Report of the Wageningen UR Expert Workshop on

Sustainable Agricultural Intensification in Sub Sahara Africa

Wageningen, May 25 2011

This workshop was organised as part of the Wageningen UR Project BO-CI Sustainable Production Limits: intensification without degradation (BO-10-011-012)

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Participants

Participants from the Dutch Government
Mr Pieter Vaandrager - Ministry of Economic Affairs, Agriculture and Innovation, Directorate of International Affairs, Cluster Policy & Strategy
Mr Paulus Verschuren - Ministry of Foreign Affairs, Member of the Task Team on Food Security
Mr Henk Eggink - Ministry of Economic Affairs, Agriculture and Innovation, Directorate of International Affairs, Dept. Advice & Coordination

Experts from Wageningen UR
Natural resources domain
Mrs Christy van Beek (Soil Science Centre – Alterra) – soil fertility specialist
Mr Kees van Diepen (Centre for Geo Information-Alterra) – agro-environmental modelling specialist
Mr Don Jansen (Plant Research International - Agrosystems) – agronomist specialized in coffee and rice systems
Mr Holger Meinke - Director of the Tasmanian Institute of Agricultural Research (TIAR) and Head of the School of Agricultural Science at the University of Tasmania (UTAS), Australia, crop and weed ecologist (written contribution)
Mr Rudy Rabbinge (Wageningen University) – Professor of the Chair Sustainable development and Food security, Member of the Task Team Food Security
Mr Koen Roest (Centre for Water & Climate - Alterra) – agro-hydrological specialist

Economic domain
Mrs Petra Hellegers (LEI) – agricultural economist, specialized in water

Social-institutional domain
Mr Wim Andriesse (Wageningen International) – international cooperation, governance
Mr Ruud Ludemann (Centre for Development Innovation) - human resource development for institutional strengthening

Participants from the project team
Christy van Beek (Alterra)
Sjaak Conijn (Plant Research International)
Jochen Froebrich (Alterra)
Annemarie Groot (Alterra)
Herco Jansen (Alterra)
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Harmen van Oosten (Van Hall-Larenstein)
Simone Verzandvoort (Alterra)

Contents

1 Presentation by Prof. Rudy Rabbinge: Promise, potential and limitations of African agriculture

Prof Rabbinge's presentation addressed megatrends in global agriculture, global food security till present, causes for Africa's backlog appearing from the IAC study (2004)[1], and a possible way forward. The IAC report was written in response to the request of the Secretary-General of the United Nations to the InterAcademy Council (IAC) to prepare a strategic plan for harnessing the best science and technology to increase the productivity of agriculture in Africa.

Prof Rabbinge distinguished 6 megatrends in the global development of agriculture in the past decennia: 1. Increase of productivity, 2. From adaptive agriculture (to environment) to maximum control (fertilizers, pesticides, irrigation), 3. Integration of chains, 4. Multiple objectives of agriculture (environmental friendly, animal friendly, landscape, health care, tourism), 5. Connection to health, 6. Interactive knowledge model (science, policy & industry).

The green revolution has multiplied the productivity of rice, wheat and maize, which at the time were not the major crops produced in Africa. The continent figures a wide diversity in crops and agricultural production systems. Most of the global production is marketed at local and regional levels, and does not enter the global market.

80% of the increased production in the Green Revolution has been obtained by intensification of agriculture, whereas only 20% was obtained by employing new agricultural land. Food shortage in developing countries is relatively highest in Africa. In absolute numbers Africa has more people suffering from hunger than Asia. Currently developments in agriculture are targeted to fine tune production of rice, maize and wheat. Wageningen UR has an important role in this process.

The large problems in Africa as identified by the IAC report are:

- The lack of scientists and research, hampering innovation
- The lack of investments in land, resulting from insecure land tenure
- Decreasing development aid from western countries
- Weak governments and policy forming communities

The IAC report recommended breaking through the process of unsustainable developments in agriculture by increasing external inputs. This recommendation needs to be tuned to crops and systems in Africa. The AGRA[2] Program results from this recommendation.

Questions from participants

Q: Did the IAC study address water productivity?
A: Yes, although water productivity is only partly relevant, because only 20% of the agricultural production systems in Africa are irrigated. Supplemented irrigation however may have potential. Water productivity is part of the AGRA program.

Q: what about foreign investments in Sub-Saharan Africa?
A: These have been limited, and concentrated in the countries which actively stimulate agriculture in the past 4 years (e.g. Ethiopia, Kenya).

Q: why a Green Revolution for Africa if sufficient food can be produced in the continent?
A: Two arguments: 1. every economic development starts with a development of agriculture (with exceptions like Hong Kong, Singapore, Taiwan), 2. Africa has a large potential that is insufficiently used. We would rather speak of a Rainbow Revolution in multiple sectors.

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[1] IAC (2004). Realizing the Promise and Potential of African Agriculture— Science and Technology to Improve Food Security and Agricultural Productivity in Africa.

2 Alliance for a Green Revolution in Africa (www.agra-alliance.org)

Q: what is your view on the importance of governance structures?
A: these certainly matter among the basic pillars of research, education and ultimate users. Current developments focus on cooperation with farmers in networks like Farmer Field Schools.

Mr Rabbinge's presentation is included in the Appendix (chapter 8).

2 Perspective on agricultural intensification by the Ministry of EL&I by Pieter Vaandrager

The subject food security is politically sensitive at the moment. Yet, the G20 council on food security is regarded as influential by the EU. Agricultural production and its increase are top priorities. The Ministry of EL&I would like to know if more data and projections are needed to evaluate potential food production, in response to the proposed set-up of a data collecting organisation in the G20 (by the French government).

The Ministry of EL&I considers knowledge development and transfer as important ways to revers unsustainable trends in agricultural production. The Ministry would rather focus on increasing agricultural production and development, instead of considering environmental limits or constraints. The present BO-CI project should contribute to the knowledge required to argument this course.

3 Perspective on agricultural intensification by the Ministry of Foreign Affairs by Paulus Verschuren

Mr Paulus Verschuren Is member of the Task Team on Food Security (initiated by the Dutch government in December 2010), and special advisor for the involvement of industry and business in development cooperation. The Dutch ambitions of the government are to deploy particularly in water management and agro-technology. The objective of the Task Team is to increase the return on investment of development cooperation by cooperation with the industry and business sectors, thereby reshaping development aid. The current political climate does not favour large investments in development cooperation. The Task Team strives to revert this view on development cooperation by obtaining tangible and fast results by internal cooperation between Ministries and with the industry and business sector. The major objective is to fuel economic development through agricultural development. Core ambitions include:

- To increase awareness of the important role of industry and business in development cooperation within the Ministry of Foreign Affairs;
- To get companies involved in cooperation networks, and willing to invest in developing countries
- To develop modules and mechanisms to show that cooperation networks with industry and business stimulate economic development in developing countries;
- To demonstrate to the Dutch society that the new view to development cooperation yields results

The working method of the Task Team consists of cooperation networks, also in agriculture. This requires a chained approach. The main lines of action are:

- Involvement of the industry and business sector
- Speeding up results in obtaining food security
- Realise economic self-manageability in target countries
- Emphasize production and consumption, food and nutrition
- Connecting markets
- Counteracting micronutrient deficiencies by improving access to improved food

The Task Team selected 6 countries for its program, with contexts differing sufficiently to enable upscaling of strategies to other developing countries. The design and execution of the programs is coordinated by the Dutch embassies in the 6 countries. The role of the Dutch government and employed research is to inform the activities in the programs. The programs are designed at the local level in cooperation with industry and business. 6 strategic missions to the target countries are currently ongoing. Wageningen UR facilitates these missions by providing knowledge required by the Ministries and embassies for choices in development cooperation programs. The Task Team will provide a plan to the Dutch Parliament with the ambitions and choices the Task Team proposes for development cooperation to be supported by the Dutch government.

Mr Verschuren expresses the demand to the BO-CI project to advice on *how* to select issues on which agricultural development should focus.

Questions from participants

Q: how does the Task Team integrate activities of other countries and programs?
A: preferably the Task Team would do this together with the European Union, but this is still too early. The role of the embassies is to make good situational analyses of the target countries together with the industry and business sectors and other organisations. The number of parties involved in the cooperation networks should be small enough to make the networks effective. The selection of parties, program elements, capital and commitment must be provided by the target countries.

Q: institutional and political processes are slow. Is the agenda of the Task Team tuned to that pace?
A: the Task Team should demonstrate that processes of economic development may run at a higher speed. This requires a political 'buy-in'. Therefore there are many contacts with the political field in the countries concerned. Agricultural production and food security have since long not figured on political agendas, and should return to these now.

4 Presentations on approaches to agricultural intensification by experts from Wageningen UR

Eight experts from different disciplines provided contributions to the workshop in the form of research cases on situations in which different forms of agricultural intensification or development were studied. The cases are described in detail in the Appendix (chapter 8), and were briefly presented in the workshop.

Kees van Diepen (Alterra - Centre for GeoInformation)
Agro-production systems may be characterised by input-output relationships. Input may consist of energy or costs; output of biomass, harvest or value. Production functions are usually lower in less favoured areas. Agro-production systems in Africa often have low external inputs (LEI) and low outputs (LO) (Figure 4-1). Roads to higher output may be reached by increasing external inputs.

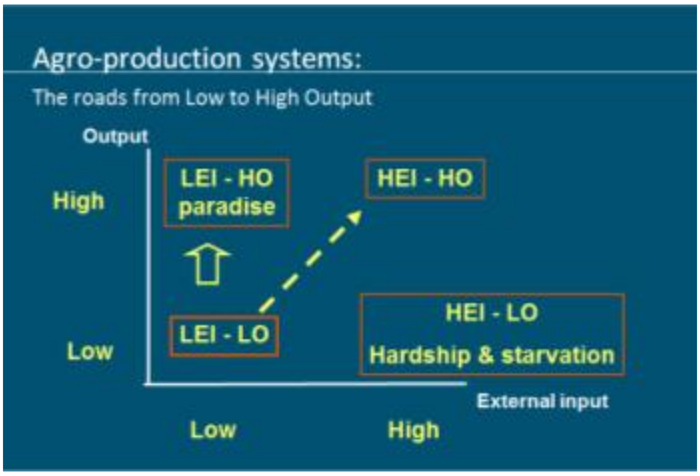


Figure 4-1 Conceptual illustration of production functions. Source: Kees van Diepen.

Often neglected requirements to increase external inputs are secured land tenure and access to water and land. In African systems, farmers often do not know if they will have access to land in the next year. Conflicts between pastoralists and farmers often result from insecure land tenure. This situation partly causes low investments in agriculture.

Don Jansen (Plant Research International and program leader of the Douwe Egberts Foundation)
In the research case on coffee production in Cameroun farmers were stimulated to work in groups (e.g. Farmer Field Schools) and to perform record keeping of inputs and outputs of their enterprises. Labour is an issue in

Cameroun, rather than the availability of land. This implies that income per unit of labour is important. Farmers move to towns to obtain additional income.

The record keeping results in operational balances of inputs and outputs, that may provide insight in what happens to inputs (e.g. nitrogen), and can be used to stimulate farmers to get balances positive. Farmers often have loans and are charged taxes. Benefits of enterprises should be optimised against operational costs.

The method of record keeping implies the recording of any activity of farmers on their land. The method is generic, and can be used in learning processes, and also to motivate farmers to adapt management strategies. The quality of the data is monitored, and feedback given to results. Record keeping is used both for physical and economic inputs and outputs.

Connection to markets is extremely important to sustain the agricultural enterprises in the area. Therefore cooperation with large external export firms is vital for these agricultural production systems. This was demonstrated in the research case.

Petra Hellegers (Agricultural Economics Institute)
The research case addressed impacts of recent private investments in irrigated horticulture and floriculture in the Central Rift Valley in Ethiopia on water availability. Water use by rose growers competed with water use by the population. The value of water appeared to differ considerably between uses (e.g. rose growing versus irrigated agriculture). This calls for a reconsideration of the recommendation to use water for local purposes, propagated by many NGOs in the area. Environmental requirements for the sustainable use of water in the area required that extraction and recharge are balanced. On the economic side costs and benefits should be balanced to guarantee economic sustainability.

Christy van Beek (Alterra-Soil Science Centre)
Christy presented a multi-facetted starting point of view to developing agriculture in small holder systems, necessary because of the numerous interactions in small holder systems compared to specialized enterprises. The research case employed the monitoring tool MonQI toolbox to two different smallholder systems in Kenya. MonQI is a registration system for farm management shared between land users. The force of the system is its quantitative nature; numbers on inputs and outputs can be used to provide tangible insight into the farm management and its consequences (e.g. if 30% of the harvest appears to be lost due to soil erosion), and also of scenarios of different farm management. The shared use is based on anonymous data input by farmers and land users. The MonQI toolbox has proved capable to support shifts in farm management towards improved agricultural production in various countries.

Koen Roest (Alterra-Centre for Water and Climate)
The two research cases presented were executed for the Dutch Ministry of Foreign Affairs and the World Bank for the assessment of drainage projects in Egypt. In the research case, 10% of the improved agricultural production appeared to be sufficient to cover the costs of the drainage intervention. In the second case subsidies for the production of wheat were removed to stimulate agricultural production.

In Egypt currently a new form of agriculture is developed in the desert, featuring successful companies growing strawberries and tomatoes with a high return on investment of water. The challenge for Egypt is how to develop the drainage-based, small-scale agriculture in the Nile valley. One way would be to connect both types of agriculture to Metropolitan Food Clusters, e.g. through agro-parks and contract-based production. Another way would be a sort of 'organic' innovation through the growth of the agricultural sector in the Nile Delta in possibly other types (e.g. greenhouses), in response to the expected decrease of water availability due to the dam on the border between Egypt and Sudan. Egypt should better not invest in its own wheat production, but import wheat from Eastern Europe. The return on water should be increased in order to increase employment at the local level.

Wim Andriesse (Wageningen International)
Wim Andriesse presented a review of the research cases presented by the other experts from a socio-institutional perspective on sustainability. Some points were highlighted with regard to the availability of inputs. A bottle-neck for recommendations on the use of fertiliser is the potential to get fertiliser on the right place on the right moment. The same applies to seed. Interventions to increase agricultural production from

local project settings (bottom-up) are often more difficult to operationalize than top-down interventions, but more effective. Another difficult topic is how to employ locally acquired knowledge in upscaling agricultural enterprises. Governments should have a 'lever' function here in service provision, for example by making fertiliser available. Quality control on inputs could be realised by the private sector.

5 Brainstorm session on assessment of sustainable agricultural intensification

Starting questions for the brainstorm were:

1. How can we assess if a development for agricultural intensification will be sustainable from an economic, environmental and socio-institutional point of view? Which indicators of sustainability should we use?
2. Which role could the private sector play in sustainable agricultural intensification?

Plots of indicators of sustainability, derived from the expert contributions, were used to start the discussion on point 1. Group participants were asked to comment on these, and to identify missing indicators or issues.

