Examples of Sustainable and Adaptable Agriculture

African responses to new challenges

By Martin Bertram, Dekha Sheikh, Mohamed Awer, Yahya Khamis Msangi, Reimund Kube

MPO/WWF International
Washington, DC, 2009

Table of Contents

Introduction: New challenges for food production and poverty reduction

By Reimund Kube/ WWF-MPO

The world is undergoing major and lasting changes, induced by climate change and a gradual end to the period of fossil fuel dominance. Both of these trends will necessitate new development paradigms, political strategies, technologies, and adaptation tools to counter unavoidable impacts, and to mitigate potential ones. Both trends are relevant from a short-term as well as a long-term perspective. As always, it is poor people and poor countries who will suffer most from these threats. Rising prices for increasingly scarce oil already contributed to a worldwide explosion of food prices in 2008. This is linked to the dependence of mechanized agriculture on oil and of all market agriculture on transport. Food items have become commodities, and Wall Street speculation increased prices even more.

But unexpected conservation efforts in the United States and the crash of the global financial system saw oil prices fall back in the second half of 2008. By then, international donors had rediscovered agriculture after decades of neglect, but without showing any sign of real policy change: they continued to focus on emergency aid, distribution of 'modern' seeds and synthetic fertilizers, and an emphasis on the need for more trade liberalization, while maintaining their damaging system of subsidizing their own agriculture. And the search for alternatives to fossil fuels gave rise to greater discussion about the much disputed use of biofuels - leading to a situation where, for example, even more corn (maize) in the US is ending up in car tanks instead of on food plates. And now, the temporary decline of oil prices makes biofuels less competitive again.

At the same time, the great international development goals are still far from being achieved. We are painfully aware that the promise of the 1992 Rio Earth Summit -- a harmonious and sustainable environmental and economic development -- was little more than beautiful words. The Millennium Development Goals, such as halving poverty and hunger by 2015, have made little progress in Africa; and where they did, as in parts of Asia, the environmental and often social consequences were and continue to be drastic.

But what does all of this actually mean for sub-Saharan Africa, a place where rural poverty is still especially rampant? Are rising food prices and the global demand for biofuels not also an opportunity for hungry smallholders? What does the explosion of fertilizer prices mean for them? What about the fact that high oil prices again make the closeness of a production site to the market an important factor of production? Should they -- can they -- produce according to the rules of a "Second Green Revolution" in Africa, with a high level of expensive external inputs? Or should they – must they -- use their farm-internal inputs and available old and new knowledge in a more intense way? Which policies and incentives are needed in the various countries and regions in order to feed people without harming the environment irreversibly? What should international and bilateral organizations, as well as civil society do and recommend, at a time of growing demand for milk and meat in mainly urban areas of the developing world -- products which are extremely energy-intensive to produce?

While these critical questions are already being considered by many others worldwide, we decided to contribute to these on-going disputes with this report by presenting existing but little known positive examples of African agriculture, that could serve as an inspiration for program planning and interventions by WWF and other international organizations. The report gives some insights into selected examples of Southern and Eastern African rain-fed farming practices that take productivity and environmental protection into account; and where farmers are organizing themselves and marketing their agricultural crops and goods in innovative and self-determined ways. They depend as little on outside resources as possible, and also have enough space to change their ways when adaptation to a changing environment -- be it climate-or market-related -- is required. The current discourse is largely divided between those who believe in the merits of greater use of high technology, in the commodization of crops and the maximization of profits at any cost, and those who consider agro-ecological systems, the right to food for everyone, and the reduction of poverty and hunger as envisioned in MDG 1, as absolute priorities.

For reasons of time and resources, we concentrate here on analyzing agricultural methods and contexts, and not on very important issues of land tenure and access to resources. But more clarity, transparency and security in this respect is one precondition for addressing the livelihood problems of African small farmers, who are often finding themselves victims of powerful 'land grabbers'. These include European-led firms interested in the production of biofuels, and more recently also Middle Eastern and Asian countries that want access to arable land in foreign countries as a way to improve their own fragile food security. Ruthless African governments willingly play along with this game, and often use the gaps created by the overlapping of traditional and 'modern' land rights, while local communities lose their only wealth: access to the lands they and their ancestors have always depended on.

Traditional tobacco curing needs large amounts of firewood (Malawi)

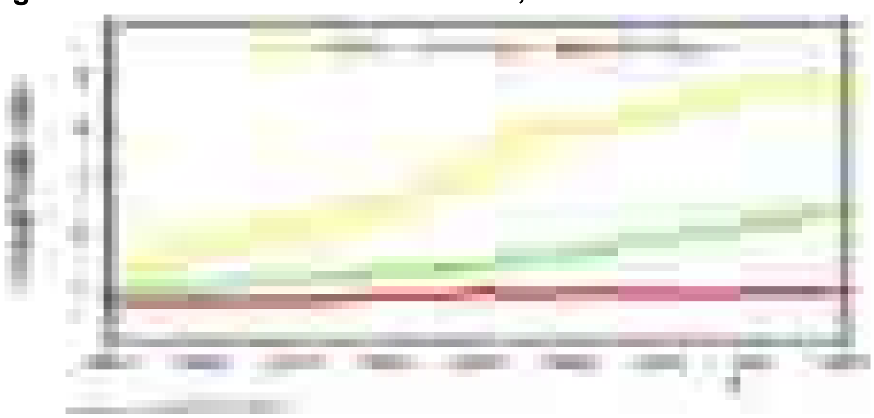
From the "Second Green Revolution" in Kenya
By Dekha Sheikh, Mohamed Awer/Good Stuff International

1. Philosophy of the "Second Green Revolution"

Agricultural productivity is far lower in Africa than in other regions of the world (Figure 1), so that Africa is not meeting the 6% growth target of the Comprehensive Africa Agricultural Development Programme (CAADP) nor its targets under the first Millennium Development Goal (MDG-1) to halve poverty and hunger till 2015. In fact, perennial food crisis has been common across Africa for the past 30 years. The Alliance for a Green Revolution in Africa (AGRA) was recently created to end this recurrent crisis by dealing with its perceived root causes.

As an entry point, AGRA recognizes that there are important lessons for improving African agricultural productivity in the Asian Green Revolution of the '50s and '60s. The Asian Green Revolution is considered a success by many; the drivers of success are seen as the use of high-yielding crop varieties and high use of inputs, as well as special policies and political will. (This contrasts with the African case, where conducive policies and an enabling institutional environment are largely lacking.)

Figure 1: Cereal Yield in t/ha for China, South Asia and Sub Saharan Africa



AGRA was unveiled in September 2006 by the Rockefeller and the Bill and Melinda Gates Foundations to provide hybrid seeds, inorganic fertilizers, water management techniques and better agricultural extension services to farmers in Africa. The intended goal is to enable the continent's small-scale farmers to prosper by building African farmer-led partnerships that draw upon the knowledge of farmers, apply the lessons of 'modern' agriculture, and work across the agricultural value chain while rigorously monitoring the impacts in terms of equity and environmental sustainability. AGRA aims to facilitate building a strong agricultural foundation, identifying high-yielding crop varieties and other tools of modern agriculture, finding uniquely African solutions to uniquely African problems, and designing solutions that improve the productivity, diversity, and nutritional quality of food crops, practice sound agro-ecosystem management across dramatically different environments, support mixed crop-livestock farming systems, and promote equity (Website AGRA-Alliance).

2. An introduction to AGRA

AGRA is trying to work across Africa to help millions of small-scale farming families lift themselves out of poverty and hunger. It wants to do this through practical solutions that are expected to significantly boost farm productivity and incomes for the poor while safeguarding the environment. The different agro-ecological zones in Sub-Saharan Africa include the Sahel drylands, which are a millet and sorghum belt; the humid forest zone, which is a cassava belt; and the (semi-)moist savanna and woodland zones, which are predominantly maize belts.
AGRA's initiatives are not exactly a repeat of the Asian Green Revolution. AGRA's philosophy is the "double green". The first "green" is to increase farm productivity through the use of both organic and inorganic fertilizers, coupled with good land and crop husbandry practices such as Integrated Pest Management (IPM) and water harvesting techniques. AGRA will support the use of both types of fertilizers in order to improve Africa's soil health based on farmers' needs. For example, phosphorous that is required for soil health to increase farm productivity cannot be obtained in large amounts from organic sources as it is not common in manure and crop residues. In AGRA, it can only be sourced from inorganic fertilizers. On the other hand, crop residues have competitive uses including animal feed.

The second "green" is environmental management, consisting of soil and water conservation techniques and the use of water recycling. This second package is based on a recognition of possibly adverse effects of agriculture on the environment and long-term land productivity.

AGRA's other strategy is to encourage interventions that can solve problems along the value chain. These programs relate to seeds, market access, soil health, policy, advocacy, monitoring and evaluation, water resources and extension. The Program for Africa's Seed Systems (PASS) was AGRA's first catalytic initiative. This program consists of education for crop improvement, real improvement of African crops, seed production for Africa, and an Agro-dealer Development Program. It is important to note that AGRA is not against genetically modified organisms (GMOs) but declares that the use of these materials rests with the respective governments. But The Bill and Melinda Gates Foundation in 2008 supported the International Centre for Genetic Engineering and Biotechnology "to strengthen and expand biosafety systems in Sub-Saharan Africa" (www.maximsnews.com) with 3 Million U$. 2009 they announced that they awarded the Donald Danforth Plant Science Center a $5.4 million grant. The funding will help the center secure the approval of African governments to allow field testing of genetically modified banana, rice, sorghum and cassava plants that have been fortified with vitamins, minerals and proteins. Thus the Gates Foundation is leading the effort to open the doors for western-based multinational biotech corporations to introduce patented GMO's in Africa. This Danforth grant is a signal that the introduction of Genetically Modified Organisms into Africa may soon be on the AGRA agenda as well (from www.foodfirst.org ,11.02.2009).

