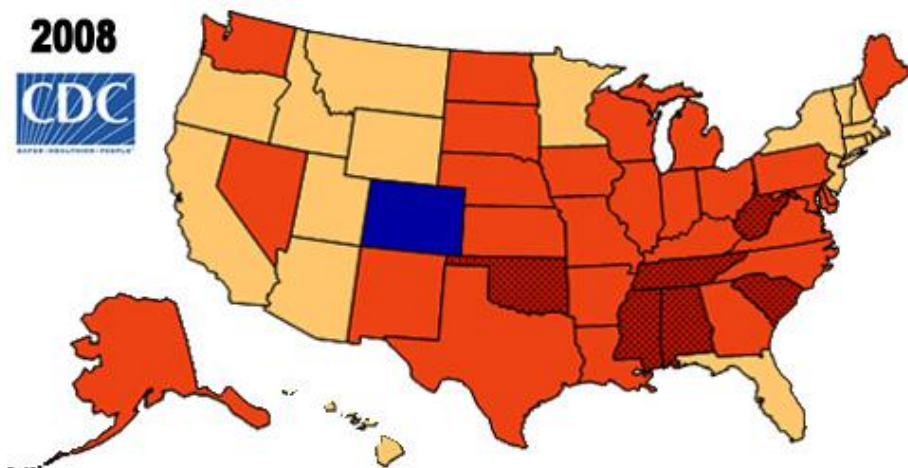
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2001

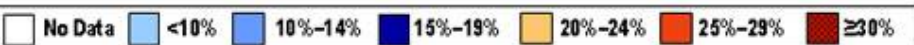
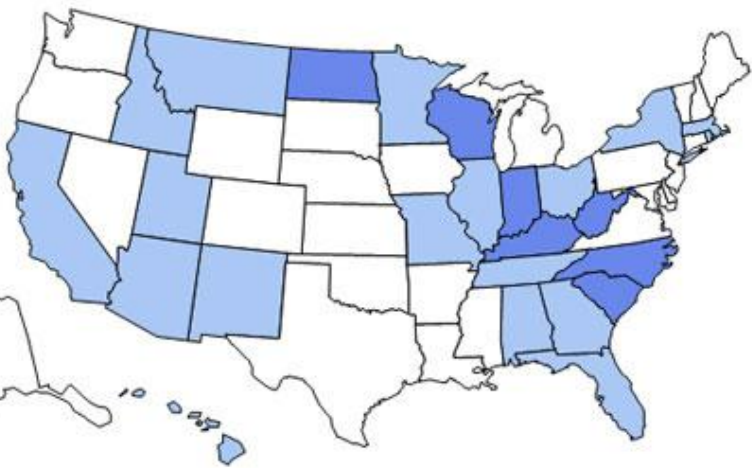


2008

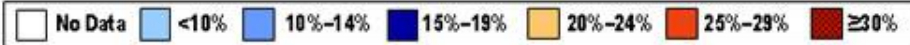
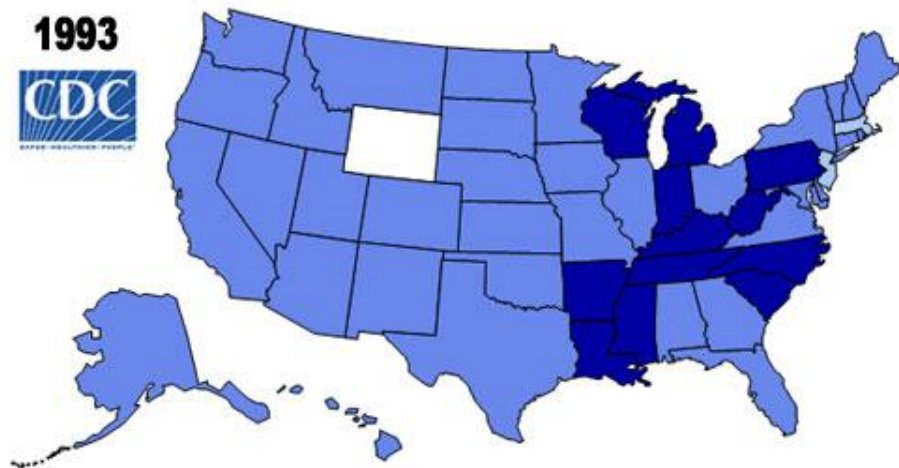


