How to Promote Sustainable Agriculture in Africa?

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Introduction

- My background in brief:
  - Background in crop science and economics
  - PhD-work on the evolution of farming systems in Zambia over the last 100 years and evaluation of the potential of agroforestry technologies
    - Key readings for all:
    - Ester Boserup (1965): The Conditions for Agricultural Change.
    - Hans Ruthenberg (1980): Farming Systems in the Tropics.

Comments to previous presentations

- My presentation is complementary
- Building on Mahmud's presentation
- Add a system perspective
  - Constraints vs. opportunities
- An incentive and policy perspective
- This implies that farm households who are the key decision-makers in agriculture are largely considered to be rational agents
  - Constrained optimizers
- Try to keep things simple
- Data and methods

What is sustainable agriculture?

- Diverse definitions of sustainable development …….
- A system perspective rather than technology perspective may be useful:
  - A specific technology, e.g. agroforestry trees may be part of a sustainable system in one setting or point in time and a part of a non-sustainable system in another setting or point in time.
  - E.g. Shifting cultivation was sustainable in Zambia when or where population density was still low.
  - Inorganic fertilizer may cause acidification and loss of land productivity in one setting but be essential for nutrient balances and sustaining productivity in another setting.

What is sustainable agriculture (SA)?

- Low-External Input Agriculture (LEISA)=SA?
- Move beyond the ”black-white” ideological debate!
- Put SA technologies under critical scientific assessment!
- Be careful with generalizations:
  - What works one place may not work another place.
  - Identify how robust specific technologies are to agro-climatic and other variation

Some of my experiences with SA

- Nitrogen-fixing plants are not efficient on very acid soils
- Agroforestry trees have limited potential as nutrient pumps on infertile soils (there is very little to pump and soils may get depleted even faster)
- Use of leguminous mulch may attract termites that kill your crops
- Poor people also often face scarcity of organic manure

Why the first Green Revolution failed in Africa

- Technologies not suitable for African agroclimatic conditions?
- Limitations of the CGIAR?
- Too little system focus? Too much crop focus?
- Too little location-specific adjustments in technologies?
- Ignorance of the importance of crop-livestock interactions?
- Too top-down research and extension systems?
- Policy distortions and other institutional constraints?
- Lack of infrastructure
- Land abundance in many countries

Paradigm shifts

- Green Revolution paradigm (TOT =transfer of technology)
  - Extension systems, e.g. Training and Visit system
- Farming Systems Research paradigm
  - Farm surveys + On farm experimentation
  - Farmer participatory research
  - Bottom – up approaches
  - Sustainable agriculture approaches

The Potential for a Sustainable Green Revolution in Africa

- Study farming systems and their potential
- Identify the constraints to improvements of the systems through farmers' adaptive behaviour
- Induced institutional and technological innovation is still required but needs to be combined with careful field studies
  - Collection of farm household survey data for analysis
    - Baseline + follow-up surveys for impact assessment
  - Experimental designs
  - Exploratory modelling (simple models)
  - Farmer participatory evaluation

Why do farmers degrade their environment 1?

- *Missing information:* The peasants are unaware of the (full) consequences of their land use practices and underestimate the severity of the problem or they are unaware of the existence of better technologies
- *Technology stagnation.* Peasants do not have access to appropriate technologies for intensifying land use and this may reduce their conservation efforts
- *Tenure insecurity*. Peasants are aware of the problem but their tenure insecurity leads to short planning horizons and reduced investment incentives

Why do farmers degrade their environment 2?

- *Collective action*. Much land degradation takes place on communal and state land and co-ordination problems undermine efforts to conserve these areas
- *Poverty.* People may be too poor to afford to invest in conservation (poverty-environment trap). Subsistence constraints may effectively reduce poor people's ability to invest (ATP) in conservation. Poverty may cause high discount rates and myopic behaviour
- *Rapid population growth.* Rapid population growth may lead to a lag in learning, technology and institutional adjustment, which may cause underinvestment in conservation

Why do farmers degrade their environment 3?