Inorganic fertilizer use per hectare in sub-Saharan Africa is the lowest in the world, and soil nutrient mining continues to be a challenge. For productivity increases to occur, it is crucial to improve soil health through the informed use of fertilizers on well-managed farms. AGRA's initiatives to improve soil fertility include supporting synthetic fertilizer distribution channels, promoting fertilizer use and improved soil management, and providing knowledge and technical support for policy change that improves fertilizer procurement, transfers knowledge to farmers, expands technologies and data resources for soil health management, and trains and networks with the next generation of soil scientists.

3. Some characteristics of smallholder farming and its environment in Kenya

a) Baseline information

Kenya's agricultural production system is predominantly smallholder-based (75%), with a smaller proportion being large-scale. The system consists of mixed farming of crops and livestock with maize as the main staple food crop, while dry bean (*Phaseolus vulgaris*) is the most important legume crop and coffee, tea, and sugarcane are the major commercial crops.

From independence in 1963 to the 1980s, the area of land under agriculture has expanded. This was driven by explicit government support which encouraged small-scale producers to adopt and expand the production of export and food crops. Government support was in the form of provision of credit and farm machinery, crop processing, markets, agricultural research and well-organized agricultural extension services. Unfortunately this support ended in the 1990s following structural adjustment programs coupled with systemic government policy failures.

Average land holdings vary from region to region but generally are small. They range from an average of 5 acres (2 ha) in the Rift Valley to less than 1 acre in the densely populated Central Kenya province. There are, however, small numbers of large-scale farms (more than 10,000 acres) in different parts of the country. Farm labor is predominantly family and community-based on the smallholder farms. Farm families take responsibility for their labor needs, and at critical stages such as planting, weeding and harvesting, neighboring communities pool their labor to work on their farms in succession.

The growth in labor has averaged 3 to 6% per year. It is AGRA's vision that land and labor productivity increases will result from the adoption of fertilizers, better yielding varieties, better choices of crop mixes, the shift to high-value horticultural crops and improved land management.

b) Adaptability to climate change (ecological sustainability)

Kenya's climate varies widely, from tropical conditions along the coast to arid lands in the interior, especially in the north and northeast. In central and western Kenya, temperature increases during the last years resulted in an extension of the land available for cultivation because some higher-elevation areas are very suitable for cropping. On the other hand, rising temperatures and increased plant water requirements may lead to dramatic reductions in the potential agricultural production, primarily in the coastal area.

Some of the impacts of perceived climate change in Kenya include increased recurrence of droughts, reduction of forest cover and other adverse effects of warming on water catchments that lead to conflicts over resources as around Lake Naivasha. Other impacts include diminishing mountain glaciers leading to over twenty rivers that flow downstream drying up; temperature increases in the higher-altitude areas; an expansion of the malaria zone with increasing malaria incidence; and increased flooding with subsequently higher numbers of water-borne diseases.

In general, most of these factors have adverse impacts on agricultural productivity, especially in marginal areas where the incidences of rain failure have increased. However, smallholder and subsistence farmers traditionally have a high resilience and efficiencies associated with the use of family labor, livelihood diversity allowing the spreading of risks, and indigenous knowledge that allows the exploitation of risky environmental niches and coping with crises. Strategies include on-farm storage of food and feed, strategic use of fallow, and late planting of legume crops.

The use of hybrid seeds which have to be bought each year, might create a higher risk for farmers if these seeds are not bred exactly for the prevailing conditions. Generally, many ‘improved’ varieties produce better only in near-perfect conditions and are not adapted to the often harsh environmental conditions of African landscapes.

c) Adaptability to market and price changes

Smallholder farmers allocate larger shares of land and factors of production to low-yielding food crops than they do to cash crops with higher market returns. This decision is based on their need to secure adequate nutrition, their necessary aversion to risk, recognition of poor access to credit and lack of good markets and insurance. Smallholder agriculture generally is dispersed over wide areas, and infrastructure connecting farms with markets is often poor, resulting in high transport costs for moving produce between farms and market centers. During rainy seasons, farmers in areas with poor infrastructure cannot move their produce to markets. In this situation, higher-paying horticultural crops may perish in the fields.

The Kenyan government has not developed a comprehensive agricultural development strategy. On the contrary, the Ministry of Agriculture has come up with donor-supported insular programs. One of these, the Kenya Agricultural Commodity Exchange (KACE) Program, has developed a market information and linkage system (MILS), designed to make agricultural markets work better for farmers, especially smallholders. MILS provides reliable and timely market information and links farmers to better markets through matching of commodity offers and bids. The KACE involves harnessing modern ICT (Information and Communications Technology) to empower farmers, traders, brokers, processors and consumers with low-cost, reliable and timely market information. This enhances the bargaining power of farmers to receive a better price in the marketplace, and it links farmers to markets more efficiently and profitably. But currently ICT access is very limited in rural Kenya, so many farmers are not able to benefit from MILS. Again, market information on its own does not provide sufficient incentives for farmers to invest in the most profitable commodities when other factors are constraining, like a lack of good roads to the physical marketplace.

Working on agricultural markets, whether directly or indirectly e.g. through market information, is an area that AGRA might not deliver on. The situation is driven by government policy or policy failures in the context of post 1990s Kenyan agriculture.

d) An international market: horticulture

With the right enabling environment, Kenyan smallholders have been able to participate in horticultural export markets despite a need to comply with the tough ‘good agricultural practices’ (GAP) and retail quality standards which are required by the European Union. Support has come from the research by ICIPE (African Insect Science for Food and Health)/Nairobi on Integrated Pest Management (IPM), the development of private-sector extension services for out-grower producers, the development of an accredited local certification body, and the development of a quality management system.

It is however important to note that profitable horticultural farming is mostly a commercial undertaking by well-to-do farmers, and smallholder farmers in Kenya have not penetrated that market barrier of investments and access.

e) Agriculture and AGRA: Integration into development plans ?

As mentioned above, there is no comprehensive agricultural development policy in Kenya that integrates all of the key variables of agriculture (institutions, credit, markets, infrastructure; food security, subsidies -- especially in view of global shocks, insurance, agricultural extension and research). On the contrary, there are tailored programs funded by donors that deal with isolated issues in the sector (see section 4c above). Consequently, the agenda of AGRA is also being implemented more or less separately from other agricultural and development programs.

AGRA has tried to overcome this weakness through engagement with the government of Kenya and other actors in the agricultural sector, while providing its own resources. AGRA recognizes that revolutionizing African agriculture requires work at two levels: agricultural services and inputs, and sustainable land management. However at this point, AGRA has not delivered convincingly on these goals. AGRA staff did not provide information on their funding levels, so it is hard to say how much resources AGRA has for the “double green” revolution.

4. Some socio-economic traits of farming families

Most smallholder farmers have at best completed basic education (eight years). In fact, the majority has not gone to school. Family units are large, usually between 8 and 10 people per household. Incomes vary from region to region; in general, small-holder farmers produce mainly for subsistence. They sell some of their produce to meet other needs, principally school fees for their children. With educational standards falling and private education remaining costly in Kenya, this is likely to perpetuate their poverty.

Smallholder farmers account for 70% of Kenyan agricultural production and 50% of marketed output, yet they are the poorest in Kenya. Most of these farmers grow crops on plots of an acre or less, and they slip quickly into a cycle of deepening poverty and misery. Inputs such as seeds, fertilizers and equipment are beyond the reach of the majority. In addition, these farmers depend on middlemen or brokers to get their produce to markets. These brokers earn over 25% of the wholesale price, so farmers earn very low prices for their produce and hence cannot afford to invest in inputs to increase yields. This cycle of deepening poverty is further aggravated by population growth, forcing the subdivision of farmland into smaller, less economically viable plots. Currently AGRA does not seem to address these issues.

One of the areas that AGRA might directly influence is the marketing of produce. AGRA will engage with policymakers to provide the right enabling environment for farmers to obtain the most from their investments in land and labor. AGRA might, for instance, engage with the cereals marketing board to remove barriers for small-scale farmers such as delays in payment after delivery, distance to collection centers and transport costs, and to deal directly with the board. It was not clear from the interview with AGRA what form this will take. Still, AGRA commits to providing seeds and other farm inputs.

Farmers have continued to grow food crops that do not do well in many areas without inputs, as the main mechanism of attaining self-sufficiency and food security. They do not get good income from crop sales either, as there are no good markets and they have to travel long distances with added transaction costs to sell their produce in nearby trading centers.

On average, farmers in Kenya use 50 kg of diammonium phosphate (DAP), 50 to 100 kg of calcium ammonium nitrate (CAN) and 10 litres of herbicides per acre. But these are aggravated figures, many farmers are not able to procure these inputs, and are unable to use organic fertilizers due to a lack of knowledge. The use of pesticides by small-scale farmers is insignificant. As noted from the case studies, only in an environment where support is provided to farmers (e.g. technical and market access) do we find inputs like fertilizers and pesticides. These farmers are normally producing on a large scale, either as individuals or as kind of a company or cooperative.

Another source of income for rural farmers is remittances from family members with formal employment in a city or town. Families with such relatives have more secure monthly incomes and so can get their children to private schools, procure farm inputs and subsequently obtain higher yields from their farms -- getting better returns to labor and land.