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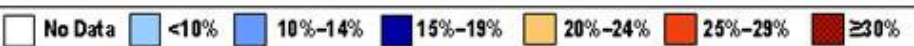
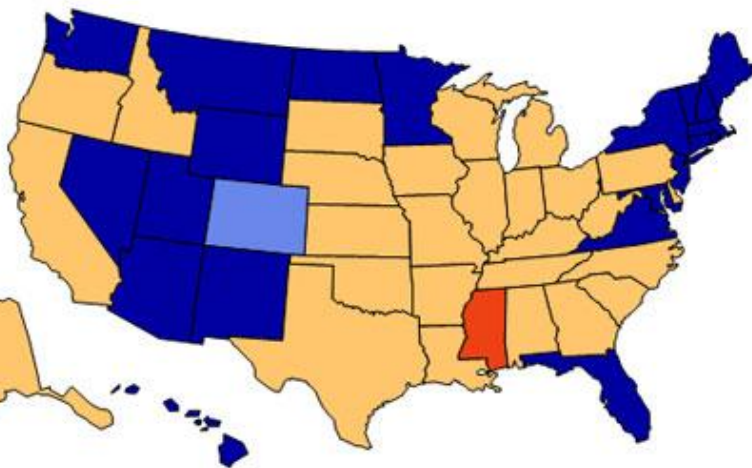
1986



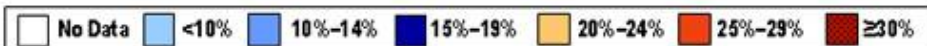
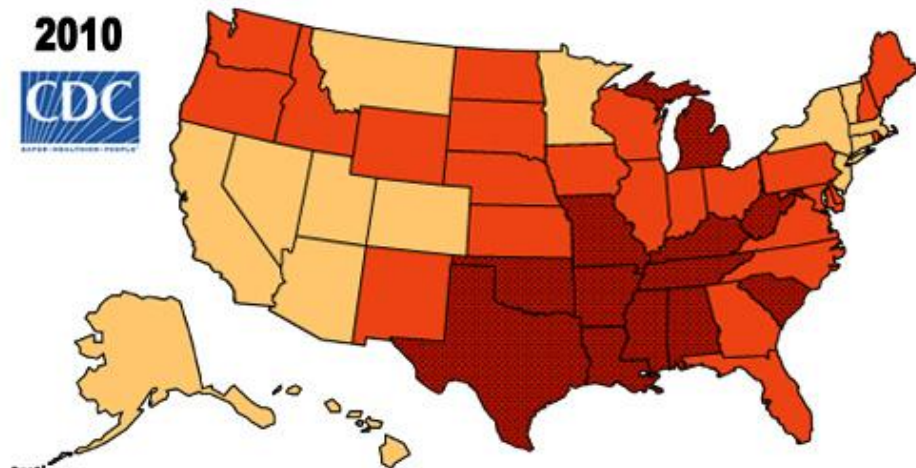
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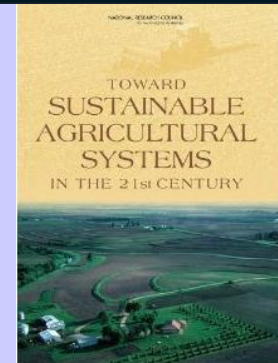
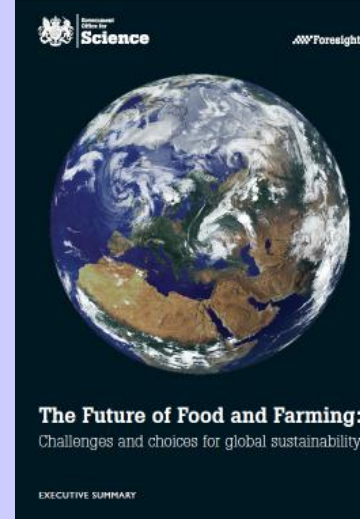