- *Market imperfections*. The lack of a land market may undermine the scarcity effect on the shadow value of land. Credit market imperfections in combination with poverty may lead to high discount rates and/or short planning horizons reducing incentives to invest in conservation
- *Policy distortions*. State interventions may have prevented the development of market and non-market institutions, which could have stimulated conservation activities
- *Transaction costs and asymmetric information*. Transaction costs and asymmetric information cause pervasive market imperfections which are particularly severe in remote marginal areas. This may be seen as an underlying cause of several of the other hypotheses stated above.
- *Power structures* may prevent the development of efficient institutions.
- *Political and social instability* may affect several of the hypotheses listed as they exacerbate or cause tenure insecurity, market imperfections and poverty

Institutional Arrangements to Stimulate Incentives for Conservation 1

- *Agricultural research and extension.* Without government intervention there will be underinvestment in technology generation and dissemination. Access to improved technologies and new knowledge may increase incentives to conserve land.
- *Land tenure policies.* Improvement of tenure security will improve conservation incentives.
- *Decentralization of power and stimulation of local collective action.* Local participation in planning, monitoring and enforcement of conservation efforts is likely to increase incentives.
- *Family planning and population control*. Reduction of population growth may reduce the need for other forms of interventions.
- *Poverty-reducing policies.* These may improve peasants' ability and willingness to pay for conservation.
- *Improvement of the functioning of markets.* Infrastructure investments and removal of distorting regulations may improve the functioning of markets and strengthen incentives to conserve land.

Institutional Arrangements to Stimulate Incentives for Conservation 2

- *Inter-linkage of markets, technologies and conservation investment.* By making access to credit and yield-enhancing technologies conditional on conservation investments, incentives for conservation may be increased. FFW targeted to investment in conservation has higher probability of success if properly combined with local participation in planning, monitoring and enforcement.
- *Pigouvian taxes and subsidies* Taxes on degrading inputs and subsidies on conserving inputs may be specified to mitigate the land degradation problem. A rise in the profitability of less erosive crops relative to more erosive crops can, for example, be expected to encourage soil-conserving crop choices and cropping patterns.
- *Payment for Environmental Services* to establish markets where their non-existence created negative environmental externalities.
- *Direct regulation* may be used when local incentives for conservation are insufficient or lacking and monitoring and enforcement costs are not too high. Direct protection, rehabilitation, conservation, setting of technology and land use standards are instruments which may be relevant.

Example:
Green Revolution for Highlands of Ethiopia

Constraints and Opportunities

Introduction

- Traditional Crop-Livestock system
  - Constraints:
    - Low and declining crop productivity
    - Low livestock productivity
    - Limited availability of organic fertilizer of good quality
    - Food insecurity due to frequent droughts
    - Poor market access
    - Low cash income
    - Free roaming animals
    - Dependence on oxen for tillage
    - High and increasing population pressure

Promising technologies?

- Crossbred cows
- Improved fodder crops /intercropping
- Minimum tillage
- Zero-grazing / Cut and carry feeding
- Improved maize and fertilizer
- Irrigation
- Soil conservation
- Tree planting

Need for technology packages?

- Constraints to adoption of individual technologies
- Technology packages may be necessary to reduce the number of constraints
  - E.g. Crossbred cows in combination with improved fodder and minimum tillage, if successfully introduced, can make a big difference, while each component may fail

What are the constraints to technology adoption?

- Lack of information about new technologies?
- Low profitability of individual technologies?
  - Low short-term benefits?
- Labour constraints?
- Cash constraints?
  - Lack of access to credit?
- Poor market access?
- Collective action problem related to control of free roaming animals?

How to stimulate adoption?

- Extension service
- Technology packages
- Credit in kind (e.g. for crossbred cows)
- Pilot projects (experiments)
  - Especially when technology ”jumps” are needed
  - Local participation / collective action important
- Technology-policy linkages
  - E.g. Food-for-work for treeplanting/SWC/road building
- Land certification to enhance tenure security
- Land laws against land-degrading practices
- Stimulate local collective action
  - Local Land Administration Committees

A quick ”back of the envelope”-analysis

- Identification of key constraints in existing farming systems
- Identification of relevant alternative technologies that may help to improve the system
- Matrix of constraints vs. Technology traits that may address the constraints
- Assess a combination of technologies and institutional support policies that can remedy multiple constraints
  - New components may involve new constraints
- An example follows:

Potential for a Green Revolution in the Ethiopian Highlands 1?