5. Kenyan Partner Organizations

There has been concern about food security in Kenya since 1993 due to a rapid decline in the production of cereals and pulses, resulting in food deficits (Kenya Agricultural Research Institute (KARI) website). This poor performance is due to biophysical constraints (droughts, diseases and pests), and socio-economic/policy bottlenecks (input-to-output economic ratios, inadequate infrastructure, lack of marketing opportunities, changing price levels).

In response to these concerns, KARI and its partners have worked on technologies to replace inefficient components with more cost-effective options such as much higher-yielding varieties, better crop husbandry practices, more efficient use of inputs, lower cost of transport/warehousing, etc (ibid). This also included a focus on sustainable soil fertility management, such as the use of locally available materials and organic fertilizers.

KARI has been partnering with AGRA and various NGOs to provide quality seed to farmers. The KARI Seed Unit (KSU) was established in May 1997 and registered as a seed trader in December 1999. Its responsibilities include developing sustainable organizational structures for producing, processing, marketing and distribution of good quality breeder, pre-basic and basic seed; and maintaining all pre-released and released parental lines, populations and varieties as well as vegetatively propagated planting materials (KARI website). In addition, the KSU is helping the informal seed sector to produce high-quality, farm-saved, open-pollinated variety (OPV) seed by training seed producers who are also assisted by various NGOs. The goal of the KSU is to disseminate knowledge and technologies and to catalyze the process of outreach and adoption of agricultural technologies, and establish sustainable funding initiatives. This self-sustaining seed unit system has started with a few pilot centers that provide seeds and planting materials to customers on a cost-recovery basis (ibid).

The contracted farmers who were interviewed are very happy with the technical support provided by KARI and KEPHIS (Kenya Plant Health Inspectorate Service) to grow good-quality seed, particularly with the ready market that is provided for their seeds. But the two farmers interviewed were model farmers who enjoy special support. With the privatization of agricultural extension, lack of credit schemes and soaring prices of farm inputs, most farmers are still constrained and reduced to subsistence farming.

Farmers will adopt technologies and good practices within a positive enabling environment when their needs (from the production along the value chain to marketing) are fully considered. The government must come up with a comprehensive agricultural development policy that encompasses the whole continuum of the production and value chain including the necessary infrastructure. This policy would also incorporate an early warning system for severe climatic conditions and market dips in order to mitigate risks. From the case studies it was noted that the single best incentive for small-scale farmers is a ready and accessible market for their produce. There may be important lessons to be learnt for the planners of AGRA from these two cases which are partly connected with them.

6. Two case studies related to the AGRA initiative

a) A couple in Kwale District

Mr. and Mrs. Mailu Ng'ata retired from the civil service seven years ago after 34 years of service. They own a 28.3 acre (11.3 ha) farm on the slopes of Mount Kwale, off the Nairobi-Mombasa highway, in southern Kenya. The area is semi-arid, but their land is fertile due to the rich volcanic soils of Mount Kwale and they consider themselves lucky as they have never used fertilizers. They do, however, use pesticides to control insects. These include Topseed, Ridomil, Danadim and Alphaguard. There have been no health problems related to the use of these pesticides, and technical support for proper use is provided by advisors. Only when pests are noticed on the farm are pesticides used, and only at a low level.

The Mailus use oxplows to cultivate their land, thus saving on labor. Both of them and one farmhand work on the farm full time, and they contract additional workers during the harvest. Every five years, they use a tractor to plow deeper into the soil to improve the land's productivity.

They have been on contract with the KARI Seed Unit (KSU) for the past six years to produce legume seeds (green grams, beans, cowpea, and pigeon pea). Farmers are linked to KSUs through local units referred to as Seed Industry Development Units (SIDUs), which are strategically placed in areas where individual seed farmers with adequate rain or some irrigation facilities produce seed. These farmers are contracted by the KSU who monitors the growth of the crop and provides technical support; certification is done by KEPHIS who also provide quality control by inspecting and certifying seed and plant variety protection. The harvested seed is bagged; sold to KSU for cleaning and packaging; and then sold to agro-dealers and NGOs (World Vision, Concern International, Food for the Hungry, ADRA etc.) for national distribution.

In his own words, Mr.Mailu notes that, "I have five children in total, two boys and three girls. The revenue generated from the program has enabled my children get a good education. I have also put up a brick house, and preparations are underway to have it opened by the director of KARI."
The Mailus plant seeds in each of the two rainy seasons. Their profits amount to 500,000 – 800,000 Kenya Shillings per annum, or $6,250 – 10,000 US. This has helped them expand into other activities including poultry and forestry. They also plan to add beekeeping and agro-forestry.

Unpredictable weather, droughts and water shortages all pose great challenges to the Mailus. They feel, however, that the program would be sustainable if there were stable market conditions, enough land, more technical advice, and government subsidies and/or insurance coverage in the case of crop loss due to bad weather.- The Mailus' case is an exception in smallholder agriculture in Kenya. They are fairly well educated, have foundation/network experience from their time in government service, and received a retirement package that enabled them to undertake better agricultural production than the average smallholder in Kenya.


The semi-permanent family house before participation in the KSU Project, and the permanent, modern house that was built using proceeds from the KSU Project

b) A CBO in Siaya District

This community-based organization (CBO) is located in Siaya district in western Kenya; it includes 45 farmers who belong to a Farmers' Field School. The group is composed of HIV-positive widows/widowers who have accepted their status and are living positively. The CBO started off as a welfare association. They have since been engaged in improved farming/livelihoods activities under a KARI, ICRAF, and World Bank project called the Western Kenya Integrated Ecosystem Management Project that has goals related to improvements in soil fertility, crop yield, nutrition, health and marketing.

Their farming practices were previously characterized by low crop yields, weed infestation, and a lack or limited use of organic/inorganic fertilizers. The low yields were the result of using uncertified seeds, continuous farming of the same crop on the same piece of land, improper land preparation techniques and lack of reinvesting into the land. Farm families also were losing weight and experiencing frequent illnesses. Meals were available only once a day, and the children were inactive. To cope with the challenges of poor health and occasional hunger, members depended on remittances from their children in urban areas, and sometimes engaged in labor migration themselves. The community was a net importer of food crops including maize, kale, cabbage and potatoes.

The project promoted the use of better land preparation techniques, proper plant spacing, certified seed, flower growing and compost. Follow-up studies on farmers' fields have shown that production of maize increased by an average of 800% between 2006 and 2007. Members currently earn an average of 200 Kenya Shillings per week from the sale of produce, and consume on average 500 Kenya Shillings worth of farm products. Health and nutrition has improved significantly due to the consumption of the assorted vegetables (kale, onions, capsicums, peppers, and indigenous vegetables) now being produced, as well as of poultry, goats, and 'security crops' like cassava and sweet potatoes.

CONCLUSIONS:

It is difficult to assess the success and approach of AGRA, as it is still in its formative stages in Kenya after only two years of operation. Also, AGRA is mainly working through Kenyan partner agencies who largely share the same agenda as AGRA -- so the effects of AGRA are difficult to assess and attribute.

A key finding of this report is that farmers in Kenya do not know about the opportunities in AGRA, as AGRA has not yet rolled out in the field. Until now, AGRA has been working with breeders to develop high-yielding hybrids and it will provide seeds later through implementers, such as KARI in the case of Kenya. This takes time, and certainly in its two first years of AGRA's existence, it has not yet been practical for it to supply seeds. So farmers in Kenya (including model contact farmers such as the two discussed in the case studies) continue to depend on themselves or on the support from others.

AGRA operates under the assumption that agricultural inputs will be available to everyone, but this is not currently the case in Kenya and it does not look like this will change rapidly. AGRA

does not seem to systematically address this issue by increasing the provision of credit facilities and organizing input distribution systems. This could lead to a very limited success of AGRA’s agenda, since it would seem to favor large enterprises with some financial means.
AGRA's analysis seems comprehensive of the Kenyan context; however, it is unclear how its approach takes into account the key constraining issues of limited access to markets and credit for smallholders.

AGRA’s agenda will never solve the agricultural challenge in Africa alone. In Kenya, for instance, it will need to act within a conducive and comprehensive agricultural policy that does not yet exist. As a powerful organization, AGRA should consider pushing the Kenyan government to establish such a policy.

To increase the odds of success and long-term sustainability, AGRA might want to consider an even increased role for the private sector, especially as implementing partners for the distribution of inputs and the provision of market access and credit.

AGRA needs to better recognize the complexity of the ‘double revolution’ in relation to the viewpoints of potential partner NGOs, especially with respect to the use of improved seed varieties, fertilizers and pesticides. Many NGOs do not share the vision of improving Africa’s agriculture through hybrid seeds and expensive external inputs but believe in more appropriate, localized solutions, especially when it comes to the cross-cutting issue of reducing poverty.