Group1: economic benefits en social-institutional aspects of sustainable agricultural intensification

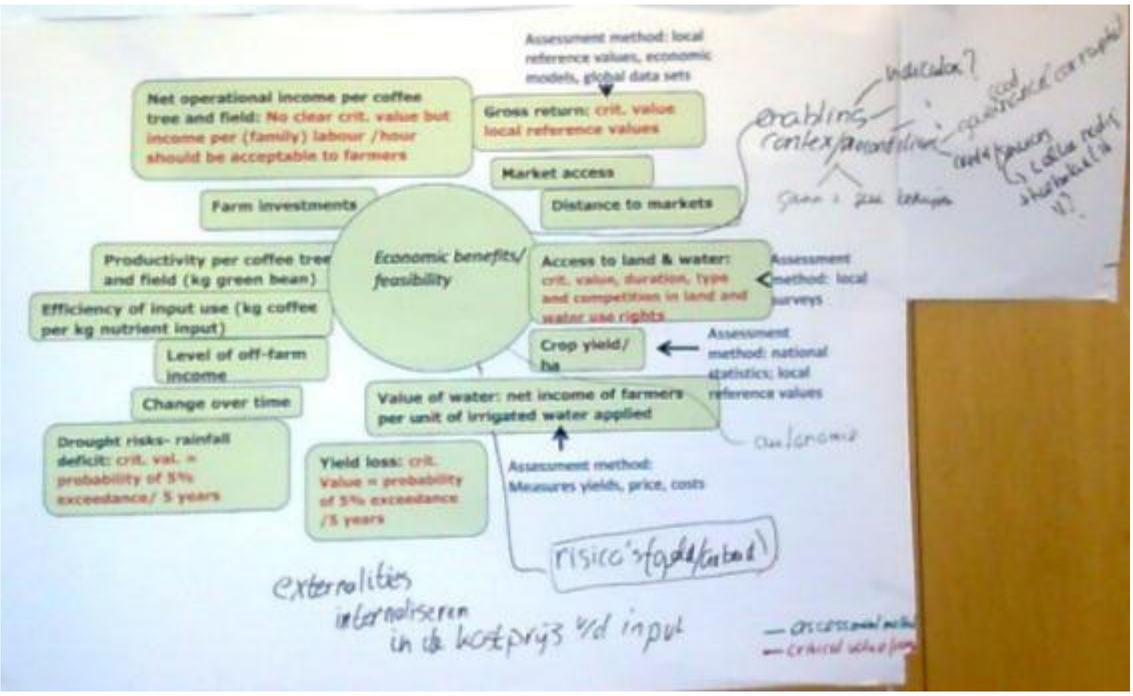


Figure 5-1 Plot of indicators for economic benefit and feasibility, critical values and methods for assessment derived from expert contributions, and comments made during the brainstorm.

Sustainable intensification of agriculture in Africa is not possible without an **enabling environment** (good governance, no corruption, credit facilities, availability of supporting services, etc.). This applies to the government and the private sector. Activities should be conducted within an enabling environment or be aimed at creating/promoting an enabling environment, for example support to services. In supporting/creating services the (future) financial sustainability of these services is critical.

Sustainability can be promoted by incorporating externalities of agricultural development (through legislation). By internalising externalities water- and air pollution, water consumption, CO2 emissions, loss of biodiversity, etc. can be reduced/minimized through regulating economic mechanisms. Activities that promote the internalising of externalities should, therefore, be promoted. It is important that the internalising of externalities should consider the various system levels (local, e.g. smell, deterioration of landscape; catchment, e.g. water depletion and pollution; regional, e.g. air pollution, wildlife; global, e.g. biodiversity, greenhouse gasses).

Sustainable intensification of agriculture should consider the spatio-temporal relationships, for example negative downstream impacts of upstream activities, which require a holistic approach. Interventions and activities that consider nested subsystems should, therefore, be promoted.

It was acknowledged that it is not possible to link (merely) economic indicators to sustainability. For example extreme high water productivity does not automatically imply (economic) sustainability.

It was also acknowledged that the economic component of sustainability is very subject to variability: A profitable system which is in perfect balance with the biophysical environment may not be profitable (economically sustainable) anymore within short notice and vice versa. The critical levels of economic indicators will vary largely over time. Economic indicators can, however, help to discriminate between the relative levels of sustainability (more or less sustainable or more or less unsustainable).

To consider and anticipate trends intensification of agriculture should consider the time perspective to ensure future sustainability. Activities that promote adaptive capacity and entrepreneurship aimed at ensuring future sustainability should be promoted.

For a number of biophysical indicators critical levels can be defined. These critical levels should be considered in any activity/intervention.

The concept of sustainability should be more related to people: It is the people that should also indicate whether an intervention/activity is desirable or possible.

Sustainable intensification of agriculture in Africa will require diversification, innovation and more large-scale market- and export oriented production, which will imply that small farmers gradually abandon the agricultural sector. Activities that promote alternative livelihoods for farmers should be promoted.

Activities / interventions that promote autonomy of the target groups should be promoted. Motivation, trust, accountability mechanisms and capacity to deal with power positions are important components of autonomy.

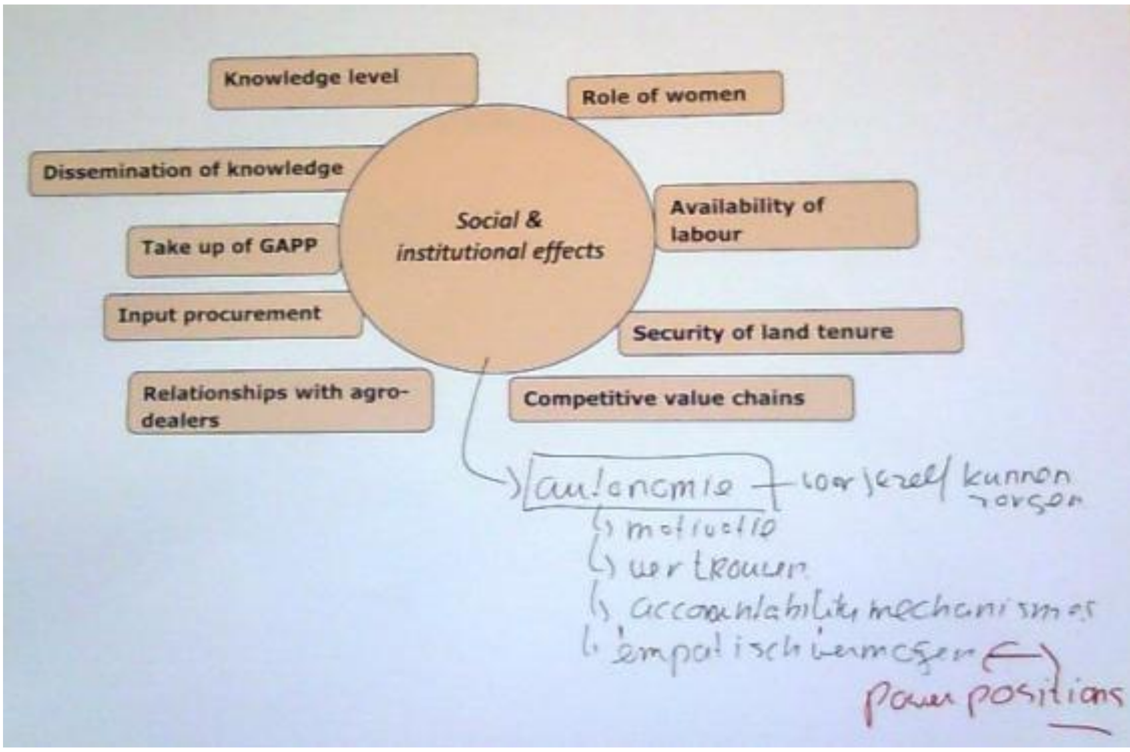


Figure 5-2 Plot of indicators for social and institutional effects, critical values and methods for assessment derived from expert contributions, and comments made during the brainstorm.

Group 2: natural resources en social-institutional aspects of sustainable agricultural intensification

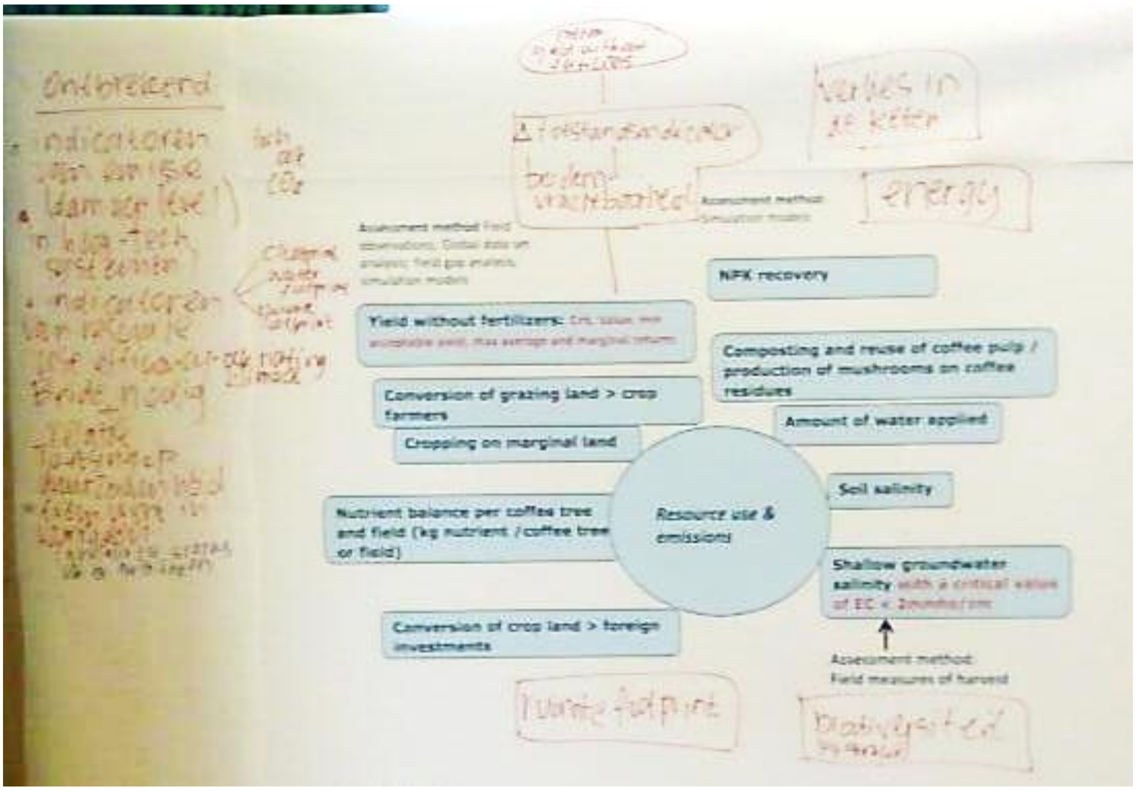


Figure 5-3 Plot of indicators for resource use and emissions, critical values and methods for assessment derived from expert contributions, and comments made during the brainstorm.

Issues identified as missing in the overview of indicators included:

- Emissions (a.o. greenhouse gases), and options to reuse these (e.g. agricultural waste as feedstock)
- The state of the agro-ecosystem (e.g. saline soil, water scarce area) and trends (e.g. soil nutrient depletion, desertification)
- efficiency of resource use expressed in 3 modes:
  - absolute difference (absolute extra or less input required to obtain a certain yield)
  - relative difference (relative extra or less input required to obtain a certain yield)
  - definition of sustainable efficiency

The sustainability of resource use and emission can be assessed by using the foot print of a certain enterprise or sector on different themes. Foot prints can be expressed relative to resources or domains of water, social capital, space (including biodiversity, and indirect land use change (ILUC)) and climate.

For the project's objective to design an outline for a tool to assess the sustainability of interventions in agriculture, the group proposed to construct a decision tree, which enables a consideration of locations, scale levels, options and constraints for interventions. The instrument should have the following characteristics according to the group:

- capable to support the full trajectory in a sustainability assessment of information demand, analysis, implementation and feedback
- capable to enable quick assessments, because the private sector and governments usually have little time for sustainability assessments preceding an intended intervention
- should include the sustainability aspect of 'process' next to 'profit', 'people' and 'planet'
- applicable to agro-chains ('from substrate to consumer')
- applicable to interventions addressing the dairy sector

The group identified the following key elements required to construct the outlined instrument:

- generic data on characteristics (or indicators) of sustainability criteria. The group considers that currently available datasets (at various scale levels) are sufficient to provide for generic data, and therefore that a global agency for data acquisition, as discussed in the G20, would not be required.
- close cooperation with the private sector
- knowledge on natural resources (soil, water), sustainability issues, agro logistics

6 Recommendations for a tool to assess sustainable intensification

The results from the expert presentations and brainstorm discussion were synthesised in general recommendations for an outline of the tool for assessing sustainable intensification in Sub-Saharan Africa, to be developed in the BO-CI project.

1. For the general shape of the tool a sustainability test is recommended (e.g. in the form of a hierarchical decision tree, measuring rule or 'code of good conduct'). The tool should enable quick and approximate assessments of the sustainability of an intended agricultural development with regard to the aspects profit (or productivity), people, planet and process.

2. The tool should be applicable at various scales (farm/household, community/market, region).

3. The tool should enable the formulation of options to adapt strategies. These could be alternative strategies with different land use or (more vital) sectors involved in the strategy.

4. The tool should deploy a diagnosis of the unsustainable situation in an agro-production system or part of the agro-production chain.

5. The private sector should be involved in either the design of the tool.[3]

6. The tool should use existing indicators to describe sustainability criteria. The novelty in the tool would be to provide advise on how to value or measure these indicators, and to indicate at which scale levels the indicators should be used.

7. Critical values of indicators should be used in the tool where available and applicable.

8. The tool should present outcomes carrying a potential politically sensitivity for actors in a neutral way.

7 Feedback received from participants after the workshop

Henk Eggink sent information on sustainability indicators for bio-energy as agreed by the Global Bio Energy Partnership (www.globalbioenergy.org/news0/detail/en/news/79357/icode/)

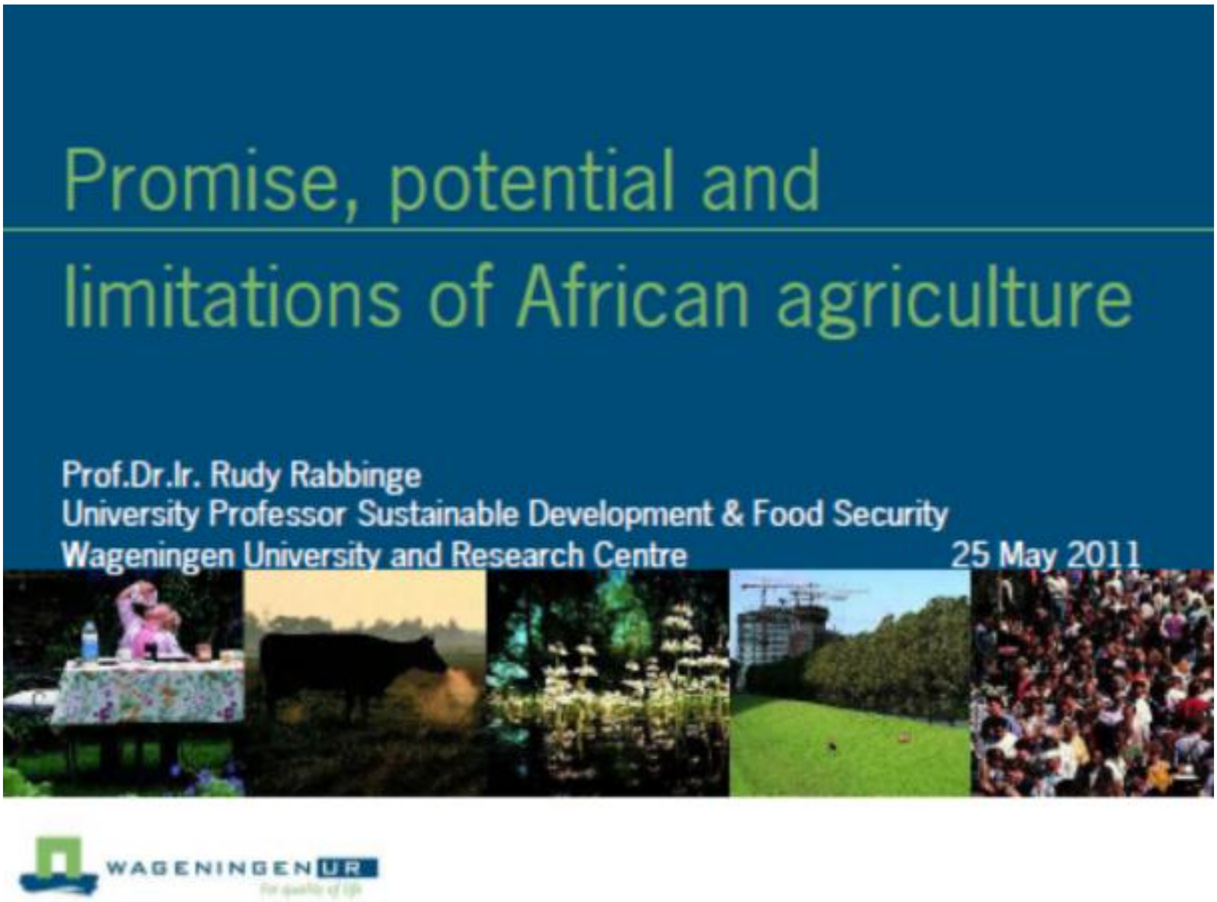
Pieter Vaandrager suggested to consider tools developed in sustainability initiatives addressing land grab, in Corporate Social Responsibility[4], the Dutch Trade Initiative (IDH), and in the Round Tables on the production of agricultural commodities.