2010

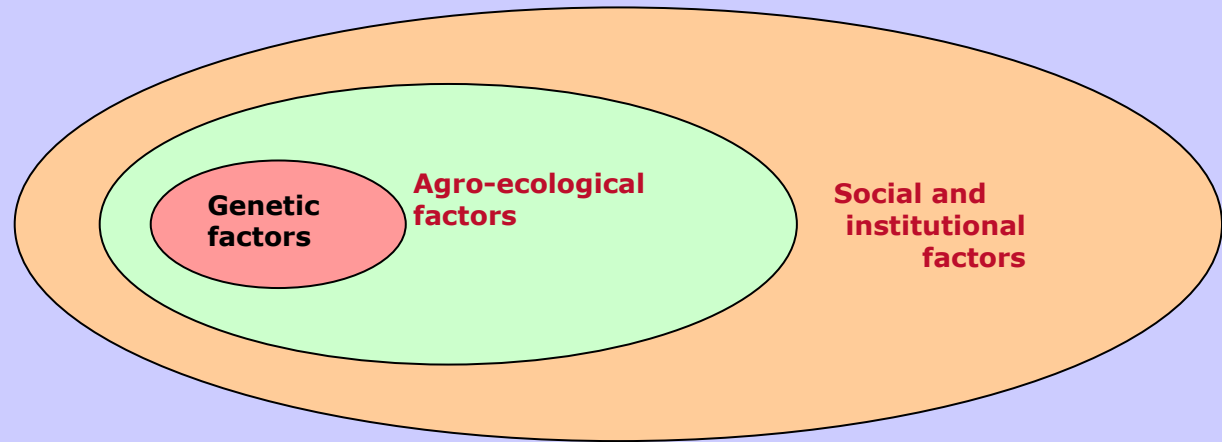


Sustainable intensification: Emerging consensus

- Major problems ahead
 - Need a substantial (50-100+%) increase in food production worldwide by 2050
 - But not at cost to important environmental services
 - Will need the best of science and social innovation
- Sustainable intensification: aims
 - Increase yields
 - Increase positive environmental side-effects
 - Decreased negative side-effects
 - ...On the same land
- *Both* improvements in crops *and* improvements in agro-ecological management
 - Make the best of all technologies, approaches and farming methods



Sustainable intensification



- **Both agricultural + environmental outcomes are sought**
 - Cannot be defined by any particular technologies or practices
 - When work best = contribute to environmental services
- **Two components to technologies and practices**
 - Crop varieties and livestock breeds
 - Agro-ecological processes to manage agricultural and wider habitats
 - Both-and, not either-or
- **Human and social capital for innovation and delivery**
 - Human capital – knowledge and capacity to adapt and innovate
 - Social capital – work together to solve common agricultural and natural resource problems

Agro-ecological knowledge

- Application of ecological knowledge to agricultural systems
 - Scientists, extensionists, farmers
- Use of ecosystem services provided by plants, animals and micro-organisms and by physical resources
 - Study of soils, pests and predators, water, trees, organic matter
 - Predation, parasitism, nitrogen-fixation
 - Scale and hierarchy
- Tendency is towards diverse agro-ecosystems with multi-functional components
 - Integrated technologies and practices complement best seeds and breeds



Social capital

- Relations of **trust** that lubricate co-operation
- Common **rules, norms and sanctions** for behaviour
- Connectedness and **social institutions**
- **3 types**
 - **Bonding, bridging and linking social capital**
- Fundamental basis for sustainability
 - lowers the costs of working together
 - facilitates co-operation between people
 - increases flows of knowledge and understanding
 - maintains cultures
- 500,000 new social groups established worldwide in late 1990s-2000s



Sustainable Intensification: some evidence

- Two University of Essex studies
 - 286 cases in 57 countries (2006)
 - 30 cases in Africa (2011)
(commissioned by Foresight)
- Approx 20 million farmers adopted sustainable intensification in 2000s
- Yields: mean increase of 1.67x (286 cases) and 2.13x (Africa)



Food improvements: sustainable intensification

- **Additive**

- New components
 - eg fish
- Small patches
 - Raised beds for vegetables
- Land rehabilitation
 - Formerly degraded becoming productive
- More livestock per household
 - More fodder trees
- New crops or trees
 - eg pigeonpea, domesticated indigenous trees
- Short-maturing vars permitting 2 crops/yr
 - eg orange fleshed sweet potato, Uganda

- **Multiplicative**

- Increased yields per hectare
 - New varieties and new management
 - **mean across projects 2.13x increase**



Integrated Pest Management in rice



Learning to
make best use
of beneficial
insects &
arthropods



Farmer
field
schools



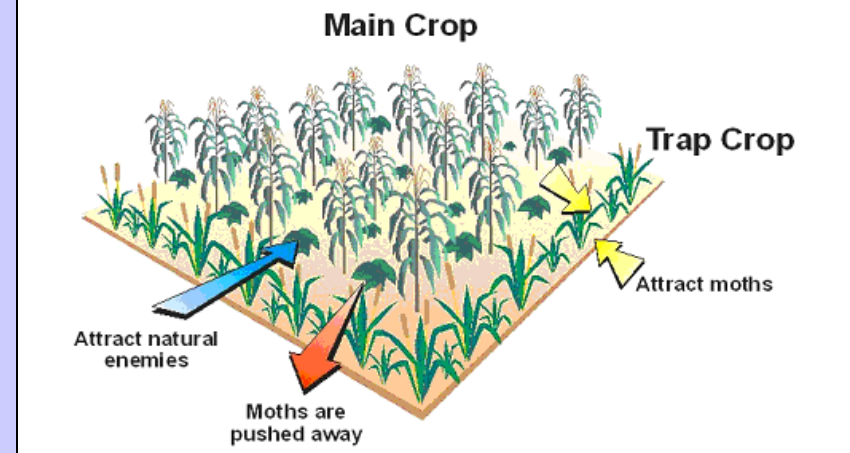
IPM in rice: farmer field schools

- Farmers attend farmer field schools (‘schools without walls’) during whole rice season
 - meet each week to learn new agro-ecological principles for rice and pest management
- 4 million farmers trained in 175,000 FFS
 - Indonesia 1.1 m; Vietnam 930,000; Bangladesh 650,000; Philippines 500,000; India 255,000
- Outcomes
 - Rice yields up 5-7%;
 - Costs of production down (Bangladesh ~ 80% of trained farmers use no pesticides)
 - Fish-rice-vegetable systems produce synergistic benefits
- Senegal, Burkina Faso, Mali, Benin
 - Farmer field schools for IPM and crop management
 - Rice, market garden vegetables, cotton, mango
 - 50,000 farmers trained and adopted