Bibliography:

1) AGRA Generic Presentation of 2003

2) Adrian Mukhebi, KENYA Agricultural Commodity Exchange Limited (KACE), Reaching the Poor in Rural Kenya with Market Information: A Case Study of a Market Information System, A Paper for presentation at the CTA Seminar 2004 on the Role of Information Tools in Food Security, Maputo, Mozambique, November 8-12, 2004

Conventional or conservation farming for the average African farmer ? [1]

By Martin Bertram, PELUM

Farming in Sub-Saharan Africa

Today, some of the best-known promoters of the so-called New Green Revolution (GR) and of mainstream agriculture (here called conventional farming, see also Questions and Anwers 1), analyse weaknesses of the African economy, rural development and agriculture and agree in many ways with the promoters of organic or conservation farming. Both sides agree that an integrated approach is appropriate to tackle the complex problems of rural Africa. Both sides acknowledge the low level of current agricultural production and its untapped potential. But while J. Sachs et al. promote the use of more external inputs, particularly synthetic fertilizer and perhaps even genetically modified organisms (GMO) -- approaches mostly dominated by foreign companies and experts -- supporters of conservation farming (CF) and organic farming (OF) search for indigenous African solutions from independent farmers that take the continent's special circumstances into account.
These are some facts:

- 50% of the World Food Program's food aid, worth $7 billion U$, has gone to Africa and is increasing. What is unclear is if this is part of the solution or part of the problem
- 20 years after the political independence of many African states, Africa has become a net importer of agricultural products
- >28% of Africa's population, often urban and living in unstable political conditions, suffers chronically from hunger
- In 2000, 10 farm households were needed to feed 7 urban households in Africa
- Africa has the highest population growth of any continent. This mostly urban growth will require from 10 farm households to feed 16 urban households in 2020.

When it comes to analysis of the root causes, there are often some things confused.

- India's breadbasket area and large parts of North America and Europe have stable soils, while Africa's soils are generally much older, more leached and vulnerable
- Many think the reason that India increased its rice production and Africa remained at a low level of productivity is a difference in the use of synthetic fertilizers - thus concluding that these are the primary means of achieving food security

[1] Data, if not stated differently, sourced with friendly permission from Conservation Farmer Unit, CFU, Lusaka/Zambia,2008

- But India's increases during the '60s coincided with the same ratio of new land brought under cultivation. Moreover, India differs largely from Africa in most regards.

Analysis of the root causes of Africa's low agricultural production shows that land is still plentiful and productivity could be increased without expensive fertilizer; but the right incentives must be in place and the destruction of soils must be stopped.

African soils need special care. One way to get there is by changing to conservation farming practices, meaning zero or minimum tillage and early sowing. Plant nutrients are placed directly near the plants in permanent furrows or basins; these might be synthetic fertilizers during the first years, to be replaced later by manure/ compost and more sophisticated systems of crop rotation and fallows. Currently, 100 million hectares are under zero or minimum tillage worldwide -- but in Africa, where it is needed most, it covers only 0.8% of that surface area.

With regard to the situation in Zambia:

The average African farmer cultivates 1.5 hectares of land, the Zambian farmer 2.75 hectares. Zambia has 15 people per km^2, compared to 150 in Malawi. In Zambia only 15 to 20% of land that could be cultivated is farmed; soils are good, and rainfall is mostly reliable for now.

More than 50% of all Zambian households farm, and nearly all of those grow maize (95%). 42% (32% over the past 8 seasons) of all maize fields are *abandoned* at the time of harvest (!).

- The average maize yield per ha in Zambia is only 1.13 tons/ha, compared to 8.5 tons/ha for rain-fed corn in the US. Conservation farmers and some large-scale farmers harvest about 7 tons.

- 73% of maize growers do not sell any maize. They are consumers as much as they are producers. These are amazing figures, being true in Zambia and vast parts of Africa.

Farmer with hired oxen. Plows Mid Dec 2007, one month after the first rains

The maize crop in March 2008- a near total failure

Why do so many farmers have so low yields?

Farmers in many parts of Africa start tilling by hoe or plow after the soils have softened from the first strong rains; in Zambia, this is between October and December. Just days after the rains, conventionally treated soils harden and largely prevent tillage. While conservation farmers take advantage of the first strong rains from mid-November on, their conventional colleagues cannot cope with the labor peaks, miss the optimal time for germination and weeding, miss other rains, and try to catch up with the season when it is too late, in late December.

Even when farmers have tilled some of their land, fertilizers are often available only at a later stage; and without fertilizer, most conventional farmers do not sow maize except on newly cleared forest land. Waiting lists for plows are long, and many farmers are still waiting when much of the rain has already ended.

The dependence of conventional farmers on a plow or hoe to mechanically prepare soils that are already physically and chemically degraded means that they miss most of the rainy season each year. One-third of all maize crops, though they are planted on tilled ground and with the seed paid for and fertilized, are not weeded and thus not harvested because the rainy season ends before the maize ripens.

Climate change is often blamed. And food aid is distributed - every year - where large-scale farmers and conservation farmers of all sizes have normal harvests. (Normal in this case does not mean the average ton per hectare, but 3.5 to 8 tons/ha.)

In eastern Zambia and Malawi farmers split ridges in the dry season. Hoe pans form under the ridges. 700 millions + tons of soil moved yearly by hand !

After years of plowing, pans form at about 10-12cms and roots are unable to penetrate to deeper layers to absorb nutrients and moisture

(Photos: CFU 2009)

Without biological soil improvement such as from termites, worms and microorganisms nurtured by plant residues or cover crops, soils harden and do not allow water or roots to penetrate the plow or hoe pan. These soils suffer from water-logging due to a lack of drainage, and from drought towards the end of the season. Floods and droughts, typical indicators of climate change worldwide, have been mostly manmade in Zambia until now, due to soil destruction.

Conventional small-scale farmers in Zambia do not work enough in the late rainy season and dry season to prepare their soils. They move and disturb it too much, and they harden it. This, then, is the reason for their unwillingness to work unless rains have soaked and softened the ground. So they cannot use the first rains for planting and lose the free gift of natural nitrogen after the first rains ("nitrogen flush") as well as the rainwater of the first weeks. This leads to a shorter effective rainy season which means a yield loss of 1.5% per day for maize and 2% for soybeans. The average Zambian farmer is 3 weeks late and has lost 30% of his/her potential harvest even before he/she starts sowing!

Permanent Planting Basins. Only 12% of surface area disturbed

Land preparation can commence in June, spreading labor inputs. In Zambia rains normally start in late November

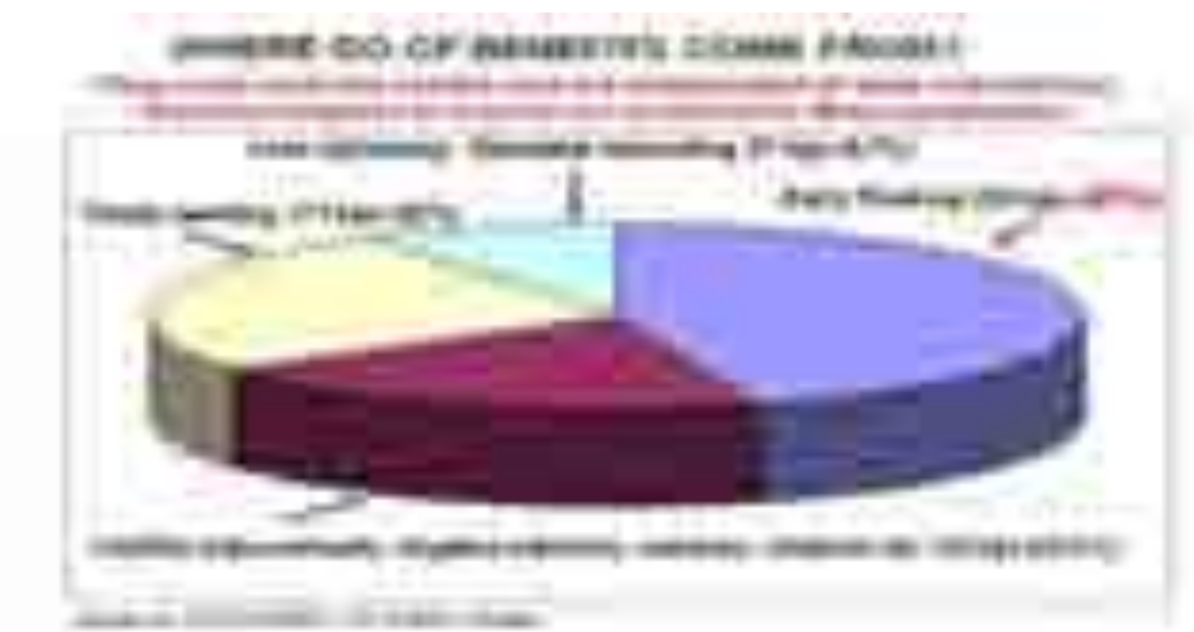
But some are doing better !

They do minimum tillage and spread the labor over the whole dry season- they have made their preparations before the rains start. They sow their fields in one go and have enough time to weed early, when the weeds have just emerged. Organic matter has been settled in the basins, and manure or fertilizer and lime has been put at the base of the plants. Termites have started to produce fertilizer out of the organic matter and to dig channels for infiltrating water and roots.

Many Zambian farmers do not spread their labor over the year, till too much, waste the little fertilizer they can afford, and are late in sowing. Moreover, they burn organic residues and do not use crop rotation, cover crops, mulch or improved fallows. These are reasons while some farmer's fields look like the one on the left picture, and many conservation farmer's like on the right one (both pictures from CFU).

A study of African farming

The study consists of 17 cases mainly from small-scale Zambian farms, but also including other scales, places and farming categories. The Zambian farms are mainly farms that have converted from conventional to conservation farming. The results, represented by the CFU/GART (Golden Valley African Research Trust) diagram (2004) below, reveal an increased yield through CF of 68-70% in the first year, whether synthetic fertilizer is applied or not.



The lower the fertilizer input, the larger can be the effect from conservation farming. Small-scale farmers profit most. But even farmers applying 300 kg of fertilizer can earn about two thirds of their harvest through conservation farming methods. Fertilizers are subsidized in Zambia; and many promoters of so-called modern agriculture demands increased subsidies and loans for fertilizer. Maize requires large quantities of nutrients; and so the dependence on maize requires a great deal of fertilizer, manure or legume crops. Input subsidization might be seen as relief by desperate farmers, but it worsens the situation in the long run. But the vicious circle of under-production, subsidization, market interventions and foreign aid could be broken with a qualified practical introduction of the described CF and organic methods into African agriculture.