[3] Cooperation with the private sector is not formulated in the current BO-CI project, but feedback on the tool outline can be asked from several selected companies. The project team will investigate this option in the project activity to organise feedback from mulit-stakeholder platforms..

[4] Maatschappelijk Verantwoord Ondernemen (NL)

8 Appendix – Contributions from Wageningen UR experts

8.1 Contribution from Mr Rudy Rabbinge - University Professor Sustainable Development & Food Security, Wageningen UR



Rijksoverheid

Content of this presentation

- Megatrends in agriculture
- Global food security till present
- Why is Africa lagging behind (IAC study)
- A way forward

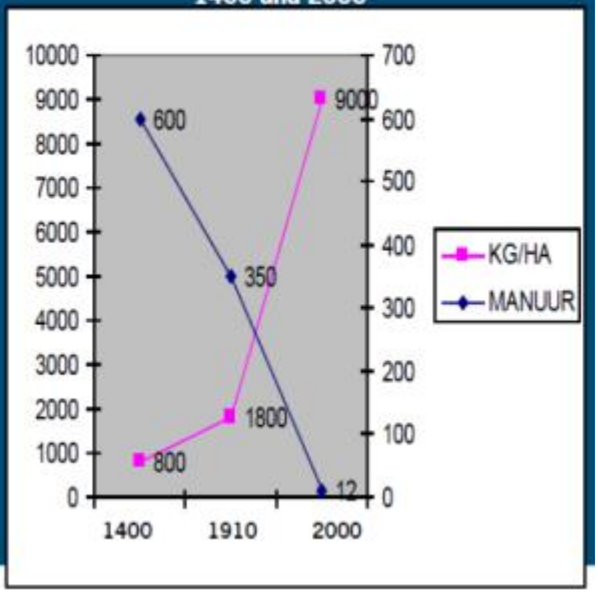
…Megatrends in agriculture…

Rijksoverheid

Megatrends (1) Productivity increase

- Land productivity
  x 5 - 6
- Labour productivity
  x 200 - 300
- Energy & other inputs
  x 2 - 4

Cereal production in the Netherlands between 1400 and 2000



Megatrends (2) From skillfulness to industrialization

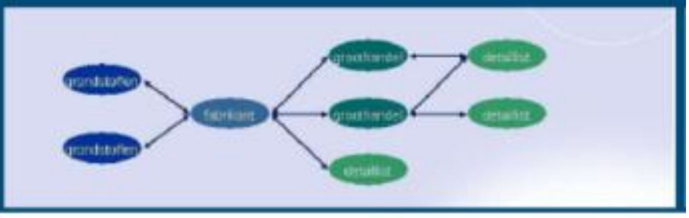
- From adaptive (adapt to environment) to maximum controle (fertilizer, pesticides, irrigation)
- Introduction of agriculture that is not bound to land

greenhouses
substrate cultivation

- High added value!!

Megatrends (3) Integration of chains

- From field to fork
- Chain reversal: consumer (or retail) dictates
- Quality, food safety, convenience food, etc.
- Efficiency in logistics (on time delivery), low cost
- Added value in different links in the chain → cumulative



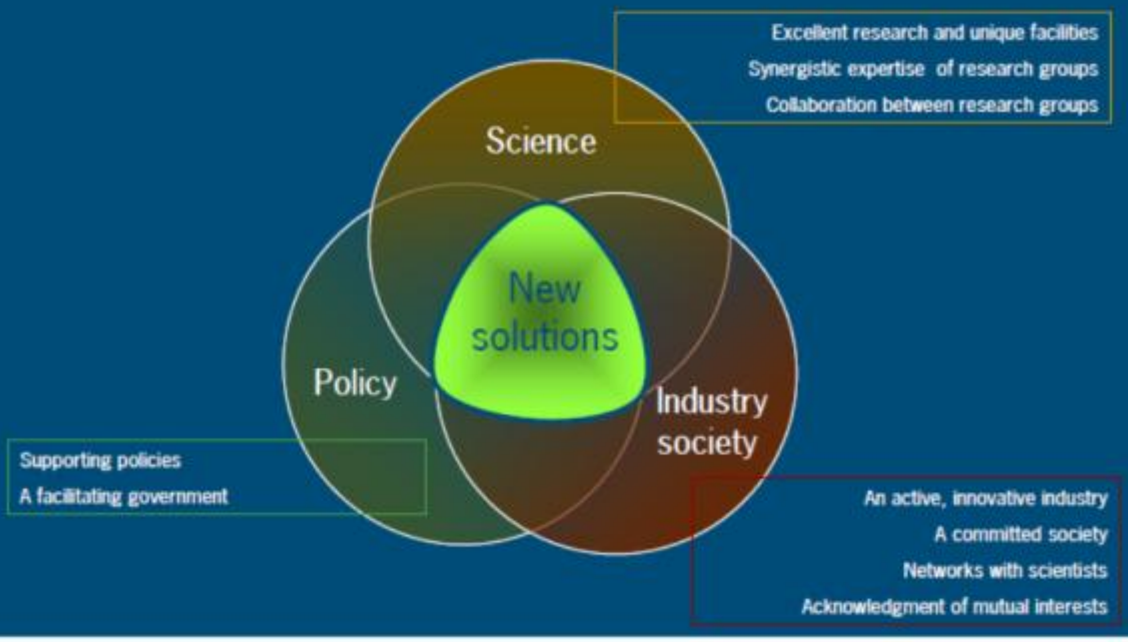
Megatrends (4) Multiple objectives

- Environmental friendly
  - no pollution
  - no waste
- Animal friendly
- Landscape
- Care farms
- Tourism

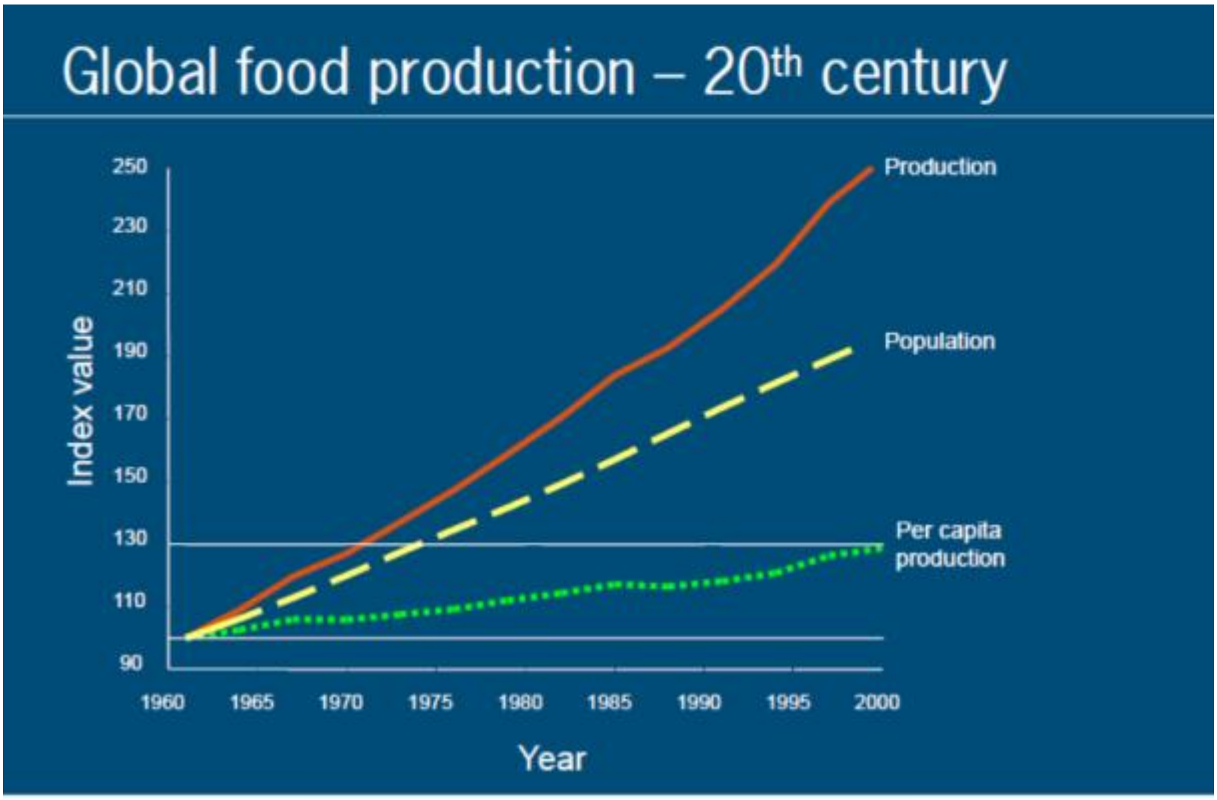
Megatrends (5) Connection to health

- Vegetables, fruit and fish are beneficial for health
- Health promoting components in food through choices in seeds, cultivation methods and processing: micronutrients, omega fatty acids
- Good Agricultural Practices: primary produce free of residues (nitrate, pesticides)
- Food safety: tracking and tracing (BSE, dioxine)

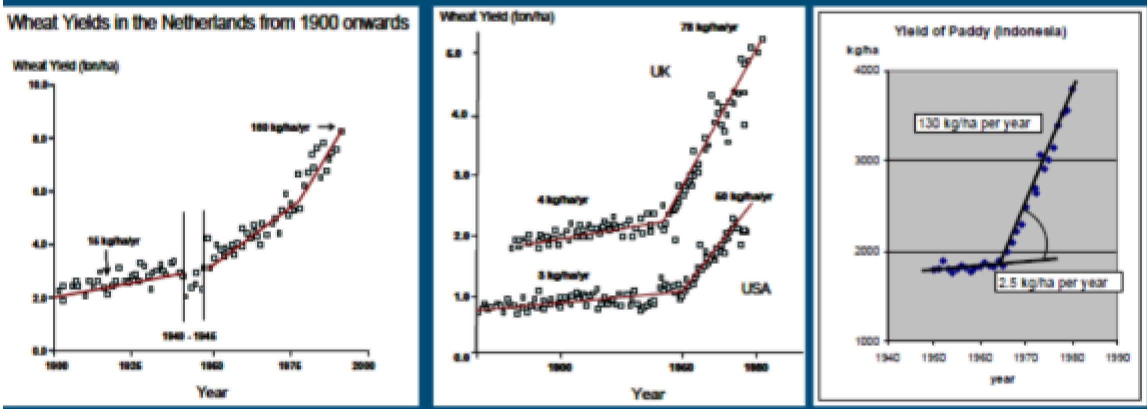
Megatrend (6): An interactive knowledge model




…Global Food Security …


Global food production – 20th century
Index value
250
230
210
190
170
150
130
110
90
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year
Production
Population
Per capita
production

Discontinuities in production trends



Green revolutions

Green revolutions

- Production ecological principles→ towards potential production
  - integrated soil and water management
  - control of pests, diseases and weeds
- Plant breeding →short straw varieties (harvest index increased) → higher proportion harvestable product
- Presence of functioning institutions
- Political will
- Functioning markets

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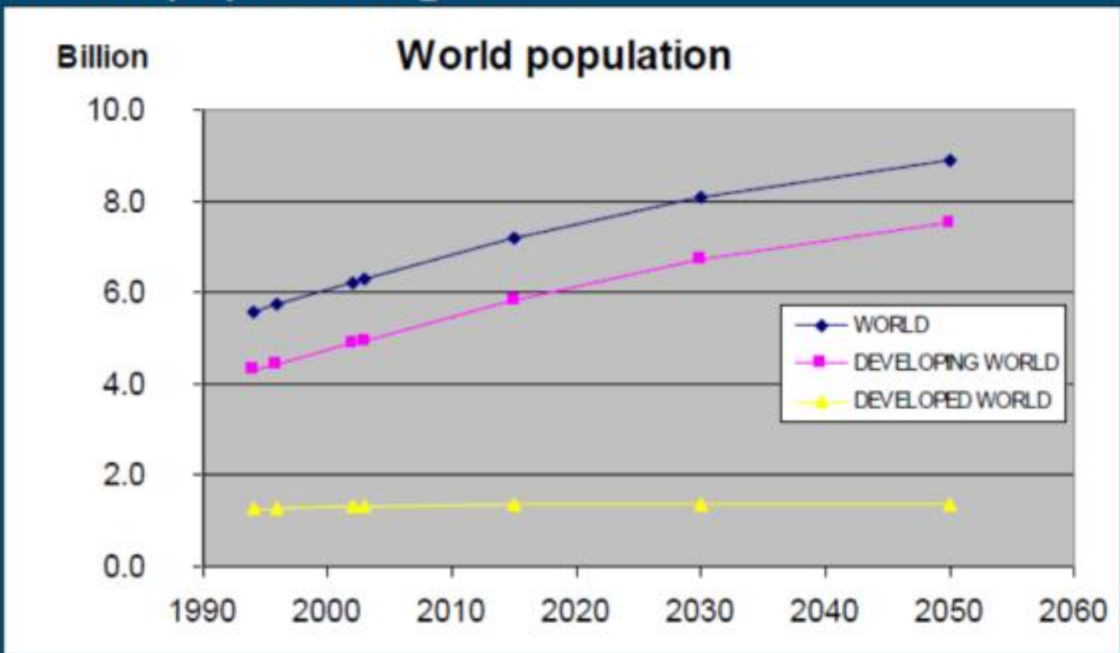
Needs for new green revolutions

- Demographic reasons (pop growth)*
- Changes in diet (more animal proteins)
- Shortage of good agricultural land
- Safeguard biodiversity
- Environmental reasons (degradation/pollution)
- Bio-based economy*
- Climate change