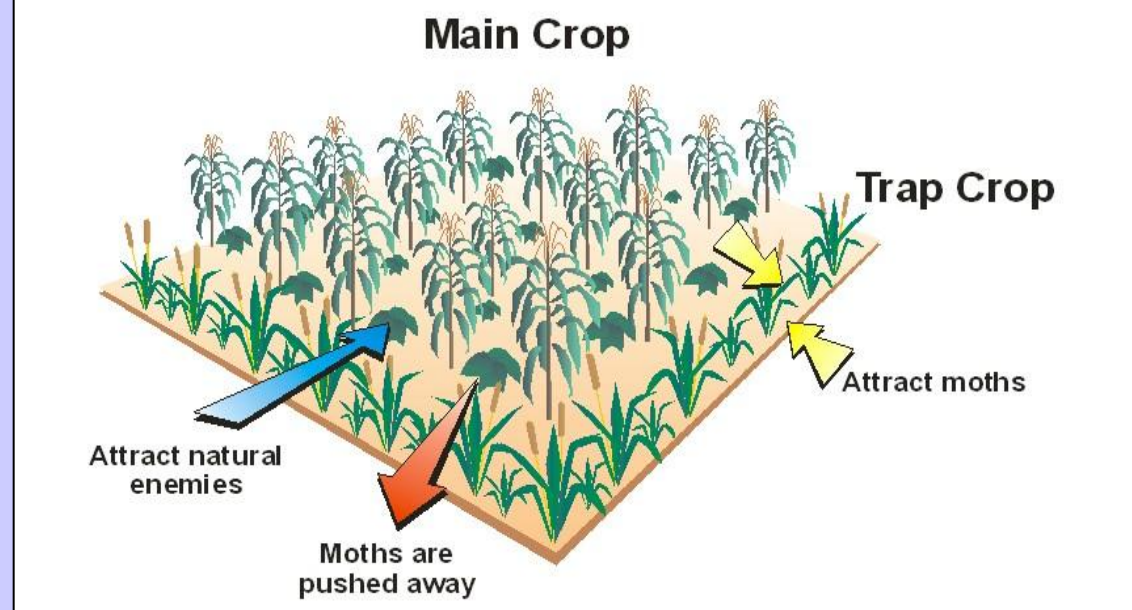


Pest management

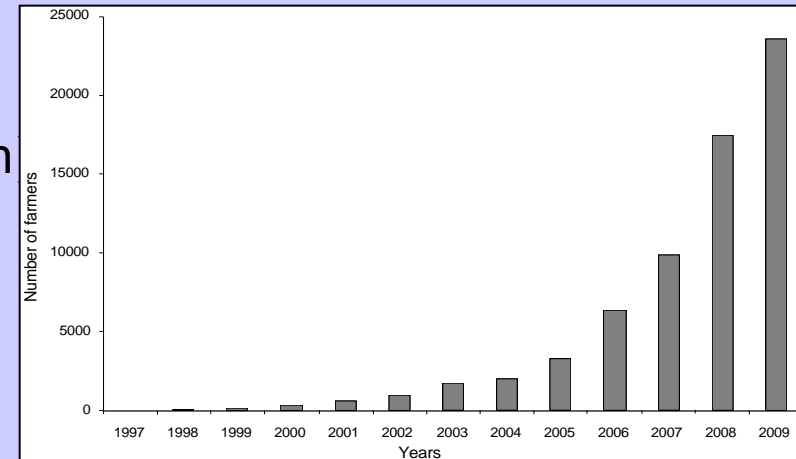
- Sound and novel science
- Introduction of new system components
 - Redesigned agricultural systems
- Building of social and human capital
- Farmer learning and training
 - 3500 FFS in West Africa
 - Mixtures of technologies



Push pull IPM, Kenya



- Locally available plants as perennial intercrop and trap crops
- Needs understanding of chemical ecology, agrobiodiversity, plant-plant and insect-plant interactions
- *Desmodium* repels stemborer moths (push and also attracts natural enemies)
- Attractant trap plant, *Napier* grass (pull) planted as a border crop around this intercrop.
- Stemborer females are repelled from the main crop and attracted to the trap crop