The 120,000 Zambian households (9.5% of all crop-growing households) already trained in CF are harvesting 40 to 120% more on their CF land than the average conventional farmer.

Photos below: "Normal" soil-destruction, left, and intelligent direct sowing into the stubble without tilling, right, in mechanized large-scale agriculture :

Dry season plowing destroys good soils . Then the soil is further damaged by discing:

(Photos: CFU)

Seed and fertilizer planted straight into ground through the previous crop. No soil disturbance. No erosion, less compaction, all rainfall captured. Fuel cost cut by 70%.

Our study examples show that small-scale conventional farming in Zambia is a failure, large-scale conventional farming misses considerable results; but both small- and large-scale conservation farming offers good yields. In Zambia, conservation farming does not mean to have to do totally without the synthetic fertilizers and herbicides typical for conventional farming, but it may include appropriate soil cover, cover-crops, crop rotation and even the integration of *Faidherbia albida* trees, which is typical for organic farming. It uses minimum tillage and avoids the burning of biomass.

On the following table, single farming tools rather than the conventional categories are evaluated for their effects and use by the farmer. It is based on various studies and experiences, and was peer-reviewed by a number of experts.

The table above shows that permanent furrows and basins, minimum tillage, the integration of nitrogen-fixing *Acacia or Faidherbia albida* (60-100 trees/ha), and permanent ground cover are essential for sustainable production and high labor and land productivity. It also shows the irrelevance of pesticides (other than herbicides in conventional farming), and the slim chances of gaining much from the use of GMOs. Improved non-GMO varieties are of medium importance. Profit was measured multiplying the yield by the market price at the respective time, deducting costs. Not mentioned in the table is the most important factor in Zambia, where there is only one relatively short rainy season: early sowing, with intensive labor, after the first 20 mm of rain falls in mid-November (see earlier discussion). Mechanical weed-control proves to disturb the soil. Unless it is done very early and frequently, it is very labor intensive. Cover-crops are a better and the most profitable way. Herbicides, typical for conventional farming, are the easiest way of weed-control, but with considerable environmental side effects and potential health hazards. Organic manure, although better and cheaper than synthetic fertilizer, needs livestock, skill and rational distribution methods, e.g. ongoing application throughout the season. The traditional work-break during the dry season that lasts for months, is the reason why most Zambian farmers are still not using manure or compost and depend on expensive synthetic fertilizer.

The interesting finding of the study is that within the investigated range, ecological and economical sustainability indicators are co-related. That means: the greener the richer. Different from results in other studies in Europe and America with convertors from conventional to organic agriculture, here in Africa yield and profit increase immediately. What is proved for organic agriculture in Africa, the higher profit AND yield, could be confirmed including the result that unlike to direct conversion to organic, there was no transitional depression in yields when CF was used.

Agriculture and Carbon

Part of the environmental footprint of each measure can be calculated in terms of increasing the greenhouse effect through the emission of greenhouse gases (GHG), or the inverse process of taking greenhouse gases from the atmosphere and storing them temporarily in the form of soil organic matter or plant matter (sequestration).

Ecological sustainability was measured through CO2 equivalent (CO2 e), an internationally acknowledged indicator.

The relative CO2 e in conventional farming:

A normal tractor in Zambia consumes X liters of diesel and has a wear-and-tear factor Y to plow one ha of land, plow under weeds and soften the soil. The next measure is to harrow or disc the field with a certain level of diesel consumption and more wear-and-tear. Then comes drilling (sowing the seed and closing the furrow with the tractor and drill machine), and applying synthetic fertilizer produced from fossil fuels and transported to the farm with a certain amount of diesel used by a truck. Then comes fertilizing and spraying against weeds twice.

Diesel, fertilizer and spray represent negative carbon equivalents added. The harvest and the produced biomass represent a positive carbon equivalent because solar energy has brought back CO^2 from the atmosphere into the maize cone and the maize plants.

But if consumption and production are added, a negative carbon equivalent results. More carbon from fossil sources was blown into the atmosphere than sequestered by biomass.

In conservation farming, we take the same tractor driving over the stubble with a direct planting machine. Seed is fertilized and sown directly in one go, and cow-peas are sown without fertilizer to suppress weeds and add nitrogen and biomass. The tractor drives across again to apply top-dressing fertilizer.

There is 90% less wear-and-tear, less diesel is needed, and the cow-pea seed is a carbon equivalent input. No herbicide is used, meaning a tractor is not needed to apply it. The harvest of maize is the same as in conventional farming, but, cow-peas can also be harvested and the soil has been covered and enriched by carbon-containing organic matter.

The carbon equivalent is far more positive; although fossil energy from diesel and fertilizer has been added to the atmosphere, more GHGs were sequestered via the production of organic matter than fossil energy was used.

Conservation farming and organic agriculture can reduce the consumption of fossil energy to nearly zero and even sequester carbon in a durable way as soil organic matter. The huge seasonal increase of biomass will be harvested and consumed, however, so that the benefit in the end is a comparable reduction of the use of fossil fuel per production unit per season plus a real mid-to-long-term sequestration by soil organic matter, permanent crop cover and agroforestry plants.

The carbon effect of CF is a reduction of the increase in CO^2 equivalents in the atmosphere. Sequestration is also provided, but on a level that needs additional measures to reduce CO^2 equivalents in the atmosphere. More importantly, the intensification of agricultural production in Africa, such as through CF, can save forests from being cut down. Additionally, as an alternative approach to worldwide food production and rural income generation, CF has the potential to compensate for increased demand through population growth for several decades to come, if sufficient funds and expertise for the necessary extension activities are provided.

Annex I About the Table on Page 20

The table evaluates the advantages for the farmer and scores them:

The first three columns are not counted in the overall score. They try to evaluate the known categories (conventional, conservation, and organic) and whether a method is typical (4), frequent (3), occasional (2), exceptional (1), or never used (0).

The following columns show factors of importance or applicability from 4 to 0.

Two columns are counted double (8 to 0):

- Adaptability (higher labor productivity by labor reduction, done quickly)

- Importance for obtaining high yields (8 essential for high yields).

The other criteria:

Immediate results: Is the result visible within one season or immediately, like inhibiting the growth of weeds (4), or does the effect take years, like planting fertilizer trees (1)?

Less wear-and-tear reduces costs for machinery. Plowing or mechanical weeding is material-intensive (0), while cover crops do the same job without any maintenance of machinery. The Energy criterion is similar; mechanical weeding requires a lot of energy (0) and spraying a little energy in the product and for application (1).

Influence on the soil structure means whether roots can reach deep soil horizons with access to water and nutrients, and whether rain is infiltrated or leads to stagnation or runoff. It is related to the softness of the soil, and the amount of medium-size pores and organic matter in the soil. It is a main indicator for flood and drought resilience.

Nutrients in the soil can be added through artificial infusion (synthetic fertilizers) or indirectly by feeding micro-organisms, which can release nutrients to the crop roots.

Weed reduction is important for labor volume, costs, and plant nutrition.

Cost reduction is important because yield alone does not guarantee profit; in many cases, conventional farmers suffer from high input costs, while small-scale farmers have no way to compensate for low profits per hectare by farming a larger area.

Plant health: Many measures might lead to an immediate increase in plant matter but affect the health of the crop, requiring more and more protective measures. An example is intense plowing and fertilizing that leads to fast initial growth but increases the susceptibility to pests and disturbances in the soil-water regime.

Resilience of farming systems and measures leading to resilience is a very important factor for food security in poor rural areas. Resilient systems need less input, are more climate resistant, tolerate a temporary lack of attention, and bear harvests even under difficult conditions.

Affordability is the price or effort to acquire necessary tools or inputs. For African small-scale farmers, affordability is crucial, as they have low cash incomes and hardly any access to loans.

CO_2 equivalent is an indicator for ecologically sustainable management (see above). A high score means the resources for agriculture are improved (more carbon means more organic matter), while low scores mean mining of soil and exhausting the production base.

Score. The measures are in order from the highest importance to the lowest. The score provides a long-term valuation of the importance of the investigated measures for successful farming in the Zambian context. Scores below 25 lead to the assumption that the measures are not essential and can be replaced by better alternatives. Scores below 20 indicate measures that might be too cost intensive and/or have adverse effects to what was originally intended.

.