Global population growth




Biobased economy: perspectives
Non usables and manure
Sust. products:
- Materials
- Chemistry
- Pharma
Non usables and manure
By-products en waste processing, compost, fermentation (energy)
Minerals
Biomass
Food & fodder
CO_2
H_2O
Minerals
Photosynthesis
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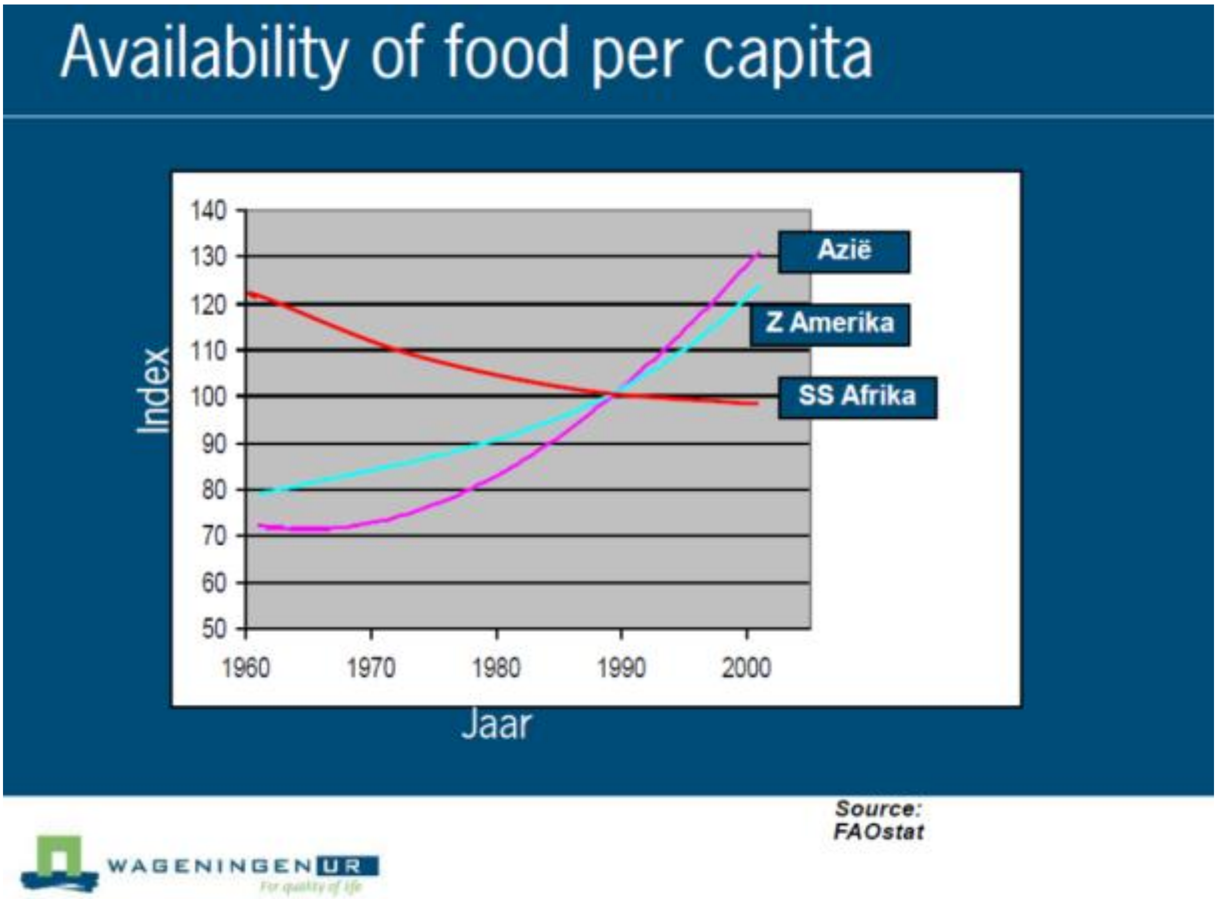
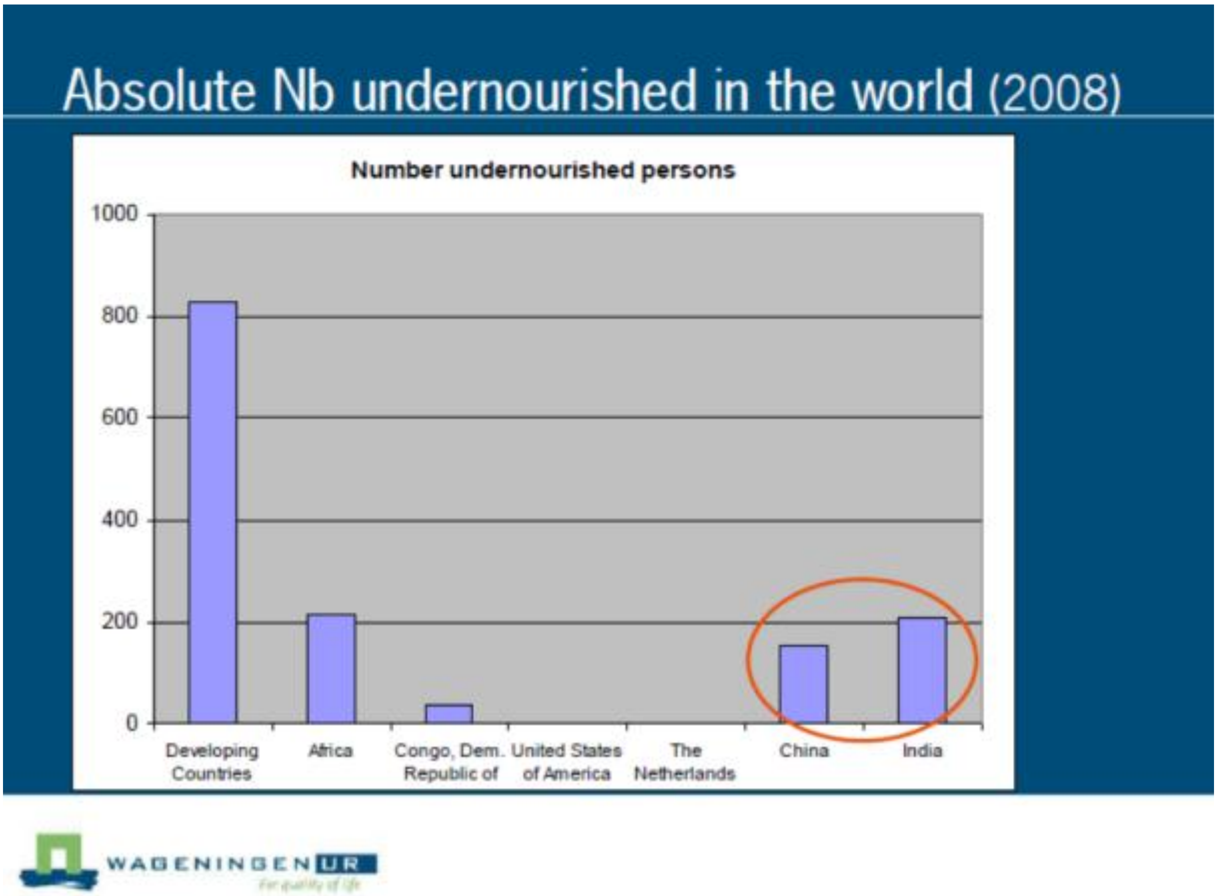
…Where do we stand now?…

WAGENINGEN UR For quality of life

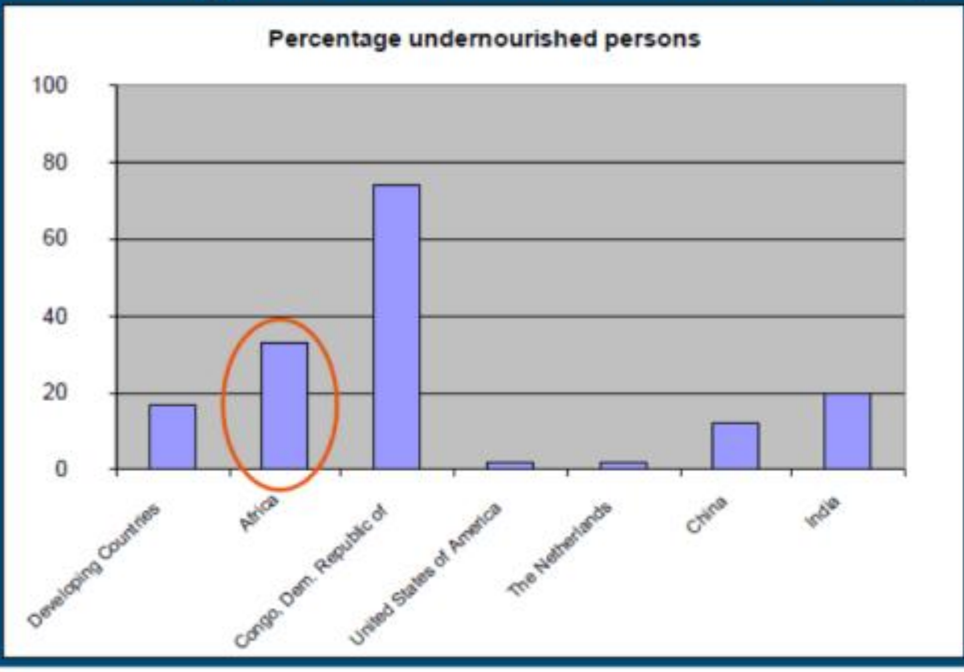
Rijksoverheid



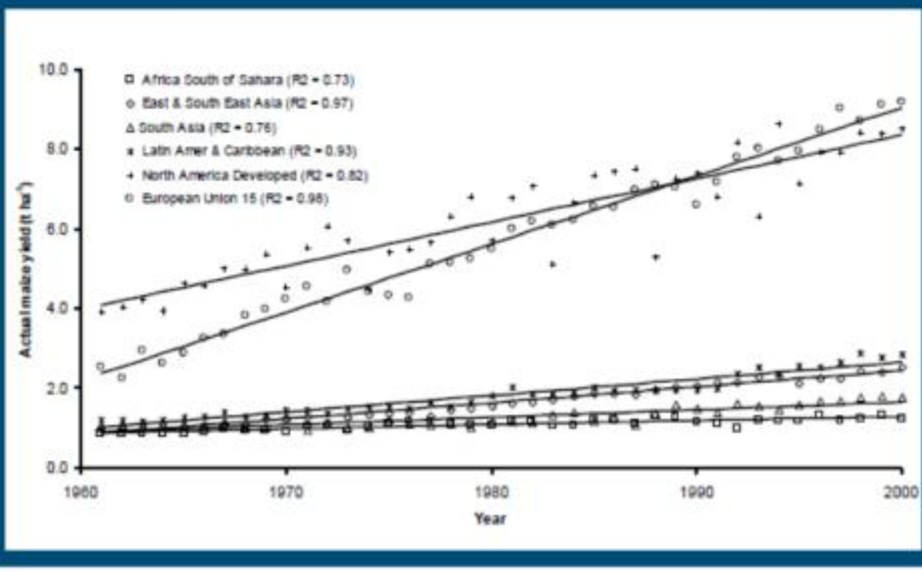


Rijksoverheid

Percentage undernourished in the world (2008)



Africa: Maize yield/ha stagnates



Food security in the 20th century

Intermediate conclusions

- Globally, the growth of production surpassed the growth of the population
- The opposite happened in Africa (yield stagnates and population grows)
- Production growth was due to the Green Revolutions
- Africa was not touched by the Green Revolutions

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Why is Africa lagging behind?

Study by Inter Academy Council
" Realizing the promise and potential of African agriculture"

"I request the IAC a report providing a technological strategic plan to provide substantial increase in agricultural productivity in Africa"

Kofi Annan, March 2002

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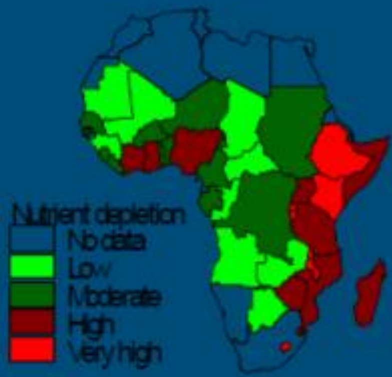
Study results (1) Problems of Africa

- Weathered soils
- Erratic rainfall
- Endemic plant and animal diseases

→ Poor resource base,

→ Vulnerable environment



- Absence of dominating food crops
- Multitude of farming systems

→ Need for many different technologies

Study results (2) Problems of Africa

- Dominant role for women – limited access to resources
- Land and Labor productivity low

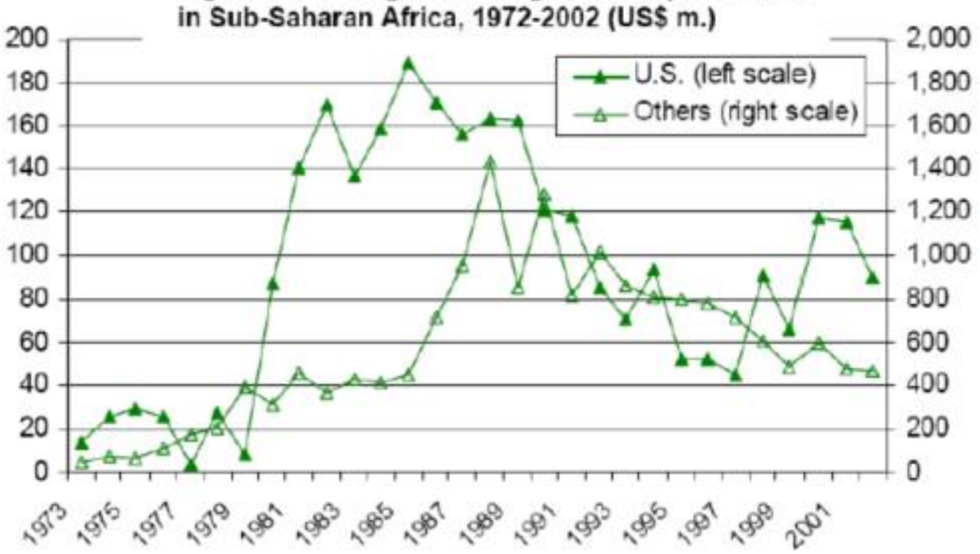
→How to become competitive?

- Lack of investment in agricultural research
- Lack of knowledge infrastructure
- Lack of functioning academic institutions
- Brain drain

→ Need for investment in research and education

Declining investments in agriculture in SSA

Figure 24. Foreign aid for agricultural production in Sub-Saharan Africa, 1972-2002 (US$ m.)



Source: Calculated from data in OECD Development Assistance Committee, *Geographical Distribution of Financial Flows to Aid Recipients 2004*. Online at http://sourceoecd.org

Study results (3) Problems of Africa

- Not functioning local and regional markets
- Land entitlement inappropriate
- No stimulating political and economic environment
- Inadequate capacity to impact global policy formulation
- Lack of good governance

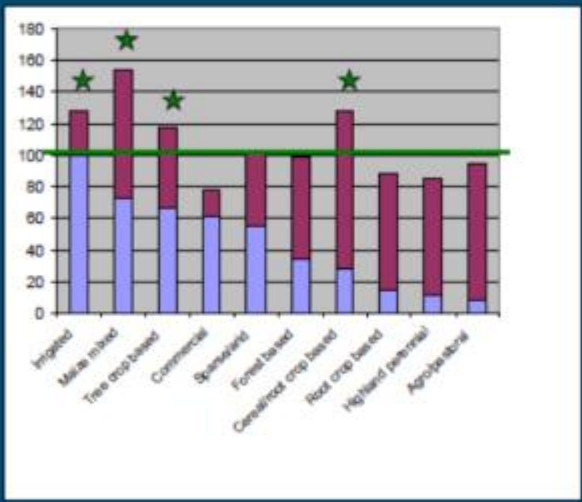
→ Need for renewal of institutional arrangements


…A way forward …


IAC report: Strategic Recommendations
Technology options that can make a difference (11)
Building impact-oriented research, knowledge and development institutions (5)
Creating and retaining a new generation of agricultural scientists (5)
Markets and policies to make the poor prosperous and food secure (5)
Increase investments in agriculture and infrastructure
WAGENINGEN UR

Rijksoverheid

IAC report: Priorities on 4 farming systems

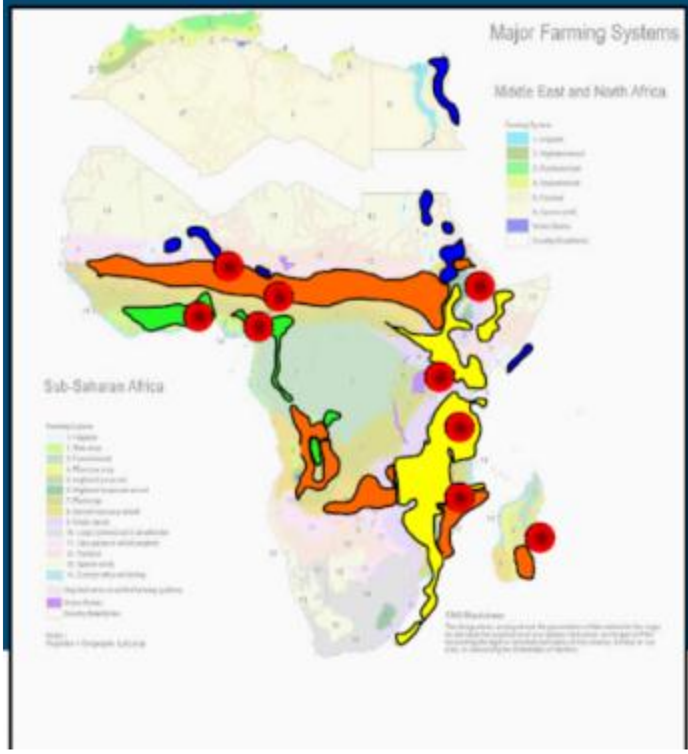


Underweight children (CIESIN)