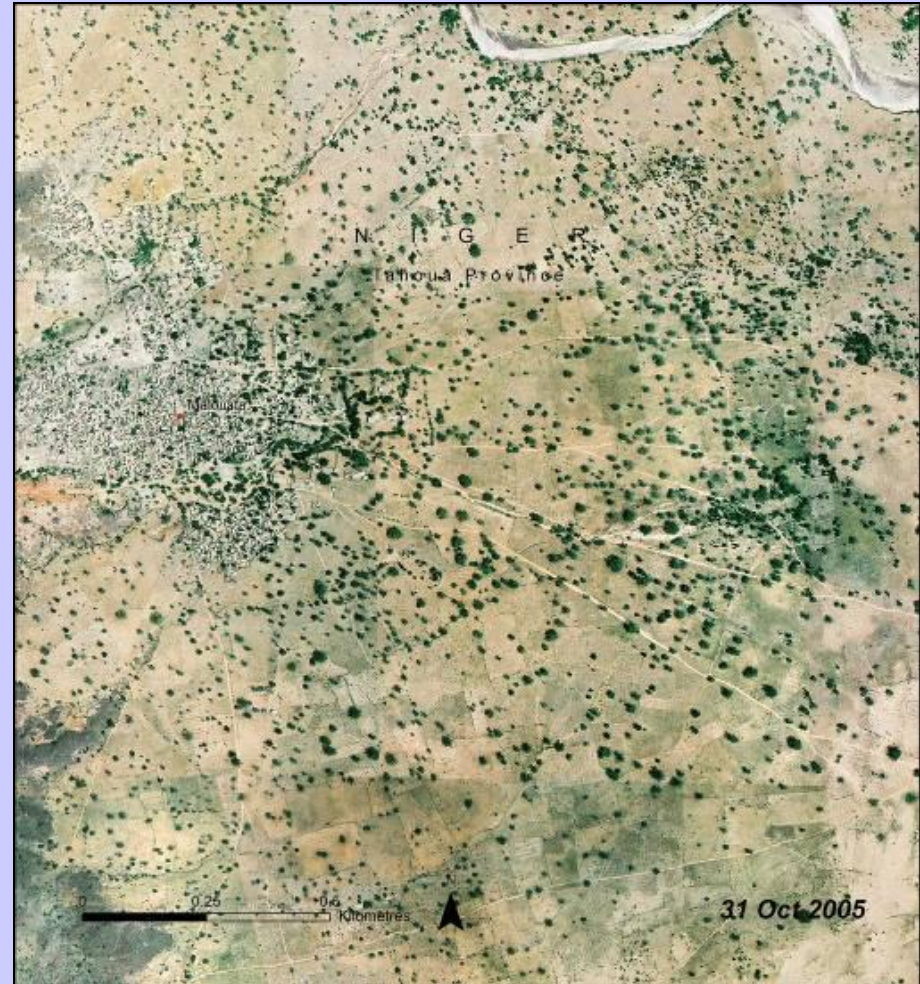
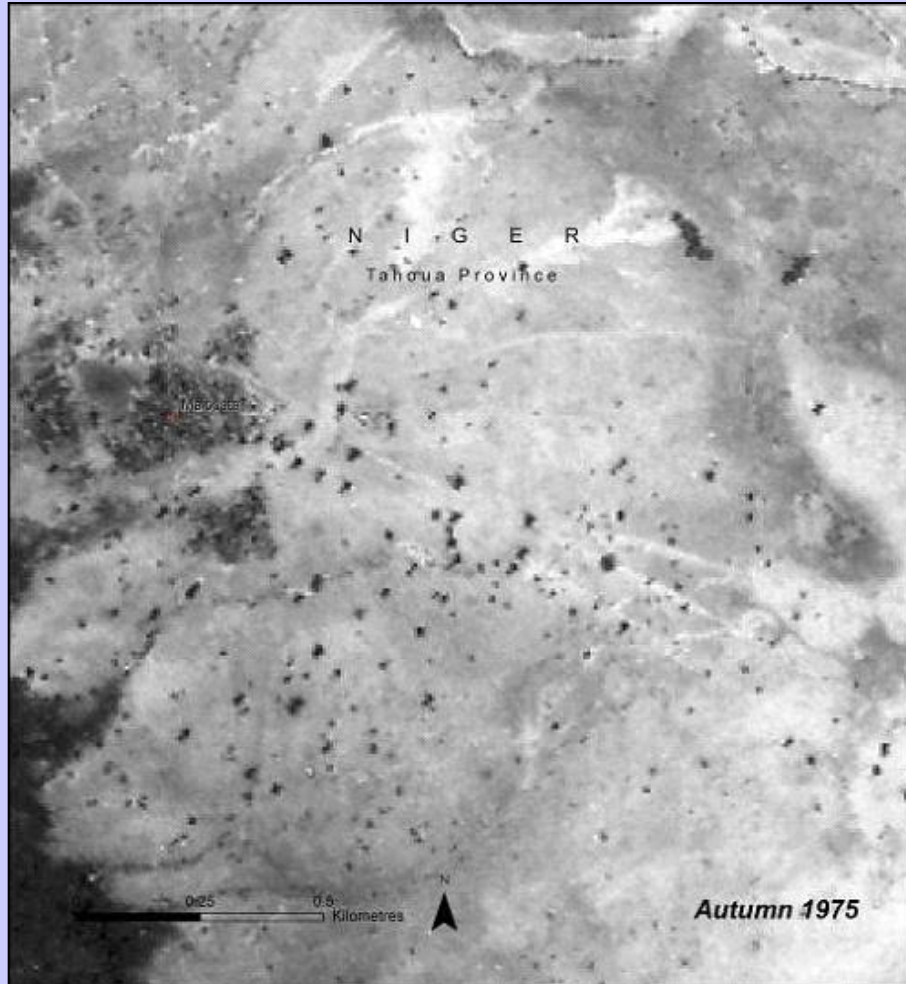
Soil Conservation & Agroforestry