Annex II Excerpt of used and recommended Literature

Badgley, C. et al (University of Michigan, 2007): Organic agriculture and the global food supply in: Renewable Agriculture and Food Systems, 22:80-86 Cambridge University Press

Bertram, M., 2007: Food security concerns in ACP countries
The role of ACP-EU Co-operation; ACP/EUJoint Parliamentary Assembly Commitee on Economic Development Finance and Trade (Brussels 12-13 September 2007)

Bertram, M., Suede, C.; 2008: 17 cases of conversion from conventional to conservation farming in Africa; PELUM

Halberg, Nils et al (2006): The impact of organic farming on food security in a regional and global perspective in Halberg et al: Global Development of Organic Agriculture - Challenges and Prospects, ISBN: 978 1 84593 078 3

FAO, (2005): "The State of Food Insecurity in the World 2005: Eradicating world hunger – key to achieving the Millennium Development Goals." (Food and Agriculture Organization of the United Nations; Rome, Italy)

FAO, 2007:
Organic agriculture and food security Conference
ftp://ftp.fao.org/paia/organicag/ofs/OFS-2007-3-rev.pdf

IPCC Report 2007:
1.8-4°C more until end of 21st century

IFAD. (2005). Organic Agriculture and Poverty Reduction in Asia: China and India Focus. Thematic Evaluation, Report No. 1664. (International Fund for Agricultural Development, Rome, Italy)

Kotschi, J. 2006. Coping with Climate Change, and the Role of Agrobiodiversity. Conference on International Agricultural Research for Development. Tropentag 2006 University of Bonn. October 11-13, 2006

Ouedraogo, E.; Mando, A. and Brussaard, L., 2006: Soil macrofauna affect crop nitrogen and water use efficiencies in semi-arid West Africa. European Journal of Soil Biology, 42, suppl 1, s275-277

Pretty, J. and Hine, R. 2001: Reducing Food Poverty with Sustainable Agriculture: A Summary of New Evidence. Final Report from the SAFE-World Research Project, Feb 2001. University of Essex, Colchester, UK. A summary of the report is available on
http://www2.essex.ac.uk/ces/ResearchProgrammes/SAFEW47casessusag.html

Pretty, J., 1999: Can sustainable agriculture feed Africa? New evidence on progress, processes and impacts. Environment, Development and Sustainability 1: 253-274. Kluwer Academic Publishers

Pretty, J. et al (2006): Resource conserving agriculture increases yields in developing countries. In: Environmental Science Technology 40 (4), 1114 - 1119

Parrot, N. and Marsden, T. (2002): The real green revolution. Organic and agro-ecological farming in the South. Greenpeace Publications

Sachs, Jeffrey, D. 2005: The End of Poverty, Penguin Press New York

Scialabba, N. and Hattam, C. eds (2002): Organic Agriculture, Environment and Food Security. Environment and Natural Resources Series No. 4. (FAO, Rome, Italy)

Yussefi, M. (2006): Organic Farming Worldwide 2006: Overview & Main Statistics. In "The World of Organic Agriculture: Statistics and Emerging Trends 2006", pp. 23-37, eds H. Willer and M. Yussefi (International Federation of Organic Agriculture Movements; Bonn, Germany & Research Institute of Organic Agriculture: Frick, Switzerland).

AN EXAMPLE FROM TANZANIA OF SUCCESSFUL ORGANIC AGRICULTURE WITH INTEGRATED PEST MANAGEMENT (IPM)

By Yahya Ksamis Msangi/TAPOHE

Background

Concerns about human health and environmental sustainability in agriculture have given rise to different farming systems and approaches. The main objective of these systems is to reduce the use of industrial inputs such as pesticides and synthetic fertilizers. Some of these systems lean towards a form of organic farming (OF) and include integrated pest management (IPM) and integrated vector management (IVM) in animal husbandry.

Tanzania developed a National IPM policy in 1997, and several IPM groups for farmers were established in the country's agricultural zones. This was driven by the Ministry of Agriculture & Food Security, with support from various national and international organizations. The concept of Farmer Field Schools was adopted, including the use of AESA (agro-ecological system analysis). Farmers were trained through these schools in how to conduct AESA on their individual or collective farms. A system of organic farming (OF) was also introduced, and the production of organic products such as cotton, tea, and vegetables began. A significant number of studies have reported cases of successful IPM initiatives in Tanzania, but very few have reported success stories of organic farming.

This is not surprising, since compared to IPM organic farming is complex in terms of production and marketing. While IPM allows for gradual reduction in the use of agrochemicals, OF doesn't allow the use of any industrial agrochemicals. This has given IPM farmers a short-term advantage over OF producers. The longtime use of pesticides has led to and intensified the resistance of certain pest species; eliminated friendly or natural pest-control agents; and degraded natural soil fertility. All of this poses unique problems to OF producers, particularly during the early stages of production/conversion. Since production is low in the early stages, organic producers need to recover costs and make profits through higher market prices compared to conventional or IPM products. Higher prices can be achieved where consumer's awareness of health and environmental benefits is high and where supportive policies and legislation are in place. Unfortunately, these critical elements for successful marketing of organic products do not exist in Tanzania. Extension services have focused on conventional agriculture and to some extent IPM systems. A look at the Agricultural Sector Development Programme (ASDP) and the National Agricultural Policy of 1997 clearly shows an emphasis on the increased use of industrial agrochemicals.

However, an initiative by local farmers in Arumeru District of Arusha Region (northeastern Tanzania), with assistance from agricultural experts at the Tanzania Pesticides Research Institute (TPRI) and regional agricultural staff, has registered a significant degree of success with the production of organic vegetables (carrots, hot peppers, okra, sweet and white potatoes, soya, baby corn, radishe; and also fruits like bananas and pawpaws).

The Kicharimpinda Organic Producers Group

Kicharimpinda is an acronym which in Swahili stands for "Kikundi cha Maendeleo cha Ari Mpya Ndatu," which in English means "The Development Group of Renewed Resolve at Ndatu

Village”. Ndatu is a village in Arumeru District of Arusha Region, on the slopes of Mount Meru. The ecosystem is delicate due to slopes with a high possibility of erosion and a shallow water table. Streams flow from Mount Meru through Ndatu to the lowlands, where commercial flower farms and small-scale food crop production are the main activities. Streams are also the major water source for most people in Ndatu and other villages.

The Kicharimpinda group was established in 2006 through the personal initiative of a former government extension officer, Ms. Penina J. Mungure. Ms. Penina and nine other farmers established the group with the goal of producing organic vegetables for the local market in Arusha Municipality. This was due to their realization that the demand for organic products was increasing in Arusha Town because of a significant number of tourists and foreign workers there. (A large number of international organizations and companies are based in Arusha.)

The founder-members were also inspired by the increased awareness of pesticide impacts among Arumeru residents after the introduction of flower production in the district. This has led to health and environmental problems, and heightened local concerns about pesticide use and water consumption.

The group has two committees (Follow–up and Preparatory), and the chair of the group is Ms. Penina, who is assisted by a secretary and a disciplinarian. Each member pays a monthly fee of 2500 Tanzanian shillings ($2 US).

Procedures adopted for Organic Farming

a. Ridge–making

Organic production here begins at the ridge–making stage. The group has adopted a ridge-making process that needs some additional labor and that makes use of a local plant.

The nitrogen-fixing plant is known as *itotoo* in the Meru language and is not edible. The ridges are dug deep into the soil (known as double digs), and this encourages good root development which allows plants to effectively extract natural soil fertility. The width of a ridge is 1½ m and the depth is 1m. After selection of the site, the top –30 cm of soil is removed and placed on the right side of the line representing the length of the ridge (normally 20 m long); and the 2nd 30cm cm of soil is dug and kept on the left side of the ridge. The remaining foot of soil is loosened and left at the bottom. Then 1½ tin of compost is added for each meter on the bottom soil.

The 1m of soil kept on the right side is now mixed with compost at the same ratio and returned to the top of the heap. Then the soil on the left side is mixed with compost at the same ratio and moved to the top of the ridge.

b. Planting

Crops are planted as mixed cultures, the main first crop must be a heavy feeder, which for KICHARIMPINDA includes maize, hot peppers, local spinach, Chinese cabbage, peppers, or any other leafy vegetable. The second crop must be a poor feeder, which includes carrots, beet root, radishes (*Raphanus sativus)*, and potatoes. In the third season, nutritive and nitrogen-fixing crops such as beans are planted. During the second and third seasons, compost is added to the top soil.

c. Pest and disease control

To avoid cross-contamination from near by non-organic farms, the group maintains a distance of 10m between their plots and those of conventional farmers. A number of plants or plant extracts are used by the group for pest control; these include marigold (*Tagetes spp*), tobacco, castor (*Ricinus communis*), and pawpaw. Other strategies used for pest and disease control by the group include strict adherence to crop rotation, mixing of friendly plants (e.g. carrots mixed with leeks or lettuce), and planting of marigold and *Tefrosia vogelii* on the borders.
Farm hygiene is also strictly observed during and between seasons. The disciplinarian enforces these requirements.

Itotoo; African marigold and Tephrosia as insecticidal plants; banana, pawpaw

Tephrosia is a genus of legumes in the Fabaceae family. Many species in the *Tephrosia* genus are poisonous, particularly to fish, because of their high concentration of rotenone. *Tephrosia* species have historically been used by many indigenous cultures as poison to immobilize fish. In the last century, several *Tephrosia* species have been studied in connection with the use of rotenone as an insecticide (against ticks on cattle) and pesticide.

d. Fertilizer application

The group uses what they refer to as “alternative fertilizer”. Each member keeps a few cattle (3 to 5), also for the production of manure; compost is made from a mixture of manure, dry crop leaves, green grass, ash, and soil, which is covered by dry leaves. The compost heap is made of layers, each layer is composed of maize straw (5-10 cm), green grass (5-10 cm), manure (5-10

cm), and ash (1½ kg). The layer is covered with soil, and water is sprinkled on top. After three months, the compost is ready for use in the construction of ridges.
After planting, the group uses urine from commercially produced worms as fertilizer. A foreign company donated two packets of worms, which the group has multiplied by feeding them with vegetable and fruit remains. The urine is used as a booster fertilizer; 1 liter is mixed with 10 liters of water before application.

e) Results and spillover effects

According to the group, nobody has experienced a disease or pest outbreak in the past four years of operation. They are currently in the process of becoming certified organic producers, with assistance from the Tanzania Organic Agriculture Movement (TOAM). The group also inspired the husband of Ms. Penina who decided to expand the concept of sustainability in the village. Mr. Justine managed to design a biogas plant that uses excess manure from their cattle. These are held in a cut-and-carry system (see photo and Q+A 6).