Agricultural value added (worldbank)

- *Irrigated system*
- *Maize mixed system*
- *Tree-crop system*
- *Cereal-root crop mixed system*

Priority Farming Systems



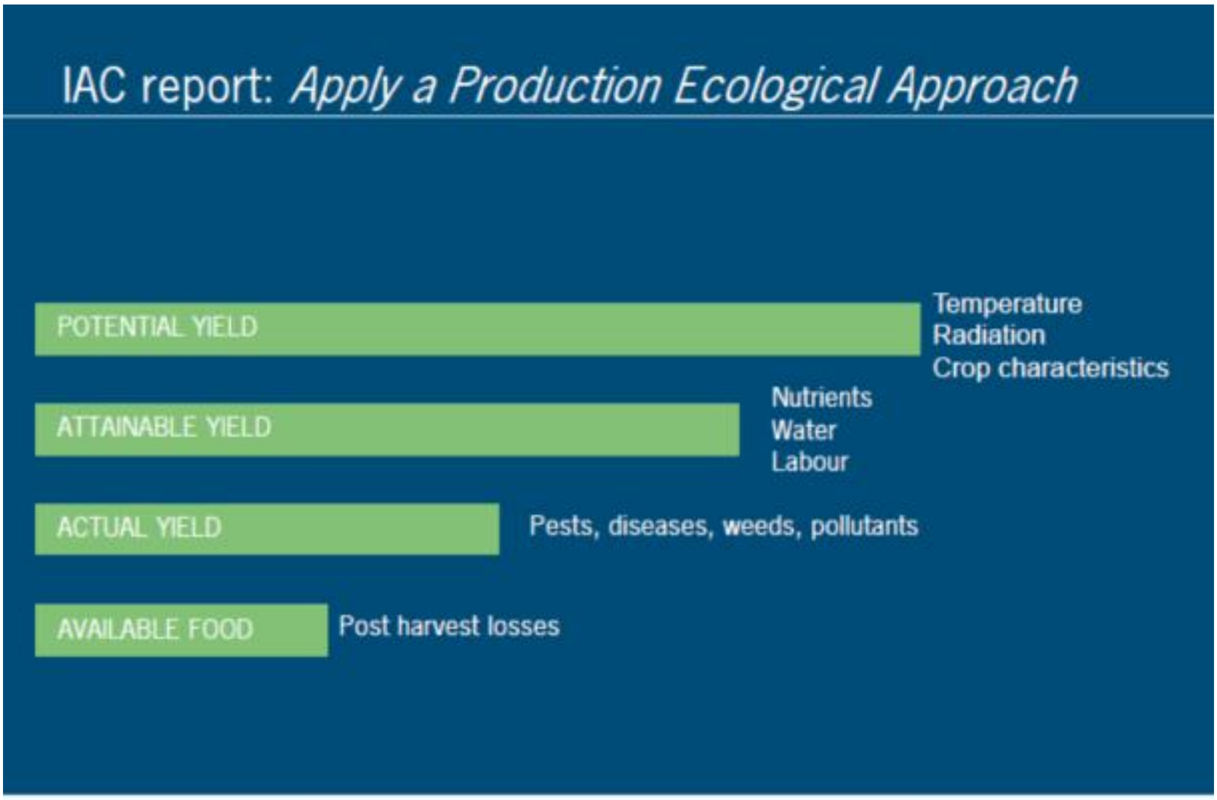
Irrigated system

Maize mixed system

Tree crop based system

Cereal root crop mixed system

Hunger Hotspot (CIESIN)



IAC report: invest in institutions

- Design and invest in national agricultural science systems that involve farmers in education, research and extension.
- Encourage institutions to articulate science and technology strategies and policies
- Increase agricultural research investment on average to at least 1.5 percent of agricultural gdp in African nations in 2015
- Cultivate African centres of agricultural research excellence.
- Strengthen CGIAR

WAGENINGEN UR
For quality of life

Rijksoverheid

IAC report: Create new scientists

- Broaden and deepen political support for agricultural science.
- Mobilize increased and sustainable funding for higher education in science and technology, minimizing dependence on donor support.
- Focus on current and future generations of agricultural scientists.
- Reform university curricula
- Strengthen science education at primary and secondary school levels.

WAGENINGEN UR

IAC report: Interventions related to marketing

- Increase investments in rural infrastructure
- Strengthen capacity to expand market opportunities
- Reduce barriers to increased African trade with OECD countries
- Improve data generation and analysis related to agriculture, food, and nutrition security and vulnerability
- Institute effective intellectual property rights regimes to encourage the private sector and facilitate public-private partnerships.

Rijksoverheid

Data supporting IAC recommendations

Investments in infrastructure

Table 2. Returns to government investments in rural Uganda

Investment	Benefit/cost ratio	Reduction in numbers of poor per million shillings
Agricultural research and extension	22.7	107.2
Education	2.7	12.8
Feeder roads	20.9	83.9
Murram roads	n.s	40.0
Tarmac roads	n.s.	41.4
Health	0.6	2.6

Impact of IAC-report: Alignment in studies

- World Development Report 2008
- International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD)
- MDG: Halving the Hunger: it can be done
- Multi-country agricultural productivity programme for Africa (MAPP)
- OECD Promoting Pro-Poor Growth: Agriculture (POVNET)
- FAO The State of Food and Agriculture (2005): Agricultural Trade and Poverty

A New Green Revolution

Alliance for a Green Revolution in Africa

AGRA programs develop practical solutions to significantly boost farm productivity and incomes for the poor while safeguarding the environment.

WAGENINGEN UR For quality of life

Implementation IAC report

- Technology options that make a difference
  - PASS program AGRA
  - Soil health program AGRA and other programs
  - Integrated programs, leapfrogging to new technologies (production ecology)
  - Improved ecological literacy, no ecological dogmatism

WAGENINGEN UR For quality of life


Implementation IAC report
Building impact oriented research, knowledge and development institutions
Strengthening FARA and national programs
Many private-public institutions
Global Challenge program Sub Sahara Africa


Implementation IAC report
Markets to make the poor prosperous and food secure
Commitment African Union
Strengthening regional and local markets
Markets oriented programs AGRA
WAGENINGEN UR

Follow-up activities

- IFDC programs on integrated soil fertility management including market development for input provision and sale of produce
- CAADP political commitment of African governments: African-led and African-owned initiative: 4 pillars: soil fertility; marketing; agricultural research; food supply and hunger
- AAA stimulation of entrepreneurship
- Strenghtening food security programs in various countries: USA, DFID, The Netherlands

Thank you for your attention

8.2 Contribution from: Mrs Christy van Beek – soil fertility specialist (Alterra)

Short description of the case study

- *Location, agro-environmental zone, period, reference*
- *Short description of low agricultural production, scarcity, stress or overexploitation of natural resources*
- *What was the target of agricultural intensification?*
- *Which stakeholder groups were involved?*

Location, period, reference
Kenya, 2002 (INMASP project)

Short description of low agricultural production, scarcity, stress or overexploitation of natural resources
Agricultural and economic data were collected from 4 farmer field schools (FFSs), divided over 2 districts in Kenya (Mbeera and Kiambu), during one growing season (March – August 2002). The FFSs in the Mbeere district were characterized by poor soil conditions and low rainfall, and falls within semi-arid areas. Contrarily, the Kiambu district was described as high agricultural potential area, but with higher population density than the Mbeere district. In this report differences and similarities between the 2 districts were studied with regard to farm structure, nutrient management and economic performance.

In both districts, livestock was an important farm activity. In the Kiambu FFSs livestock largely depended on imported feeds (mainly concentrates), while in the Mbeere FFSs livestock was left grazing on the pastures. As a consequence, the Kiambu farmers were able to retain more nutrients for crop production from livestock production than Mbeere farmers, but Mbeere farmers achieved higher margins on livestock production.

In the Kiambu district more emphasis was placed on, but less financial margins were achieved from, livestock production compared with the Mbeere district. However, investments made in livestock production in Kiambu paid off in increased crop production as a result of improved manure treatment. Overall there were no significant differences in economic performance between both districts and thereby both strategies were equally valued. However, in Kiambu soil depletion was more severe.

Target of agricultural intensification: to improve rural livelihoods.
Stakeholder groups involved: farmers

Interventions
Which interventions were used to achieve the target of agricultural intensification? Examples are: water management, nutrient management, genomic techniques, plant & animal health, bio refinery, mechanisation, economic or institutional interventions.

This project aimed to improve rural livelihoods by joint learning. Farmers jointly managed central learning plots in which they performed and managed their own trials, which were often related to fertilizer application.

Indicators of effects of interventions on natural resources and economy
Which indicators were used to express effects of interventions on a) the use of natural resources, b) emissions to the environment (e.g. leaching of nutrients, soil loss), including options for reuse, and/or c) the economy of the area?

Please specify the indicators in the cells below.

The main indicator was yield and dissemination of knowledge.

Indicators of resource use (soil nutrients, water)

1. *Definition*
2. *Measurement unit*
3. *Methods used to assess (measure, model, estimate) the indicator*
4. *Critical values (or intervals) of the indicator, which would point to an unsustainable condition of the agro-environmental system in the case study*
5. *Origin of critical values (e.g. your experience, research, existing policy, legislation, defined by stakeholders)*

-

Indicators of emissions and options to reuse these

1. *Definition*
2. *Measurement unit*
3. *Methods used to assess (measure, model, estimate) the indicator*
4. *Critical values (or intervals) of the indicator, which would point to an unsustainable condition of the agro-environmental system in the case study*
5. *Origin of critical values (e.g. your experience, research, existing policy, legislation, defined by stakeholders)*

-

Indicators of economic benefit or feasibility

1. *Definition*
2. *Measurement unit*
3. *Methods used to assess (measure, model, estimate) the indicator*
4. *Critical values (or intervals) of the indicator, which would point to an unsustainable condition of the agro-environmental system in the case study*
5. *Origin of critical values (e.g. your experience, research, existing policy, legislation, defined by stakeholders)*

The main indicator was yield and dissemination of knowledge.

Methods to assess effects of agricultural intensification

- *Which method was used in the case study to assess effects of agricultural intensification (e.g. trade-off analysis, ecological footprint analysis, multi-criteria analysis)?*
- *Would you recommend this method for a general concept to identify intensification limits or thresholds in Sub Sahara Africa?*

None.

8.3 Contribution from: Mr Kees van Diepen - agro-environmental modelling specialist (Alterra, Wageningen UR)

Short description of the case study

- *Location, agro-environmental zone, period, reference*
- *Short description of low agricultural production, scarcity, stress or overexploitation of natural resources*
- *What was the target of agricultural intensification?*
- *Which stakeholder groups were involved?*

Note: questionnaire does not fit my experience, but it triggers me to raise some issues
Case study: = my experience

1978-1981 Benin: soil erosion, soil degradation, conservation farming, climatic zones and optimum sowing dates, land use planning, irrigation development
1984 DGIS mission to Office du Niger, Mali: soil management constraints and salinity
1986, Zambia, Project formulation mission: drought monitoring and early warning system,
2003, Senegal, Global monitoring for Food Security, consultancy ESA funded project.
2002-2004 Ghana, Burkina Faso,. Impact of changing land cover on the production and ecological functions of Vegetation in Inland Valleys in West Africa (VINVAL Project) EC- INCO-DEV funded

My research actions were in the planning of interventions, rather than in the monitoring or assessment of their effects.

Interventions

Which interventions were used to achieve the target of agricultural intensification? Examples are: water management, nutrient management, genomic techniques, plant & animal health, bio refinery, mechanisation, economic or institutional interventions.

- Which are most suitable climatic zones and optimum crop calendars for specific crops (maize, cassava, millet, sorghum, cowpea, cotton, yam, cacao, oil palm, sugar cane, rice). What are best soils in each zone?
- Soil nutrient depletion, how to appreciate fallow, bush fires, organic manure
- Shift from smallholder farming to large industrial state farms (failure)
- Transition from shifting cultivation to permanent cultivation
- Break up of traditional land tenure systems, insecure land use rights, access to land
- Seasonal male labour migration, division of field work between women and men
- Transition from manual labour to use of draft-cattle and tractor

Indicators of effects of interventions on natural resources and economy

Which indicators were used to express effects of interventions on a) the use of natural resources, b) emissions to the environment (e.g. leaching of nutrients, soil loss), including options for reuse, and/or c) the economy of the area?

Please specify the indicators in the cells below.

Indicators of resource use (soil nutrients, water)

1. *Definition*
2. *Measurement unit*
3. *Methods used to assess (measure, model, estimate) the indicator*
4. *Critical values (or intervals) of the indicator, which would point to an unsustainable condition of the agro-environmental system in the case study*
5. *Origin of critical values (e.g. your experience, research, existing policy, legislation, defined by stakeholders)*

Indicators of resource use potential

Length of growing season, soil moisture deficit, climatic probability values
USLE soil loss by water erosion, soil erodibility, climatic erosivity

Indicators of emissions and options to reuse these

1. *Definition*
2. *Measurement unit*
3. *Methods used to assess (measure, model, estimate) the indicator*
4. *Critical values (or intervals) of the indicator, which would point to an unsustainable condition of the agro-environmental system in the case study*
5. *Origin of critical values (e.g. your experience, research, existing policy, legislation, defined by stakeholders)*

-

Indicators of economic benefit or feasibility

1. *Definition*

2. *Measurement unit*
3. *Methods used to assess (measure, model, estimate) the indicator*
4. *Critical values (or intervals) of the indicator, which would point to an unsustainable condition of the agro-environmental system in the case study*
5. *Origin of critical values (e.g. your experience, research, existing policy, legislation, defined by stakeholders)*

-

Methods to assess effects of agricultural intensification

- *Which method was used in the case study to assess effects of agricultural intensification (e.g. trade-off analysis, ecological footprint analysis, multi-criteria analysis)?*
- *Would you recommend this method for a general concept to identify intensification limits or thresholds in Sub Sahara Africa?*

-

Other issues

My discussion points:

Eco-efficiency as described by Keating et al (2008) and the land use systems approach of the LADA project (Nachtergaele and Petri, 2008) are valid reference frameworks providing analytical methods for biophysical (or agro-environmental) assessments. After reading both articles I feel they cover only part of the what-to-do story.
Keating is very vague on how to “break out of the vicious cycle of soil fertility constrained low productivity”, and he focuses on increasing the resource use efficiency, the technical solution, which can be successful only when a number of other problems are solved first, or simultaneously

In my view there is a need for a move to modernisation from traditional family farm to a more commercial, mechanized, market oriented farm type. This commercial enterprise –type farmers will operate above subsistence and minimum risk level. The first necessary condition is secure land tenure, guaranteeing long term access to land to farmers. Now in many situations there is a kind of wild west open access to land, and investments must be recovered within the current crop season. The longer time horizon will influence the cost-benefit balance of investments in soil improvement measures, and farmers may also be stimulated to invest in tree-crops.

It will be very hard to achieve this. It is not only the population pressure that must be blamed for the poor state of affairs in Africa,, it is the competing claims problem, which makes that there is not enough land of sufficient quality for all land users, and the lack of know-how and money The current situation is overexploitation of the traditional cultivated areas and of the expansion of cropping on marginal lands. Next, the pastoralists have lost traditional grazing lands to crop farmers, and both groups will lose land to the new foreign investors.