- Improving soils, capturing water, changing the landscape
 - Soil conservation & rainwater harvesting – zai pits, contour bunds, half moons
 - Tree planting
 - Livestock intensification
- Social capital formation



550,000 hectares of land rehabilitated

Green Wall of Sahel



Terroirs côté Niger

19 km au nord de la frontière Niger-Nigeria



12 km au nord de la frontière Niger-Nigeria



8,5 km au nord de la frontière Niger-Nigeria



Terroirs côté Nigeria

1,5 km au sud de la frontière Niger-Nigeria



14,5 km au sud de la frontière Niger-Nigeria



38 km au sud de la frontière Niger-Nigeria

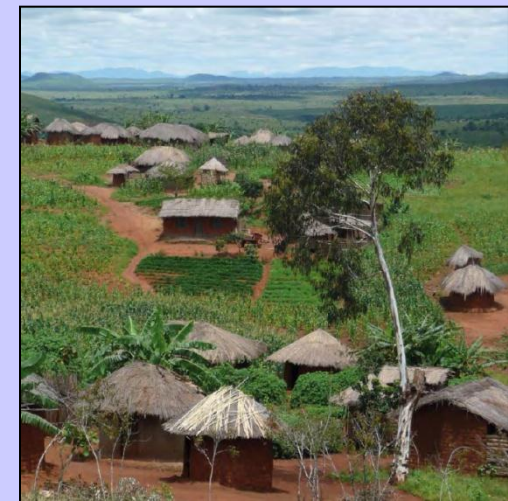


Figure 2 : Vue comparative de trois terroirs de part et d'autre de la frontière Niger-Nigeria

Fertilizer fallows

E and S Africa

- Improved fallows with Sesbania, Tephrosia, pigeonpea, Croton, Gliricidia
 - 2 years in fallow, then 3 years of maize
- Zambia yields
 - maize continuous for 5 years 4.8 t ha⁻¹
 - improved fallows (2 fallow, 3 maize) 8.5 t ha⁻¹
- Management intensive, farmer involvement in technology development, whole farm approach, use of organic and mineral fertilizers
 - Zambia – 65,000 farmers
 - Malawi – 42,000 farmers
 - Kenya – 15,000 farmers
- Malawi 345 farmers groups formed



Conservation agriculture

- Conservation agriculture, min- or zero-tillage
 - Began Brazil & Argentina
 - GM soybean + herbicide use
 - Brazil – 25.5 M ha; Argentina – 19.7 M ha
- Benefits
 - better input use, water retention, increased organic matter in soils (& more carbon sequestration)
 - reduced erosion and water pollution
 - Yields up and more stable year on year
 - maize - from 3 to 5 t/ha (Brazil)
 - wheat - from 2 to 3.5 t/ha (Argentina)
- Zambia
 - Minimum tillage, legumes, mineral fertilizers and herbicides, crop residue retention, planting basins
 - Yields of maize up 50-100%; cotton up
 - 125-175,000 farmers
- CA estimates ~ 106 M ha worldwide