All the cooking in their house is done with biogas. Justine designed a cooking pot and iron that uses biogas; he won a national prize for this innovation. This encouraged him to develop and build a small hydro-power station using relatively simple technology in a stream near their house.
Apart from supplying power to his residence, he is now also supplying power to nearby houses in the village.

The ultimate objective of this group is to transform their community into the first Tanzanian 'eco-village'. They seem to be heading in the right direction, but need some financial and technical assistance to fully realize their dreams and aspirations. Certainly, this group has moved beyond IPM and even OF and has succeeded in negating several arguments against these approaches. There is clear evidence that small–scale agriculture can be carried out without the use of industrial agrochemicals. They have also demonstrated that the broader concept of sustainable development can be put into practice at a village level, and that small–scale farmers can play a significant role in achieving sustainable development.

Answers to ten questions about African agriculture you've always wanted to ask

1. What are the specific characteristics of different agricultural approaches?

"**Conventional**" **farming** depends on the purchase of external inputs; it externalizes environmental damage and diminishes its own production base in the long run, but is comparably easy to learn. Maximizing profits is its primary goal. Overall, it is an adaptable system.
Conservation farming (CF) minimizes the most expensive inputs, but does not necessarily forego all synthetic inputs. It is characterized by the precise concentration of inputs on each individual plant; its adaptability is high and the combination with other approaches is easy; sustainability is most important.
The many forms of **Organic agriculture** avoid synthetic inputs and, normally but not necessarily, intense soil disturbance. It requires greater labor unless combined with CF. In such a combination it achieves both high economic and ecological sustainability. Adaptive use and distribution require highly qualified practitioners and on-farm training facilities.
Perma-culture (often agro-forestry systems) has a very high land productivity and is the most sustainable approach, but as a mixed culture it produces a constant variety of products that makes mechanization and bulking difficult. It is most resilient and fits small, subsistence-oriented systems.
"Conventional" farming mostly exploits non-renewable resources, and pollutes water and air, but it provides high yields and incomes under conditions of large-scale production, though these are often subsidized and only available to relatively few farmers. Incomes will probably decline in the future due to rising prices for fossil fuel resources and the internalization of damage to the natural production base. This system is not appropriate for the 70% of Africa's population that are smallholders.
Conservation farming offers economically and environmentally friendly incentives for small and large farms. Using minimum tillage and keeping the soil covered, it can be considered as intermediate between conventional and organic farming and is a necessary step in the transition to and qualification for **Organic agriculture.** In the latter, animal manure and leguminous fertilizers adsorbed in organic matter are key for soil nutrition and fertility, and also for pest prevention. Some key knowledge relates to how to minimize nitrogen losses and how to manage space for the establishment of improved fallows. Combinations of organic and conservation methods can compete favourably with labor requirements and yields of conventional agriculture.
Perma-culture, as intense intercropping of deep-rooting trees, annuals and other perennials exists in small units. Data about larger units with mechanization and a rational large-scale production of single products were not found. There are simple agro-forestry systems, such as tree plantations with one understory crop, but these lack the stabilizing complexity of permaculture systems with higher species diversity. The latter are often indigenous systems that are especially viable for rural and even urban populations with little land and close to markets. Research is underway in many places to explore the multifold opportunities that these mixed-cropping systems offer.

In practice we found that farmers select a mixture of different tools that are offered by the different approaches and that seem to fit their ecological and socio-economic environments. We have remained here with the more traditional division in order to simplify the subject and to better understand where different methods come from. Small farmers in the tropics are generally not driven by the search for maximized profits but for food security and risk avoidance.

Key characteristics and essential combinations of different agricultural systems in Zambia

	"Conventional"	**Conservation (CF)**	**Organic (OA)**	**Perennial Poly-culture= Agroforestry= Perma-culture**
	▪ Synthetic input oriented system ▪ High dependence on external products and forces	▪ Site-appropriate ▪ Minimum tillage ▪ Precision application	▪ Integrated, carbon-oriented system ▪ No synthetic inputs ▪ Normally combined with Conservation Farming	▪ High biodiversity ▪ Using natural synergies
	High costs - Reduced costs through CF- High labor -Low labor in combination with CF- Large-scale reduces labor through mechanization Very high yield/ha Low profit/ha	Lower costs Reduced labor High yield Reduced use of synthetic inputs High profit/ha	Lowest costs Most inputs farm-produced High labor demand -Lower labor in combination with CF- High skills demand High yields possible Good profits on niche markets in capitals and export	Lowest costs Most inputs produced on-farm Low physical labor input High yields of mixed crops/ha
	High income per mechanized farm but Only minimal profit for small-scale farmers -CF offers cost-reduction and yield improvement even for small-scale-	High profit even on small-scale -when properly done-	High profits/ha possible if done with sophistication Most adapted for small-scale –Mechanizing/up-scaling possible with new CF-machinery-	High food security and profits possible
	Easy to adopt when resources available and affordable The mainstream: Supported by private sector /extension/ commercial interests prevail	Easy to adopt Most Development Organizations suggest CF	Adoption needs intense training, difficult transition phase Still a niche-market	Knowledge and skills needed Several years until bio-diversity (trees !) have developed
-	High possibility of soil degradation and water pollution –reduced through CF- Concentration of land and power in few hands is typical for this system	Reduced ecological foot-print	Most soil, water and climate-friendly	Most soil, water and climate-friendly Highest resilience An old system with an endless array for still unknown possibilities ! And potential (self)employment !

2. How should soils be treated?

Each crop produces best on a particular soil of particular structure and with a particular composition of nutrients, but the world's main terrestrial crops have some common needs:

Soil/Water
Water is retained and released from capillary structures between and within soil particles. While sand has predominantly large pores where water infiltrates and percolates quickly and clay has mainly dead-water in micro-pores, loess and organic matter have more medium-sized pores where plant-available water is found. Medium-sized pores exist mainly between soil particles of a special size, within organic particles, metal oxides, excrements of soil animals, and aggregates of organic matter with fungus hyphen and bacteria colonies. Mulch and humus protect the pores from being flooded and demolished.

Air/Oxygen
Air does access the underground through wide pores created by termites, earthworms, and wide spaces between particles and medium-sized pores. Fast-infiltrating water brings dissolved air but only for a very short period. Plowing can make soils hard and suffocated.
Mainly organic matter (humus), mixed with clay particles, provides positive electrically loaded inner and outer surfaces that can adsorb cations like calcium, magnesium, and potassium that fertilize soils and improve soil structure. Under natural conditions, those nutrients are found in organic compounds and are released by active processes of plant roots and by symbiotic mycorrhizal fungi and bacteria.

Low Salinity/The right pH
The less rain washes the soils, the more salt (mainly sodium chloride) remains from the weathered minerals within it. Since World War II, more soil has been salinized and destroyed by improper irrigation than gained through irrigation.
Brazil, the US, India and many other countries systematically destroy soils under (semi-)arid conditions by applying "modern methods" without drainage. Kazakhstan lost an area as large as the Canadian and Australian corn-growing areas combined by plowing steppe soils and then losing them through wind, water and salt.
Salts under dry conditions cause high pH and toxic soils; acids from synthetic fertilizers under humid conditions or on old, mineralized soils cause low pH. This leads to the leaching of calcium and magnesium and kills beneficial organisms through ammoniac, cyanide and other toxic agents that occur in high concentrations. But slow-acting natural fertilizers may be used, like limestone flour. Left to nature, plant roots and mycorrhizae create favorable conditions in their immediate surroundings, mobilizing nutrients even under otherwise adverse conditions.

High populations of beneficial organisms
Just as bees and cows are more useful for humans than fleas and rats, healthy soil needs certain micro-organisms. Mycorrhizal fungi multiply the capacity of crop roots to absorb nutrients, mainly phosphorus, and water. They protect plants from root-eating nematodes and dissolve nutrients even under pH conditions in which intensively treated soils would normally have their nutrients occluded and locked in chemical compounds unavailable for crops. Bacteria set oxygen free in the soil or gain hundreds of Kg of nitrogen/ha for their symbiotic plant partners.

Insects and worms produce more manure per ha than cows. Predators like spiders and ladybirds prevent outbreaks of pests.
But all of this happens only if soils are not plowed intensively, thus cutting the mycelia; if soluble phosphorous does not kill the fungi; if there is enough organic matter in the soils; if ammoniac from fresh manure or synthetic fertilizer is absent; and if the ladybird has prey throughout the year, leading to low levels of a "pest" population.