It is a good idea to intensify agricultural production, but it should be kept in mind that the current situation is the result of gradual intensification above a sustainability threshold, above the carrying capacity of the land resource, so we need either another type of intensification to increase the carrying capacity or an extensification so that the land use system will operate below carrying capacity. Extensification or abandonment can also be part of the solution

As in the case of scarce land resources, competing claims on water will appear as well. So it is not a matter of improving resource use efficiency, at the same time the access to all resources should be taken into account.
Keating et al do not discuss the poverty and biodiversity issues

Very popular approaches during the last 20 years have been participatory research and incorporation of indigenous technical knowledge. The scientific and indigenous knowledge are often complementary, in the sense that farmers focus on day-to-day local problems and hardships, or successes like real crop yield, and scientists focus on thematic issues and generic problems like yield gaps and causal relations. Farmers explain invisible things from beliefs, researchers from science. So scientific and indigenous knowledge are two worlds of different perceptions, and it is it is not possible, and not even necessary to merge them.

Both Keating and LADA view the problems from global and universal perspective. To find solutions for Africa we have to act locally. Globally land use is the driver for land degradation. Locally the local socio-economic and technological conditions are the drivers for land use: access to land, availability of money, road access, distance to market town, functioning of the market (of inputs and outputs), knowledge level, availability of labour, possibility to work elsewhere, income sources from outside agriculture, role of women, . These are very variable, but essential factors that influence farmer behaviour and thus the functioning of the land use system.

En de maatregelen, of best practices die in aanmerking komen zijn daarom ook erg lokaal geldig.

8.4 Contribution from: Mrs Petra Hellegers – agricultural economist (LEI, Wageningen UR)

Short description of the case study (derived from work with Huib Hengsdijk, PRI)

- *Location, agro-environmental zone, period, reference*
- *Short description of low agricultural production, scarcity, stress or overexploitation of natural resources*
- *What was the target of agricultural intensification?*
- *Which stakeholder groups were involved?*

The Central Rift Valley in Ethiopia is a closed river basin where poverty and natural resource degradation are firmly intertwined. The rapidly growing population increasingly over-exploits the scarce natural resources in their struggle for survival. Symptoms of resource over-exploitation are the falling water levels of lakes, the gradual erosion of wood stocks, the over-grazing of common pastures and the lack of proper soil management resulting in decreased land productivity and expansion of cultivated land to marginal areas. Recent private investments in irrigated horticulture and floriculture for local and international markets, respectively, stimulate economic growth and development but claim their share of the limited resource base, especially water. Since the Central Rift Valley is a closed river basin, i.e. there is no inflow and outflow of freshwater, relatively small changes in water use have a great impact on downstream areas. Climate change may further intensify problems. In the downstream part of the Central Rift Valley is the Lake Shala-Abijata National Park located, which is already seriously threatened mainly by upstream water extraction for irrigated agriculture. There is an urgent need for integrated resource planning and management at different levels, and the identification of options for more sustainable land use practices, especially in the rainfed agriculture on which the majority of the population depends.
http://www.crv.wur.nl/UK/

Interventions

Which interventions were used to achieve the target of agricultural intensification? Examples are: water management, nutrient management, genomic techniques, plant & animal health, bio refinery, mechanisation, economic or institutional interventions.

Private investment in irrigated horticulture and floriculture as well as provision of pumps by NGOs to local farmers to expand irrigated agriculture in the catchment of Lake Ziway and along the Bulbula River.

Indicators of effects of interventions on natural resources and economy

Which indicators were used to express effects of interventions on a) the use of natural resources, b) emissions to the environment (e.g. leaching of nutrients, soil loss), including options for reuse, and/or c) the economy of the area?

Please specify the indicators in the cells below.

Further uncoordinated exploitation of the land and water resources may have dramatic consequences for the local population and development options as Lake Ziway may become a closed lake resulting in increased salinity levels of the largest fresh water reservoir in the region.

Indicators of resource use (soil nutrients, water)

1. *Definition*
2. *Measurement unit*
3. *Methods used to assess (measure, model, estimate) the indicator*
4. *Critical values (or intervals) of the indicator, which would point to an unsustainable condition of the agro-environmental system in the case study*
5. *Origin of critical values (e.g. your experience, research, existing policy, legislation, defined by stakeholders)*

In contrast with the common believe, the greenhouses along Lake Ziway are not the major water consumers in the Central Rift Valley. The open-field irrigated horticulture sector is by far the largest consumer of fresh water resources in the Central Rift Valley.

Recent reductions in the level of Lake Ziway and Lake Abyata are associated with land developments (especially the expansion of irrigated agriculture) in the catchment of Lake Ziway and along the Bulbula River.

The dam that is currently being constructed in the Bulbula River is expected to further reduce the outflow by the Bulbula River to discharge levels that are well below the critical environmental flow required to keep Lake Ziway fresh. Obviously, the water availability for people and ecosystems downstream of the dam will be negatively affected in that case.
There is no evidence that the amount of rainfall in the Central Rift Valley has decreased in the past 30 years. Hence, the rapid shrinkage of Lake Abyata in the last 10 years cannot be related to lower rainfall.

Indicators of emissions and options to reuse these

1. *Definition*
2. *Measurement unit*
3. *Methods used to assess (measure, model, estimate) the indicator*
4. *Critical values (or intervals) of the indicator, which would point to an unsustainable condition of the agro-environmental system*

in the case study

5. *Origin of critical values (e.g. your experience, research, existing policy, legislation, defined by stakeholders)*

-

Indicators of economic benefit or feasibility

1. *Definition*
2. *Measurement unit*
3. *Methods used to assess (measure, model, estimate) the indicator*
4. *Critical values (or intervals) of the indicator, which would point to an unsustainable condition of the agro-environmental system in the case study*
5. *Origin of critical values (e.g. your experience, research, existing policy, legislation, defined by stakeholders)*

Although the open-field horticulture sector provides income to a growing part of the population in the Central Rift Valley, the little information available suggests that its economic performance is generally poor and associated with low water use efficiencies

The net value of irrigation water used is shown in Table 1. It is calculated on the basis of the net income received by farmers per unit of irrigation water applied, expressed in Birr m-3 water. By subtracting the cost of other production factors from the gross production value, the net value added per unit water can be calculated. Net income is the marketable product (yield) multiplied with its price minus the variable production costs such as machinery, hired labour, fertilizers, biocides and seeds. These costs vary according to crop and production system. In addition, family labour in smallholder production systems is not accounted for.

Table 1 shows that flower production clearly generates the highest economic value per unit of irrigation water applied. The value of irrigation water may even be negative as in the case of grapes due to low yield and product price relative to the high production cost. The possible impact of different product prices on the value of water is shown for tomato production. The State farm received a much lower price (0.72 Birr kg-1) (as they are risk averse and sell their product for a fixed contract price) than the highest price (2.2 Birr kg-1) that some vegetable smallholders received for tomatoes in the CRV (Scholten, 2007).

Table 1 The value of water for various irrigated crops in the Central Rift Valley.

	Yield ($kg\ ha^{-1}$)	Price ($Birr\ kg^{-1}$)	Costs ($Birr\ ha^{-1}$)	Water applied ($m^3\ ha^{-1}$)	Value of water ($Birr\ m^{-3}$)
Flowers	$2.5 * 10^6$ [1)]	1.5 [2)]	$3.16 * 10^6$	20,000	17-29.5
Grapes (state farm)	7,000	3.65	34006	22,000	-0.4
Tomatoes (state farm)	37,800	0.72 - 2.20 [3)]	17389	17,100	0.6 - 3.8
Maize for hybrid seed (state farm)	6,000	2.55	8229	11,800	0.6
Tomatoes (smallholder)	26,000	1.00 - 2.20 [4)]	21863 [5)]	17,100	0.24 - 2.1

[1)] Million stems
[2)] Birr per stem
[3)] Minimum price was received, and maximum price was highest price observed in survey (Scholten, 2007).
[4)] Minimum and maximum price as derived from survey (Scholten, 2007).
[5)] Costs based on Alemu (2004)

Methods to assess effects of agricultural intensification

- *Which method was used in the case study to assess effects of agricultural intensification (e.g. trade-off analysis, ecological footprint analysis, multi-criteria analysis)?*
- *Would you recommend this method for a general concept to identify intensification limits or thresholds in Sub Sahara Africa?*

Net value of irrigation water or economic water productivity or return to water (Birr/m3).

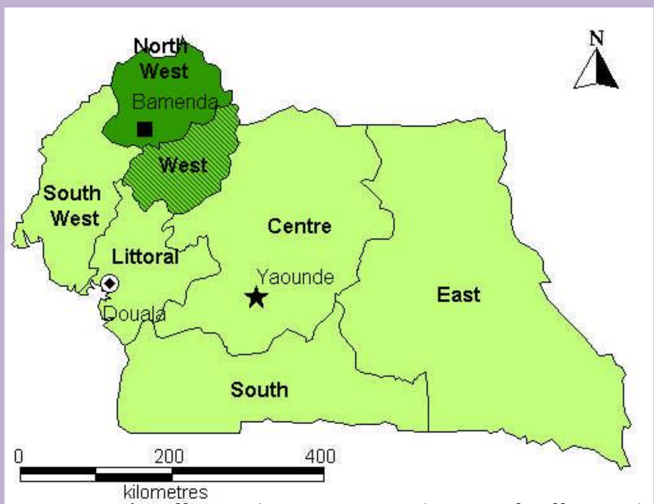
8.5 Contribution from: Mr Don Jansen (Plant Research International - Agrosystems) – agronomist specialized in coffee and rice systems

Short description of the case study

- *Location, agro-environmental zone, period, reference*
- *Short description of low agricultural production, scarcity, stress or overexploitation of natural resources*
- *What was the target of agricultural intensification?*
- *Which stakeholder groups were involved?*

- Location: North-West Province of Cameroon (**Error! Reference source not found.**)
- Agro-environmental zone: Tropical Wooded Savana in the Western Highland area with elevation between 500-2000 m asl; rainfall 1.5-3000 mm rain/year, average temperature 21 ^{o}C , ferralitic soils of volcanic origin, rather fertile but with pH and P availability at low side
- Coffee production very low (around 200 kg green beans / ha, compared to 600 kg/ha in Uganda, 300 in Kenya and 1200 in Colombia), related to low fertilizer use (around 7 kg/ha/yr, mainly Urea), little use of organic fertilizers (including coffee pulp[5]), general lack of proper crop maintenance (specifically pruning, management of shade trees), general tendency to keep soil bare under the coffee trees, rather high level of coffee berry disease; overexploitation of land in coffee due to insufficient and unbalanced fertilization and erosion caused by food crop production on (steep) slopes, with clean weeding and lack of terracing or other anti-erosion measures.
- Focus on Arabica coffee as this is the major cash earning crop with potential to provide higher income
- Stakeholder groups involved: farmers, exporter/buyer, national coffee cocoa board

Map of Cameroon.



Cameroon's coffee producing provinces by type of coffee. Dark green areas represent Arabica growing areas

Figure 1 Location of project in North West Province of Cameroon, east of Bamenda town.

[5] Coffee pulp is the residue of the coffee cherry after processing; farmers store and trade coffee as ‘ parchment coffee’, i.e. the green coffee bean still inside a hard hull

Figure 2 Agro-ecological zones in Cameroon

Interventions

Which interventions were used to achieve the target of agricultural intensification? Examples are: water management, nutrient management, genomic techniques, plant & animal health, bio refinery, mechanisation, economic or institutional interventions.

- Formation of farmer groups to improve logistics for trading coffee
- Training of farmers in Farmer Field Schools on Good Agricultural and Processing Practices (GAPP)
- Facilitation of credit for fertilizers to interested and trustworthy farmers
- Promotion of GAPP through radio-shows

Indicators of effects of interventions on natural resources and economy

Which indicators were used to express effects of interventions on a) the use of natural resources, b) emissions to the environment (e.g. leaching of nutrients, soil loss), including options for reuse, and/or c) the economy of the area?

Please specify the indicators in the cells below.

Indicators of resource use (soil nutrients, water)

1. *Definition*
2. *Measurement unit*
3. *Methods used to assess (measure, model, estimate) the indicator*
4. *Critical values (or intervals) of the indicator, which would point to an unsustainable condition of the agro-environmental system in the case study*
5. *Origin of critical values (e.g. your experience, research, existing policy, legislation, defined by stakeholders)*

Indicators of use of soil nutrients (availability of water is not an issue)

Input, export and balance of nutrients (kg nutrient / coffee tree or field); no clear critical values, but intention to have balance slightly positive).

Indicators of emissions and options to reuse these

1. *Definition*
2. *Measurement unit*
3. *Methods used to assess (measure, model, estimate) the indicator*
4. *Critical values (or intervals) of the indicator, which would point to an unsustainable condition of the agro-environmental system in the case study*
5. *Origin of critical values (e.g. your experience, research, existing policy, legislation, defined by stakeholders)*

- Composting and reuse of coffee pulp (% of farmers)
- Production of mushrooms on crop residues (coffee pulp, maize husk)
- Critical value: 100% farmers to properly reuse the residues

Indicators of economic benefit or feasibility

1. *Definition*
2. *Measurement unit*
3. *Methods used to assess (measure, model, estimate) the indicator*

4. *Critical values (or intervals) of the indicator, which would point to an unsustainable condition of the agro-environmental system in the case study*
5. *Origin of critical values (e.g. your experience, research, existing policy, legislation, defined by stakeholders)*

- Net operational income (gross income minus operational costs) per coffee tree and per field (CFA); change over time; no clear critical value, but operational income per (family) labour hour should be acceptable to farmers; prove is in % of farmers taking up GAPP):
- Productivity per coffee tree and field (kg green bean)
- Efficiency of input use (kg coffee per kg nutrient input)

Methods to assess effects of agricultural intensification

- *Which method was used in the case study to assess effects of agricultural intensification (e.g. trade-off analysis, ecological footprint analysis, multi-criteria analysis)?*
- *Would you recommend this method for a general concept to identify intensification limits or thresholds in Sub Sahara Africa?*

- Record keeping by farmers; digitized and analysed by project team; strongly recommended to use the results as input to farmer trainings to ensure data quality.
- Documentation of sales by farmers and farmer groups to exporter; indicates viability of value chain.

8.6 Contribution from: Mr Koen Roest – agro-hydrological specialist (Alterra, Wageningen UR)

Short description of the case study

- *Location, agro-environmental zone, period, reference*
- *Short description of low agricultural production, scarcity, stress or overexploitation of natural resources*
- *What was the target of agricultural intensification?*
- *Which stakeholder groups were involved?*

Location, agro-environmental zone, period, reference
Egyptian Nile Delta, arid climate (30 – 150 mm precipitation); 1975 – present

Short description of low agricultural production, scarcity, stress or overexploitation of natural resources
The switch of flood agriculture with only one crop to two crops per year in the Egyptian Nile Valley and Delta was made possible by storing the summer floods in the Aswan High Dam. The negative effects of continuous water supply (year-round) in the flat deltaic area were high groundwater levels and secondary salinization of the soil. The natural drainage capacity was insufficient.

What was the target of agricultural intensification?
Case 1:
The subsurface drainage program that was implemented between 1965 until today was targeted at lowering the groundwater tables and thereby preventing soil salinity build up. A research program carried out by the Drainage Research Institute in Cairo on the "Economic evaluation of sub-surface drainage projects" monitored the crop yield increases for a number of years (1980 – 1990). Unfortunately, this research is done in the pre-digital era and I did not save the analogue reports. Crop yields increased in the range of magnitude from 10% (on the better fields) till more than 100% on saline soils.
Case 2:
From 1985 onwards, the Egyptian Government (Ministry of Agriculture and Land Reclamation, MALR) took bold steps to abolish gradually the subsidies on food (mainly on bread) and on agricultural inputs. This market liberalization was guided by technical Assistance provided by USAID and resulted in a wheat yield increase from 3.5 ton/ha in 1985 till 6 ton/ha in 1995 (Kherallah, M., H. Löfgren, P. Gruhn, and M. M. Reeder, 2000. Wheat Policy Reform in Egypt: Adjustment of Local Markets and Options for Future Reforms. International Food Policy Research Institute Washington, D.C.).