Legume intercrops Central America

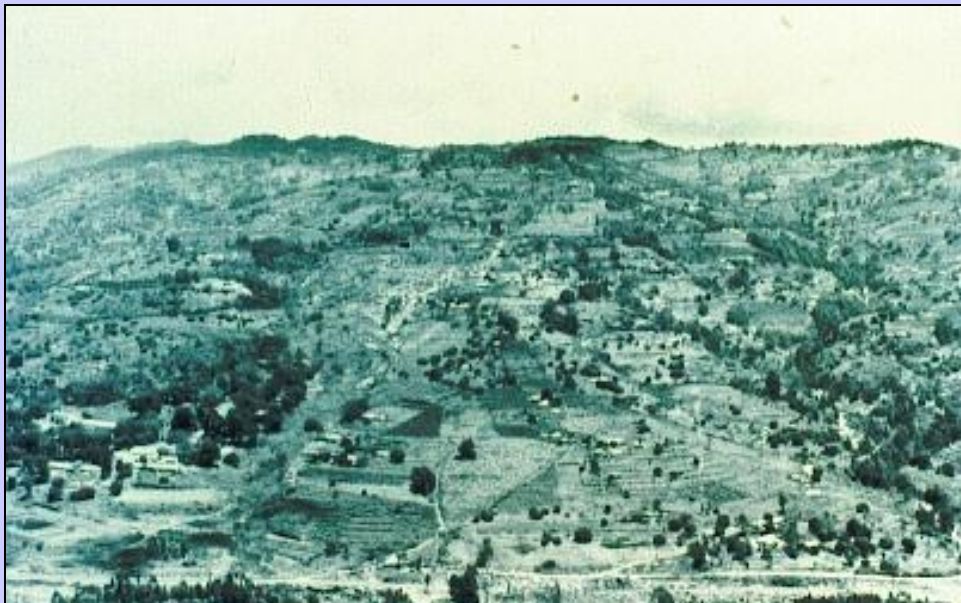
- Velvet bean (*Mucuna pruriens*)
 - Multiple cropped with maize
 - 150 kg N fixed ha⁻¹ yr⁻¹
 - 50-100 tonnes biomass ha⁻¹ yr⁻¹
 - Improves and regenerates soils
- 45,000 families in Guatemala, Honduras & Nicaragua intercropping *mucuna*
 - Maize yields up
 - from 400-600 kg ha⁻¹
 - To 2000-2500 kg ha⁻¹
 - Social capital critical
 - farmers' groups, experimentation, and extension



Catchment approach to soil and water conservation, Kenya

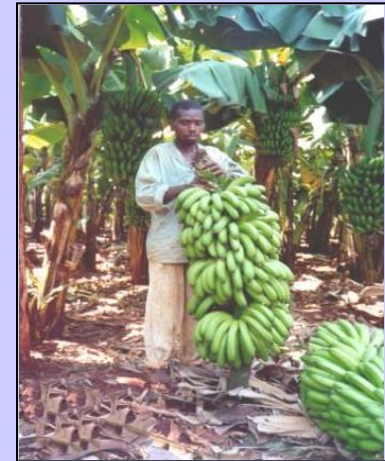
- Social processes
- Farmers' groups





Crop improvements

- Local research highly effective
- Participatory
 - research, varietal testing and breeding
- Locally-developed plant and animal materials
- Focus on orphan crops
 - Cassava, plantain, orange fleshed sweet potatoes, tef, pigeonpea, soybean



Common lessons

Social infrastructure

- Social capital a prerequisite to impact and scaling up
 - Farmer Field Schools, cooperatives, Rural Resource Centres, business groups, Common Interest Groups, micro-credit groups, catchment groups
- Local research capacity highly effective
 - Participatory
 - Locally-developed plant materials and animals
- Increased knowledge leads to increased productivity
 - Farmers don't know everything – especially on pests & diseases



Common lessons

Social infrastructure

- Innovative co-learning and extension platforms
 - Videos
 - Mobile phones
 - Participatory plant breeding
 - Farmer field schools
 - Rural resource centres
 - Civil society campaigns
- Focus on women and children
 - Women' groups; food for children
 - Orange-fleshed sweet potato;
 - Milk
 - Business opportunities for women's groups
 - Cassava processing – Cameroon, Uganda
 - Vegetables