Constraints	**Baseline: Traditional crop-livestock system with oxen-cultivation**	**New technology: Crossbred cows**	**New technology: Improved fodder species/ intercropping**	**New technology: Minimum tillage**
Low crop productivity	X	X	→+	X
Land degradation	X	X	→+	→+
Low livestock productivity	X	→++	→+	
Vulnerable to drought	X	X	?	?
Low food production	X	→+	→+	X
Low cash income	X	→++		
Require market access		X		
Fodder shortage (seasonal)	X	X	→++	→++
Poor utilization of fodder	X	X	X	
Poor fodder quality	X	X	→+++	
Free roaming animals	X			
Oxen for ploughing required	X	X?	X	→++
Require herbicides or new tools				X
Require change of crops				X?
Labour demanding				
Require zero-grazing				
Require access to seeds/seedlings			X	
Require better veterinary service		X		

Potential for a Green Revolution in the Ethiopian Highlands 2?

Constraints	**New technology: Cut-and-carry animal feeding**	**New technology: Fodder trees**	**New technology: Tree planting (eucalyptus)**	**New technology: Maize+fertilizer**	**New technology: Urea treated fodder**
Low crop productivity	X	X	X	→+++	
Low livestock productivity	→+	→+	X	→+	→+
Vulnerable to drought	X	X	X	X	
Low food production	X	X	X	→++	
Low cash income			→++	→+	X
Require market access			X	X	
Fodder shortage (seasonal)	→++	→+	X		X
Poor utilization of fodder	→++		X		→+
Poor fodder quality	→+	→++			→++
Free roaming animals	X	X			
Oxen for ploughing required	X	X		X	
Require herbicides or new tools					
Require change of crops				X?	
Labour demanding	X	X			
Require zero-grazing		X			
Require access to seeds/seedlings		X	X	X	
Require change in food habits				X?	
Require secure tenure rights			X		

Potential for a Green Revolution in the Ethiopian Highlands 3?

Constraints	**New technology: Crossbred cows for traction**	**New technology: Irrigation**	**New technology: SWC**	**Combination: SWC+ tree planting**	**Combination: Crossbred cows+ imp.fodder intercropping**
Low crop productivity	X	→+	→+?	→+?	→+
Land degradation		→+	→++	→++	→+
Low livestock productivity	→++				→++
Vulnerable to drought	X	→++	→+	→+	→+
Low food production		→+	→+	→+	→+
Low cash income	→+	→+		→++	→++
Require market access	X	X		X	X
Fodder shortage (seasonal)	X				→++
Poor utilization of fodder					
Poor fodder quality	X				→+
Free roaming animals					X
Oxen for ploughing required	→+++				X
Require herbicides or new tools					
Require change of crops		?			
Labour demanding		X	X	X	
Require zero-grazing					
Require access to seeds/seedlings		X			X
Require change in food habits					
Require secure tenure rights				X	
Require better veterinary service	X				X

Potential for a Green Revolution in the Ethiopian Highlands 3?

Constraints	**Combination: Crossbred cows, improved fodder, min. tillage**	?	?	?	?
Low crop productivity	→++				
Land degradation	→+				
Low livestock productivity	→++				
Vulnerable to drought	→+				
Low food production	→++				
Low cash income	→++				
Require market access	X				
Fodder shortage (seasonal)	→+++				
Poor utilization of fodder					
Poor fodder quality	→++				
Free roaming animals	X				
Oxen for ploughing required	→++				
Require herbicides or new tools	X				
Require change of crops	X				
Labour demanding					
Require zero-grazing					
Require access to seeds/seedlings	X				
Require change in food habits					
Require secure tenure rights					
Require better veterinary service	X				

More serious bio-economic modelling

- Simple models for initial technology and policy assessments
- More complex models for more complex issues:
  - Dynamic models
  - Stochastic models
  - General equilibrium models
  - Spatial models
  - Agent models vs. System models vs. Economy-wide models
  - Biophysical vs. Micro-level vs. Meso-level vs. Macro-level economic models

Conclusion

- A lot of opportunities for improvement in technologies, knowledge, and policies
- Many organisational challenges
- This workshop may help to bridge the gap between those who have useful knowledge that can help to alleviate constraints and those who sit on the funds but do not always know how best to use the funds
- Long-term projects and long-term engagement of researchers