Which stakeholder groups were involved?
Case 1: Subsurface drainage installation was performed by the Government, generally with loans from the World Bank. Farmers have to repay the investments.
Case2: Unilateral Government action. Courageous, because it included increasing the price of bread which is politically sensitive.

Interventions
Which interventions were used to achieve the target of agricultural intensification? Examples are: water management, nutrient management, genomic techniques, plant & animal health, bio refinery, mechanisation, economic or institutional interventions.

Which interventions were used to achieve the target of agricultural intensification? Examples are: water management, nutrient management, genomic techniques, plant & animal health, bio refinery, mechanisation, economic or institutional interventions.
Case 1: Installation of subsurface drainage (water management).
Case 2: Economic intervention: removal of subsidies.

Indicators of effects of interventions on natural resources and economy
Which indicators were used to express effects of interventions on a) the use of natural resources, b) emissions to the environment (e.g. leaching of nutrients, soil loss), including options for reuse, and/or c) the economy of the area?

Please specify the indicators in the cells below.

Indicators of resource use (soil nutrients, water)

1. *Definition*
2. *Measurement unit*
3. *Methods used to assess (measure, model, estimate) the indicator*
4. *Critical values (or intervals) of the indicator, which would point to an unsustainable condition of the agro-environmental system in the case study*
5. *Origin of critical values (e.g. your experience, research, existing policy, legislation, defined by stakeholders)*

1. Definition
Case 1: soil salinity; shallow groundwater salinity
2. Measurement unit
Case 1: mmho/cm

3. Methods used to assess (measure, model, estimate) the indicator
Case 1: Soil samples, groundwater samples
4. Critical values (or intervals) of the indicator, which would point to an unsustainable condition of the agro-environmental system in the case study
Case 1: Depends on the crops grown. Generally EC<2 mmho/cm is quite good.
5. Origin of critical values (e.g. your experience, research, existing policy, legislation, defined by stakeholders)
Case 1: International literature, confirmed by the research program (evaluation of drainage projects).

Indicators of emissions and options to reuse these

1. *Definition*
2. *Measurement unit*
3. *Methods used to assess (measure, model, estimate) the indicator*
4. *Critical values (or intervals) of the indicator, which would point to an unsustainable condition of the agro-environmental system in the case study*
5. *Origin of critical values (e.g. your experience, research, existing policy, legislation, defined by stakeholders)*

-

Indicators of economic benefit or feasibility

1. *Definition*
2. *Measurement unit*
3. *Methods used to assess (measure, model, estimate) the indicator*
4. *Critical values (or intervals) of the indicator, which would point to an unsustainable condition of the agro-environmental system in the case study*
5. *Origin of critical values (e.g. your experience, research, existing policy, legislation, defined by stakeholders)*

1. Definition
Crop yield (both cases)
2. Measurement unit
Ton/ha
3. Methods used to assess (measure, model, estimate) the indicator
Case 1: Field measurement by weighing at harvest
Case 2: National statistics
4. Critical values (or intervals) of the indicator, which would point to an unsustainable condition of the agro-environmental system in the case study
NA
5. Origin of critical values (e.g. your experience, research, existing policy, legislation, defined by stakeholders)
NA

Methods to assess effects of agricultural intensification

- *Which method was used in the case study to assess effects of agricultural intensification (e.g. trade-off analysis, ecological footprint analysis, multi-criteria analysis)?*
- *Would you recommend this method for a general concept to identify intensification limits or thresholds in Sub Sahara Africa?*

NA

8.7 Contribution from Mr Wim Andriesse (Wageningen International/Africa Desk)

The objective of the workshop today, is:

“.... to make an inventory of available knowledge and instruments (at Wageningen UR) which could be used to identify limits or thresholds of intensification of agriculture in Sub Sahara Africa (SSA) for different agro-environmental systems, with regard to economic feasibility and natural resources (use of water and soil nutrients, emissions). *Social and institutional effects are not within the scope of this workshop,* (but may be addressed by the experts)”.

Sustainability, however, is generally being defined with reference to environmental, economic ánd socio-institutional aspects of development/intensification, in particular if we take a time perspective. For example, refer to Keating, 2010 as quoted in Holger Meinke’s paper: “We cannot do without socio-institutional considerations ...” Or, as Kees van Diepen states in his contribution: ”Locally the socio-economic and technological conditions are the drivers for land use: Access to land, credit facilities, farm inputs, physical infrastructure (roads, markets), labour, skills and knowledge levels, alternative sources of income, etc. … ” co-determine the sustainability of interventions.

Perhaps, as a gross statement, this has been the main aim of international development cooperation: To have a lasting impact, beyond the lifetimes of projects on poverty, food security and livelihoods. And this has been one of the main issues underlying the recent WRR Study on 60 years of well-intended but not-so-very effective Dutch development effort. Also, this has also been the starting point of important reports asking for renewed attention for agriculture as an engine for economic development in countries in Africa and elsewhere: The IAC Report of 2004, the World Development Report, 2008 and others as summarized in our own Wageningen MDG1 Review, of 2007.

From that socio-institutional perspective on sustainability I had a look at the cases presented in the workshop:

The **INMASP project** looked at performance of mixed crop-livestock systems in two districts in Kenya (Kiambu and Mbeera). The project applied a FFS/Farmers Groups approach for joint learning mainly from fertilizer trials. The indicators of effects were yields and dissemination of knowledge.

From an institutional point of view, an important issue is to know *what* was disseminated: knowledge about the (participatory) process that was applied, or knowledge about the amounts of fertilizers recommended? And, in view of the need for up- and out-scaling *how* was this dissemination organised and anchored in local institutions: Who extends the message and in what way: Governmental extension services that have a record of being in-effective and carrying linear messages, NGO’s, farmer groups themselves.

At another level: What about the operational effectiveness of (input and output) services providers –either governmental, ngo’s, or private sector- and what about the possibilities for farmers to market extra production, to whom, where, when and at what prices?

The **Flori- and Horticulture project in** Ethiopia looked mainly at environmental impact and economic benefits of the current (rapid) development of floriculture (mainly export oriented) and horticulture (mainly for the local market) in the Central Rift Valley. Indicators of effect included changing land use, changing water levels in Lake Ziway and water quality.

Here, the institutional/policy issue at stake is that the Ethiopian government, with support of donors, is investing in market-oriented horticultural development either in greenhouse floriculture or in open-field irrigated horticulture. However, from the participatory research an unpopular message emerged: The sector’s development leads to falling water levels in the lake, causes threats to water quality and to biodiversity/tourism potential. This message was not readily welcome at (higher) political levels, and as a result partners shied away from the project. The ecological situation may aggravate once the Bulbula River dam is operational. There is a need for interdisciplinary planning procedures but these require an operational inter-institutional governance environment/culture that is presently lacking in the country.

There is a related other issue at stake in relation to the rapid emergence of floriculture enterprises in the Rift Valley. These are quite enormous in size (the Sher plant, for example comprises several hundreds of hectares of *greenhouses) and investments are being done with the best of intentions, as witnessed, for example, by the sector-initiated 'Code of Conduct' that addresses both social and technical issues: from remuneration of labourers and social security and health issues to the use of pesticides etc. However, the sector attracts many labourers (women mainly) external to Ziway and there are signs of social/gender balance disruption. Also, the sector's initiatives in building facilities like a hospital and a football field are overtaking (local) government's responsibilities and may eventually undermine local authority.*

In Cameroon, **the Coffee project** aimed at increasing coffee production through better crop management and use of fertilizer including re-use of coffee pulp. The pulp was also used as substrate for mushroom cultivation. Interventions were mainly made in the institutional realm: (i) Farmer groups to improve logistics, (ii) training in farmer field schools, (iii) credit facilitation, and promotion of GAP's (radio). Impact was measured in terms of numbers of farmers applying better practices in coffee cultivation, or in growing mushrooms, net operational incomes and coffee unit productivity.

As in the case of the INMASP project, institutional issues relate mainly to dissemination or out-scaling issues: How to come from local, site-specific methods and results to larger and different areas: promoting methods, or results?. Skill levels of targeted farmers play a role here: managing (micro-)credit, managing risks under increased use of input require basic administrative skills.

In the **Nile valley and delta project** in Egypt the aim was to increase agricultural production under conditions of land and water scarcity and overexploitation. Interventions were twofold: (i) Technical (drainage and desalinization) and (ii) Institutional/political (market liberalization: abolishing subsidies on food and on agro-inputs). Accordingly, effects were assessed technically (groundwater and salinity levels) and economically: In the absence of subsidies crop yields almost doubled in ten years' time. Please note that, in comparison to the other cases, the Nile setting is special as it can be taken as one, perhaps two, specific and singular physiographic unit(s): Beyond the delta and valley, there is no big out-scaling issue at stake.
The project provides a clear case to underscore the importance of institutional/governance issues in development: The bold governmental decision to cut subsidies on bread (and on farm inputs) resulted in large (almost double) production increases over relatively short time (10 years).
On basis of the above, I came to distinguish:

'Intra-interventional' institutional issues:
Technical interventions: improved cropping practices, fertilizer use, pulp use, pruning, interdisciplinary land use planning, drainage and flushing of salts.
Process-level interventions: Participatory planning and implementation, farmer empowerment/training, farmer field schools, service provision/facilitation, engagement with (local) government, knowledge sharing.

'Extra-interventional' institutional issues:
Implementation dialogue from local through regional to national governance levels and vice versa, power positions, knowledge dissemination pathways, service provision, (micro-) credit and insurance schemes, markets and infrastructure, logistics and quality control, access/right to land, labour availability, off-farm employment/income, skills training and education.

8.8 Contribution from Mr Holger Meinke - Director of the Tasmanian Institute of Agricultural Research (TIAR) and Head of the School of Agricultural Science at the University of Tasmania (UTAS), Australia, crop and weed ecologist

Sustainable agricultural intensification – oxymoron or Africa's salvation?

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Background document for the expert workshop on 'Sustainable Agricultural Intensification in Sub Sahara Africa', 25 May 2011, Wageningen, The Netherlands

Abstract

Rates of global changes are accelerating. Global populations and average per capita income continue to grow, increasing the demand for agricultural products, while climate change puts pressure on agricultural production. Global changes also put increased pressure on natural resources resulting in agriculture increasingly competing with other sectors for inputs such as land and water, while the size of the environmental footprint of agriculture remains of concern. These trends led to the catch-cry 'we need to produce more with less', also referred to as the 'factor four challenge' (i.e. double production using half the inputs). However, whenever we start to unpack the complexities of this issue it becomes apparent that this catch-cry is an unhelpful over-simplification. In fact 'producing more with more, but smarter' is often more productive and sustainable, particularly for Africa, even if such a message might not be perceived as politically correct by some interest groups. We need to acknowledge that we can only increase the efficiencies of our exhaustible production factors (land, water, capital and labour) if we substitute and compliment them with the non-exhaustible production factors *knowledge* and *practical wisdom*; effective and efficient farming is all about good resource management, which requires access and use of knowledge intensive technologies. The complexity of the issue further highlights that science has to play an important, but partial role in problem solving. Unless good science is underpinned by goodwill, good policies and good governance, investments in science will not yield the desired returns. Particularly for Africa this requires sustained investment in education, infrastructure development, institutional networks and trans-disciplinary approaches to agricultural problem solving.

Background

About 12,000 years ago the world's climate system shifted suddenly and entered a period of unprecedented stability (Hansen et al., 2007). This resulted in the emergence of agriculture, a development that ultimately led to our modern societies with all their complexities. Complex agricultural systems developed as a consequence of often unforeseeable interactions between climate, farmers, communities, market forces, governments, rural industries and businesses. Today global changes such as population growth, urbanisation (e.g. Fig. 1), industrialisation, trade liberalisation, climate variability and climate change have important consequences for agriculture and food security. Today's agricultural production systems are competing with alternative users for production factors such as land, water, labour and energy. These competing claims for resources mean that farmers need to increase their resource use efficiencies. This is particularly challenging in subsistence agriculture that is still prevalent in large parts of Africa, where the daily struggle for survival focuses farmers on short term gains that often compromise their long term sustainability. Beyond subsistence, farmers need to improve their resource use efficiencies sustainably while making a profit not only for themselves but also for the rural communities that need to support them. Resource constraints also create internal competition within agricultural systems as alternative crops or livestock could be produced with these resources: food versus feed versus fibre versus fuel; usually the system wins for which the highest purchasing power exists.

At the time of writing (May 2011), global food prices remain close to their 2008 peak (World Bank, 2011). The recently published Foresight Report (2010) underlines the '*unprecedented confluence of pressures over the next 40 years*' on the global food system. As a consequence there *'… is a strong likelihood that food prices will rise significantly…*' and that the '… *long-term trend over the past century of low food prices is at an end. This has major implications for achieving food security in the future*'. The report also stresses that '… *while the amount of volatility remains uncertain, price spikes in the future are inevitable*'. It is therefore paramount that we begin to understand this '*confluence of pressures*', their interactions and possible science, policy and management responses that might alleviate them. This is particularly important for Africa, a continent exposed to enormous stresses, yet with considerable and, as yet, largely untapped potential. Crucial in this debate is the development of a shared vision of the role that science can and should play in managing this 'confluence of pressure'.

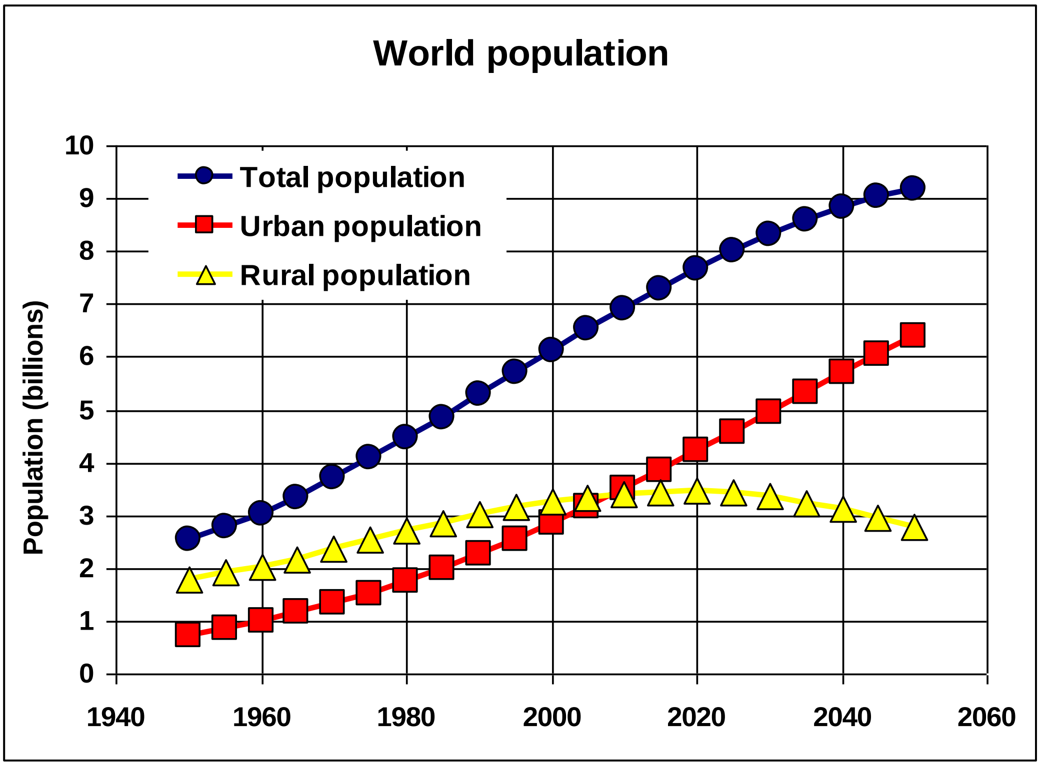

Fig. 1: Real (1950 to 2007) and projected (2007 to 2050) increases in urban and rural global population. The diagram shows 2010 as a turning point in global demography: for the first time in our history more people now live in urban centres than in rural communities (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2006; nb: the most recent updates from the UN suggests a total population increase to 9.5 billion by 2050).