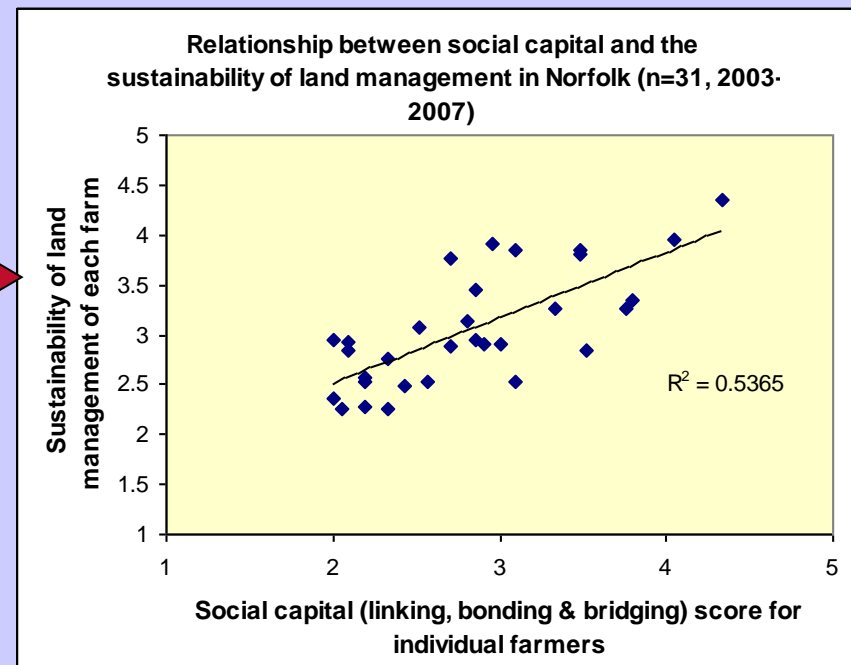


Social capital in UK farming

- 5 year trial (1999-2004): NALMI
- 31 farmers, 12,140 ha
 - 16 arable, 15 mixed
- Social capital and sustainability of land management
- Elements of social capital
 - **Linking** (engaging with those in authority)
 - **Bonding** (engaging with those with similar goals)
 - **Bridging** (engaging with those with different goals)



- Strong relationship between social capital and sustainability



- Sharp drop in linking social capital in past 40-50 years
 - Gradual distancing
 - Growing disrespect
 - Increasing divergence from government
- Loss of face-to-face contact from 1980s
 - Makes policy implementation harder
 - Slows transitions towards sustainability



1980s: 97% of comments about ADAS & "The Ministry" were **positive**

2000s: 87% of comments about govt agencies were strongly **negative**

Common lessons Emergent private sectors

- Emergence of new private sectors
 - Aquaculture entrepreneurs
 - Business development driving economic growth
 - Private seed and input suppliers
 - Crops, trees & shrubs
 - Women's groups
- Novel partnerships (a form of social capital)
 - Private sector, NGOs, public sector, CSOs, farmers, banks
 - Create trust
 - Narrow-sense better than wide-sense (to avoid transaction costs)
 - New associations emerging
- New private sector partners
 - Ghana grains partnership
 - Unilever (Liptons) and smallholder tea growers



Common lessons

Enabling policy environments

- Incentives: Often needed to help establish social and technical infrastructure
 - WFP for Conservation Agriculture
 - Subsidies for fertilizers (eg Malawi)
 - Support for stone bunds, nursery trees, FFS
- Research, extension and incentives
 - Kenya NALEP
 - 20+ years of support to extension
 - 500,000 farmers reached per year
 - 7500 CIGs; many new enterprises
 - Malawi
 - Fertilizer subsidies
 - Surplus food production for country
 - Also 345 fertilizer fallows groups



Transformations are possible



Guatemala



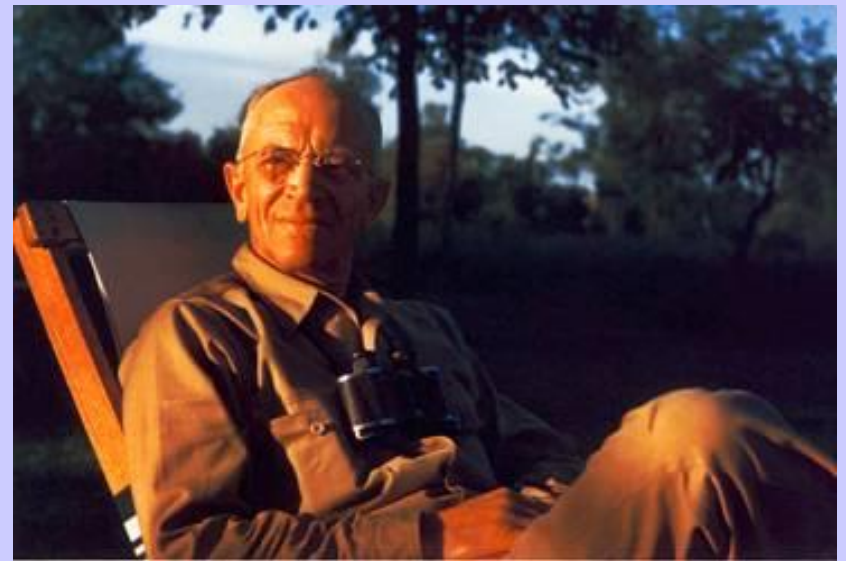
Kenya



India



Thinking like a mountain



- Aldo Leopold – Sand County Almanac (1949)
 - Idea of the Land Ethic
 - ***“We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect...”***
- This century – a new opportunity to transform consumption behaviour and landscapes?
- And maintain biodiversity and economy?
- And reduce hunger?
- Whilst producing enough food for all?

Thinking like a mountain



Transylvania, Romania



Priorities for 21st C

For all countries

- More food from same land without harming supply of ecosystem services
 - And with growing constraints on resource inputs
- Improve investments in science and technology for both genetic and agro-ecological/agronomic outcomes
 - “Both-and” narratives
- Find ways to scale up “successes”
- Improve delivery and engagement mechanisms
 - Better partnerships between disciplines, agencies and sectors
 - Increase investment in agricultural research and extension
- Focus on developing **innovative and adaptive** agricultural systems for 21st C