As a result of population increases (Fig. 1) the demand for food and other plant-based products is projected to rapidly outpace increases in supply (von Grebmer et al., 2008). While demand for food is likely to double over the next 50 years, there are clear limits on the amount of additional land and water that can be used for agriculture. Meeting the demand for food and the resources needed for the production is a global challenge. It is therefore encouraging to see a renewed, international focus on agricultural research (e.g. Nature, 2010). The expectations for science to deliver are high, but in order to get the best value from our science investment we need to accept that science alone can't solve the problem, and that the repositioning of the role of science in problem solving must continue (e.g. Pielke, 2010). More than ever do we need science that goes beyond mere knowledge acquisition (Meyer, 2011). We need science that is engaging and eager to help humanity to tackle issues such as healthy living conditions and access to sufficient food. We need a science paradigm that is accepted by scientists and by civil society and that sees science as a legitimate and outcome-focused endeavour to tackle problems of highest societal priority. As Meyer (2011) points out, the ''knowledge as progress'' approach to scientific conduct might be inappropriate for achieving broader public values. He goes on to argue that to be successful *science must avoid the assumption that any advance in knowledge is inherently good, and offer a clearer account of the kinds of research and knowledge advance likely to generate desirable social outcomes*.

This is a huge challenge in a global, academic environment that still relies largely on counting scientific papers, categorised by disciplines, as evidence of 'scientific excellence'. This approach is particularly absurd in the context of agricultural science, which by its very nature, is always interdisciplinary (e.g. involving many disciplines such as chemistry, physics, biology, soil science, hydrology, climatology to name just a few) and often trans-disciplinary (i.e. involving social sciences as well as natural sciences, and close interactions with stakeholders).

Competing claims for scarce resources have also led to the emergence of a new, global trend: foreign investments in land resources that are regarded as 'underexploited', particularly (but not only) in Africa ('land grab'). In a recent IFPRI report, von Braun and Meinzen-Dick (2009) stressed that these shifting power relations can endanger the livelihoods of the poor, if win-win solutions for smallholder farmers and investors are not pro-actively sought. Global drivers of change also interact strongly with local circumstances (e.g. soil fertility, water availability or socio-economic conditions), resulting in often intractable scale interactions (Wilbanks and Kates, 1999). In such situations, simplistic slogans such as 'we need to produce more with less' can become counterproductive as they are exploited by special interest groups and ideologically coloured production principles that might not necessarily be in the best interest of farmers or civil society (Giller et al., 2009).

Discussions

Water is becoming increasingly scarce. A recent IFPRI report estimates that by 2025, water scarcity could cause annual global losses of 350 million tons of food production - slightly more than the entire average annual grain crop grown in the US - if urgent measures are not taken now (www.ifpri.org/media/water_summaries.htm). Although there is some scope to increase irrigated agricultural production, there are also clear limits (e.g. FAO, 2009; Rabbinge, 2007; Rockström et al., 2009). According to a recent modelling study by Rost et al. (2010), even the most ambitious and large-scale water management efforts on present cropland will not be sufficient to achieve the required production increases. Hence, we must achieve substantial productivity gains in terms of production per unit of water.

Likewise, arable land is limited. Asia, for instance, accounts for 91% of global rice production and will be unable to satisfy the increasing demand for rice due to limited arable land. Hence, we must achieve substantial productivity gains in terms of production per unit of land.
In Africa, on the other hand, crop production is severely limited by a lack of nutrients, even in semi-arid regions where water limitations are usually the dominant constraint (Giller et al., 2006). Hence, we must achieve substantial productivity gains in terms of production per unit of applied nutrients. In other words: we must simultaneously improve the various eco-efficiencies of these production systems. Although eco-efficiency in the simplest of terms is about 'achieving more with less', the concept requires careful consideration of all production factors and their co-dependencies. The concept '*…encompasses both the ecological and economic dimensions of sustainable agriculture. Social and institutional dimensions of sustainability, while not explicitly captured in eco-efficiency measures, remain critical barriers and opportunities on the pathway towards more eco-efficient agriculture*' (Keating et al., 2010).

In sub-Saharan Africa, for instance, it will not be possible to increase production with fewer nutrients; in fact, this is a clear case where more nutrients are urgently required to achieve any productivity and efficiency gains. Here the catch-cry should be 'producing more with more, but smarter', which is very profound, but not exactly 'headline stuff'. In China and India, however, where years of subsidies for fertiliser and electricity for water pumping have already led to serious environmental degradation, 'producing more with less' is considered feasible and of highest (environmental) priority. 'Eco-efficiency' is a means of thinking about systems and their performance. To make the eco-efficiency concept work requires *knowledge* and *practical wisdom*: it requires trans-disciplinary and solution-focused scientific teams and a well-educated agricultural sector (knowledge) supported by good policies and governance that are based on *practical wisdom*. Schwartz and Sharpe (2006) argue that when it comes to decision-making *practical wisdom* is a master virtue essential to solving problems of specificity, relevance and conflict that inevitably arise when contentious actions must be taken. Practical wisdom allows people to use sound judgment rather than rules to determine what to do in any particular situation. The authors further argue that practical wisdom is becoming increasingly difficult to nurture and display in modern society, so that attention must be paid to reshaping social institutions to encourage the use of practical wisdom rather than inhibiting it. Clearly practical wisdom is also a scarce resource.

In addition, Park et al. (2010) pointed out that it requires more than eco-efficiencies to improve food security. In contrast to most of the technologies that enabled the green revolution of the 1960s and 1970s, the technologies needed to achieve substantially improved eco-efficiencies are knowledge intensive. Green revolution technologies were largely delivered as 'packaged knowledge' that required little intellectual effort by the users. For instance, considerable scientific understanding and industrial-scale processing is needed to produce large quantities of fertiliser or hybrid seed. Yet, their application is relatively straight-forward. In contrast, most of the transformational technologies needed for agriculture of the 21st century are knowledge intensive and cannot be supplied in 20kg bags. To make this point, Table 1 provides a deliberately polarised view by contrasting the characteristics of 'knowledge embedded technologies' (e.g. mineral fertiliser) with those of 'knowledge intensive technologies' (e.g. legume-based crop rotations) that are needed to address the challenges posed by global changes. In reality, of course, the transition between these two types of technologies is fluid and rarely clear-cut. However, the trend towards knowledge intensive technologies is obvious and needs to be facilitated by good policies and good governance. While we need to push the scientific frontiers of knowledge, we simultaneously need to provide education that will result in farmers who are knowledgeable and who have access to technologies developed by well-trained scientists who, in turn, are able and encouraged to look beyond their own disciplinary confines, and who are willing to involve farmers and researchers in a co-learning process (Rodriguez et al., 2011). The development, assessment and sharing of sustainable land management strategies in networks like WOCAT[6] helps to provide access to technologies by farmers, pastoralists and practitioners, while at the same time using their knowledge in negotiating the implementation of such strategies with local communities and policy makers (e.g. Reed et al., 2010).

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[6] World Overview of Conservation Approaches and Technologies – www.wocat.net

Table 1: A deliberately polarised view that contrasts the characteristics of 'knowledge embedded technologies' (e.g. mineral fertiliser) with those of 'knowledge intensive technologies' (e.g. legume-based crop rotations). The green revolution was largely based on knowledge embedded technologies. The next agricultural revolution will increasingly depend on knowledge intensive technologies.

Characteristics of knowledge embedded technologies	**Characteristics of knowledge intensive technologies**
provide control over environment	improve understanding functions
derived from traditional, reductionist, disciplinary science with clear problem statements; rarely contested at that level	based on interdisciplinary knowledge; account for norms & values that often lead to different problem definitions with the result that every answer can be contested
non-contextual in time and space	highly contextual in time and space
mono-causal perspective	multi-causal perspective
single effects	interactions
addressing technical problems	addressing societal problems
silver bullets	co-innovations
Examples • mineral fertiliser • hybrid seed • irrigation systems • farm machinery • GM technology	*Examples* • legume-based crop rotations • models that improve breeding programs • aerobic rice systems • precision farming • GM crops embedded in production systems that have gained public acceptance

Effective application of knowledge intensive technologies relies on the ability to foresee likely consequences without the luxury of detailed and time-consuming experimentation. This requires systems thinking for scenario-development, i.e. the ability to envisage alternative, desirable futures. Such scenario development is often based on scale-specific modelling in order to provide quantitative information to all stakeholders about possible management and policy options and their likely consequences for farmers, the environment and civil society (Meinke et al., 2009). Such modelling can (a) help to better understand systems dynamics, (b) identify research gaps, (c) elicit stakeholder engagement to identify and implement adaptation options, (d) inform the societal debate about the range of alternative futures for agricultural systems including their likely environmental and social impacts, and (e) help to achieve a fair allocation of resources to produce what is most needed in quantities that make such products attainable for all.

Concluding remarks

Africa is a continent characterised by a diverse environment with considerable untapped production potential. Whether sustainable agricultural intensification will remain an oxymoron or will become part of Africa's salvation will largely depend on the willingness of policy makers, politicians and the global science community to change their insular approaches to problem solving. Global changes demand local adaptations of agricultural systems to achieve necessary, sustainable productivity increases. The development of Africa's agricultural sector is impaired by multiple constraints or co-limitations, which can only be alleviated by co-innovations, i.e. the ability to simultaneously address multiple constraints. A wide range of potential innovations exist, ranging from breeding (either selective breeding or genetic modifications), improved matching of physiological traits to the environment, better management practices or irrigation technology, targeted fertiliser applications, community engagement and education, to the development of local, national and global policies that encourage productivity gains. Deciding on which strategy to pursue is a huge challenge for designers and managers of these systems: In contrast to the green revolution, this time there are no obvious technological 'winners' – productivity increases have to come from a combination of efforts and technologies that must be tailored to specific regional, bio-physical, economic and societal circumstances. In particular, co-dependencies of limiting input factors such as nutrients and water need to be considered simultaneously at local scales. This makes an effective connection between global and national policy and local agency even more imperative and draws attention to the fundamental importance of scale and the different perspectives that exist between the 'macro' and the 'micro' level. Conceptual and quantitative modelling offers a way to bridge this gap by providing tractable 'in silico' solutions that can be evaluated in terms of their eco-efficiencies and in terms of their desirability by multiple stakeholders across scales before they are implemented 'in vivo'. This needs to be supported by good policy and governance that generates science beyond the 'knowledge as progress' paradigm.

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References

FAO, 2009. The state of food insecurity in the world. 61 pp.

Foresight, 2011. The Future of Food and Farming. Final Project Report. The Government Office for Science, London.

Giller, K.E., Rowe, E.C., de Ridder, N. and van Keulen, H., 2006. Resource use dynamics and interactions in the tropics: Scaling up in space and time. Agricultural Systems, 88: 8-27.

Giller, K.E., Witter, E., Corbeels, M. and Tittonell, P., 2009. Conservation agriculture and smallholder farming in Africa: the heretics' view. Field Crop Research, 114: 23–34.

Hansen, J., Sato, M., Kharecha, P., Russell, G., Lea, D.W. and Siddall, M., 2007. Climate change and trace gasses. Phil. Trans. R. Soc. A 365: 1925–1954.

Keating, B.A., Carberry, P.S., Bindraban, P., Asseng, S., Meinke, H. and Dixon, J., 2010. Eco-efficient agriculture: concepts, challenges and opportunities. Crop Science, 50: S109-119.

Meinke, H., Howden, S.M., Struik, P.C., Nelson, R., Rodriguez, D. and Chapman, S.C., 2009. Adaptation science for agricultural and natural resource management – Urgency and theoretical basis. Current Opinion in Environmental Sustainability, 1: 69–76.

Meinke, H. and Nelson, R., 2010. Agriculture, food security and climate change – why science alone can't fix the problems. Invited key note, ARDA conference 'Agriculture under the Climate Changing World', Bangkok, 8-9 September 2010. Unpublished.

Meinke, H. and Struik, P., 2010. Multiple drivers of change – a challenge for cropping systems designers and managers. Invited Key Note, AGRO2010, Montpellier, France, Aug/Sept 2010.

Meyer, R., 2011. The public values failures of climate science in the US. Minerva, 49: 47-70.

Nature, 2010. News Feature Food, Vol 466, p.456-561.

Pielke, R.A., 2010. Expert advice and the vast sea of knowledge. In: Inter-und Transdisziplinarität im Wandel? Neue Perspektiven auf problemorientierte Forschung und Politikberatung, A. Bogner, K. Kastenhofer, H. Torgersen (eds), Nomos Verlagsgesellschaft, Baden-Baden, Germany, p. 169-187.

Park, S.E., Howden, S.M., Crimp, S.J., Gaydon, D.S., Attwood, S.J., Kokic, P.N., 2010. More than eco-efficiency is required to improve food security. Crop Science, 50: S132-S141.

Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2006. World Population Prospects: The 2006 Revision and World Urbanization Prospects: The 2007 Revision, http://esa.un.org/unup

Rabbinge, R., 2007. Food, Feed, Forest of Fuel? Summing up of consensus and debate. In: Haverkort, A., Bindraban, P. and Bos, H. (eds). Food, Fuel or Forest? Opportunities, threats and knowledge gaps of feedstock production for bio-energy. Proceedings of the seminar held at Wageningen, The Netherlands March 2, 2007, pp. 3-4

Reed, M. et al., 2011. Cross-scale monitoring and assessment of land degradation and sustainable land management: a methodological framework for knowledge management. Land Degradation & Development, 2011.

Rockström, J., W. Steffen, K. Noone, Å. Persson, F. S. Chapin, III, E. Lambin, T. M. Lenton, M. Scheffer, C. Folke, H. Schellnhuber, B. Nykvist, C. A. De Wit, T. Hughes, S. van der Leeuw, H. Rodhe, S. Sörlin, P. K. Snyder, R. Costanza, U. Svedin, M. Falkenmark, L. Karlberg, R. W. Corell, V. J. Fabry, J. Hansen, B. Walker, D. Liverman, K. Richardson, P. Crutzen, and J. Foley, 2009. Planetary boundaries: exploring the safe operating space for humanity. Ecology and Society 14(2): 32. [online] www. ecologyandsociety.org/vol14/iss2/art32/

Rodriguez, D., deVoil, P., Power, B., Cox, H., Crimp, S. and Meinke, H., 2011. The intrinsic plasticity of farm businesses and their resilience to change. Field Crop Research, in press, available on-line; doi:10.1016/j.fcr.2011.02.012

Rost, S., Gerten, D., Hoff, D. Lucht, W., Falkenmark, M., and and Rockstrom, J., 2010. Global potential to increase crop production through water management in rainfed agriculture. Environ. Res. Lett. 4 (2009) 044002 (9pp) doi:10.1088

Schwartz, B. and Sharpe, K., 2006. Practical wisdom: Aristotle meets positive psychology. J. Happiness Stud., 7: 377-395.

von Braun, J. and Meinzen-Dick, R., 2009. 'Land Grabbing' by Foreign Investors in Developing Countries: Risks and Opportunities. IFPRI Policy Brief 13, April 2009.

von Grebmer, K., Fritschel, H., Nestorova, B., Olofinbiyi, T., Pandya-Lorch, R. and Yohannes, Y., 2008. Global Hunger Index. The Challenge of Hunger 2008. Bonn, Washington D.C., Dublin, October 2008.

Wilbanks, T.J. and Kates, R.W., 1999. Global change in local places: How scale matters. Climatic Change, 43: 601-628.

World Bank, 2011. Food price watch, http://www.worldbank.org/foodcrisis/foodpricewatch/april_2011.html, April, 2011.