Imagine soil as a huge urban building with vertical lift-shafts, water-pipes, supply-channels, air-condition, corridors, rooms, workshops, and a population living, working and competing therein. This endless mega-polis is nurtured by and nurturing the roof that is built from the residues of the plants that shade and protect the building.
And now imagine a heavy tractor and plow coming in…

3. How much fertilizer is needed?

Recommended fertilizer use ranges from very high inputs in conventional farming to no synthetic fertilizer at all in organic farming. We have evaluated fertilizer use in the different categories of farms in Zambia and many other places in the tropics.
Natural fertilizers, accepted through the organic standards in Africa and the world, have in common that they get very slowly dissolved and build a source of nutrients for micro-organisms rather than quickly release dissolved nutrients for plant roots as do synthetic fertilizers. Admitted (long-term) depot-fertilizers have to be applied in soils rich in organic matter to be adsorbed and absorb free nutrients, thus preventing nutrients from leaching and plants from being overfed. Organic matter can include digested agricultural waste, roots and stubble on the field, or compost, composted manure and urine or charcoal (biochar) applied from outside the field. Aside from the main nutrients, trace nutrients should be available and can be added from natural (mainly aquatic) or artificial sources. Under natural conditions, these trace elements are available. But intense soil management can reduce them significantly by leaching them through fertilizer ions. African soils, especially in zones with high rainfall, have naturally low quantities of some elements. In any case, fertilization even at small quantities (in g/ha) has significant effects on yields, plant health and health of consumers. Zinc and selenium, for instance, have been proven to improve immune response e.g. in HIV-infected people.
Some basic facts about the main fertilizing elements:

- Nitrogen is produced by rhizobium bacteria living in the roots of leguminous plants (beans, acacias etc.).
- Potassium from ash is produced as a by-product in several industrial and agricultural processes in Zambia.
- Phosphorous is normally fixed in a way that plants cannot access it from their mineral compounds unless released by root acids, but particularly through mycorrhiza, the symbiosis of a plant root and a fungus. Mycorrhizae are damaged by phosphate fertilization and tillage.
- Slowly dissolving rock-phosphate, available in its natural form in Africa, is recommended to increase long-term stocks in soils.

- Lime from locally available ground limestone regulates the pH and thus the availability of nutrients, and improves the living conditions for micro-organisms. It contains calcium (Ca) and magnesium (Mg).

Under conditions of conventional farming, high concentrations of easily soluble acidic nitrogen compounds dissolve existing organic compounds, often over-feeding plants and percolating a significant quantity of nutrients in deeper zones of the soil towards the groundwater and beyond the reach of plant roots (which contributes to the eutrophication of ground- and other water). Nitrogen acidifies the soil and leaches potassium, magnesium and calcium. Potassium and calcium fertilizers leach nitrogen and make “rich fathers and poor sons” in the Northern hemisphere; in the Southern hemisphere, on old soils, they yield a few good harvests until the organic matter and clay particles are gone, and the remaining soil is salinized and compacted. Conventional farmers mainly feed their crops with externally sourced nutrients that produce high amounts of GHG.

Only natural fertilizers are allowed and needed in organic farming, nutrients are recycled with the use of animal manure and deep-rooting plants. Conservation farmers reduce fertilizer needs by concentrating all kinds of fertilizer near the single plant and using the same micro-site permanently.

4. **What importance does plant breeding have?**

Traditionally, plant breeding does not have strong roots in Africa.
Maize varieties grown in Zambia differ in yield up to about 50% under equal site conditions. Naturally open-pollinated varieties (OPVs) and commercial hybrid varieties with defined characteristics only in the purchased seed and not in the seed they produce, and genetically modified varieties (GMOs, genetically modified organisms) – their yields are all in the same range. With a long rainy season or early sowing with eventual backup through irrigation, hybrid seed produces slightly more than OPV.

More important in Zambia and the Eastern and Southern African lowlands is timeliness. High-yielding varieties need more time, and require water harvesting or sometimes irrigation at the beginning and end of the rainy season. Zambian farmers traditionally sow late, till incorrectly and do not fertilize and weed properly. These are the reasons for an average yield of only 2 MT of maize per ha in Zambia.

The same farmers, using hoes, can yield 4-7 MT of maize with even less input in labor and fertilizer by using conservation farming methods. Early sowing, water harvesting, soil maintenance, and minimum tillage that breaks plow/hoe pans, allows these farmers to achieve high yields with OPVs.

GMOs have lower yields than hybrid seeds but are resistant to certain mainly Northern pests and provide some herbicide resistance, e.g. against the grass-killer Roundup. As Monsanto, one of the main providers of herbicides and herbicide-resistant crop seeds, offers to reduce the need for

herbicides, large-scale conventional farmers might have an advantage in using both products together and paying less for the herbicides.
Traditional farmers often reuse a small quantity of their best plants' grains selected for desired features to re-sow each year. Of course, agro-industries cannot gain from such a system.

Large international agrochemical enterprises are buying local, national and regional seed suppliers and are reducing the genetic variety of OPV seeds in order to force clients to buy hybrid seeds with unpredictable performance which may even produce infertile seed (so-called "Terminator technology"). The distribution of GMOs is a serious threat to crop biodiversity which increases the dependence of farmers on few seed producers and damages the gene-pool of the earth irreversibly. Local seed banks of improved crop varieties under the control of communities seem better adapted to the fight against hunger and for better livelihoods than monopolized imports of hybrids.
Herbicide use can be reduced and even avoided and the disposition for pests reduced by appropriate measures in both conservation farming and organic agriculture. This requires additional skills but preserves the indispensible genetic variety of the world's food species.
Genetic manipulation is only acceptable if it includes a full liability package. Breeding has to be controlled and restricted; side-effects have to be considered. Until now, GMOs have not proven significantly useful except for their producers.

Plant breeding without mixing different taxonomic groups, like bacteria and plants, is useful, maybe even necessary. Biotechnologies and the role of micro-organisms are a most promising sector in agriculture.

A field where breeding is of high potential economic value is the polyploidization of crops. This involves limiting the natural reduction of the plants' set of chromosomes (carriers of genes). Contrary to genetic manipulation, where humans tinker with the blueprint of nature, here the entire blueprint is multiplied which results in a strong and vigorous specimen. This happens in nature, but only rarely. The difference to a 'normal process' becomes obvious when comparing common grains of wild grasses with maize or wheat, a normal grass-stalk with bamboo (a polyploidy grass), or normal herbs with a polyploidy herb, the banana-plant.
These examples show the potential of yield improvement through polyploidy plants.

The second field of useful biotechnology is the attempt to use beneficial micro-organisms. Specific inoculants, mycorrhizae as water and nutrient providers, effective microorganisms (EM) for the improvement of nutrient recycling, and alternatives to disinfectants are part of a possible future of a production for people with nature.

5. How to best manage pests?

Introduction

Pest management has always been a concern of humans, particularly farmers. Different approaches, techniques and principles have been developed and applied depending on the stage of development, the types of crops and pests, the size of farms, and available indigenous and/or scientific knowledge.

Two basic approaches have been applied by societies in managing pests: **chemical** and **non-chemical** approaches. The choice between the two is influenced by concerns about human and environmental health; these concerns became more obvious after publication of *Silent Spring* by Rachel Carson in 1962. Different techniques have since been developed to meet the demands of workers, consumers and concerned citizens.

The chemical approach

The chemical approach has a long history, as it has been used at different levels of societal development. In Tanzania, for example, ash and seeds from some native plant species known to have chemical properties were used to control pests particularly at the post-harvesting stage. Seeds were also soaked in solutions made from such plants to control pests in the field (also known as biological control). The introduction of industrial pesticides in the late ‘30s pushed many local communities to abandon the use of traditional methods. More and more farmers adopted industrial chemicals for the control of pests.

Though their effects on human health and environment were minimal, the traditional bio-pesticides could not cope with changes in agricultural production. The increase in population and demand led to an increase in farm size, inputs and production, and the amount of bio-pesticides available could not satisfy the demand for pest control. Moreover, due to poor technology, the efficacy of such traditional concoctions was not assured.

On the other hand, though industrial pesticides are quite effective in controlling pests, the side effects for human and environmental health are quite serious. In some areas, unused pesticides have been accumulated in large stockpiles that leak into the environment and for which disposal is expensive. The use of industrial pesticides as a single magic bullet has also created the problem of pest resistance and resurgence in the field. This has necessitated the use of larger amounts of pesticides and even more toxic products (the so-called pesticide treadmill or vicious cycle), which has increased production costs and exacerbated the impact on human and environmental health.

Recent developments, particularly in the field of biotechnology/GMO, have incorporated the chemical approach into the development of pesticide-resistant seeds or seedlings (see also 4.). For example, crops that can tolerate some of the chemicals being applied in the field are now available in the market. A good example is Roundup (glyphosate); commercially-available varieties of maize and soybean that are resistant to glyphosate are now under cultivation worldwide. The problem associated with this high-tech approach is that it promotes the intensive use of industrial pesticides, since large quantities can be applied without harming the new pesticide-resistant varieties, but while still polluting ground and river water.

The non-chemical approach

Non-chemical approaches include traditional physical ones such as burning or hand-hoeing weeds and collecting animal pests like snails. They also include old and new forms of biological control; a good example at the local level is the use of animals to graze in the field. At the national level, another example is the control of water hyacinth in Lake Victoria or the predation of cassava weevils in coastal Tanzania by laboratory–bred wasps. At the local level, biological control lowers production costs, but the use of animals can sometimes cause unwanted secondary effects. The use of biological agents to control pests is very cost-effective in the long term, but may result in environmental problems in the future. The introduction of new predatory species in particular geographical regions may disturb the ecological balance and thus affect the ecosystem. Moreover, once the intended pest is eradicated, it is not well-known what happens to the introduced species; it is not possible to remove it from the ecosystem, and there is a possibility that it may turn into a pest itself.

Indigenous knowledge has identified several plant and animal products that have the ability to control pests. However, the techniques have its limitations; for one, they are not based on sound scientific data and may sometimes be risky to human and environmental health. Second, due to associated technology, they are only applicable to small farms of 1 ha or less.

Modern non-chemical approaches were adopted to mitigate human and environmental damage resulting from the intensive use of pesticides, particularly during the first Green Revolution. A variety of techniques were developed to put this approach into practice. The first notable technique was through plant breeding programs, in which scientists bred varieties that were resistant to specific pests. The assumption was that increased resistance would lead to reduced application of industrial pesticides. Though this technique was successful to some extent, it had its own setbacks. First, such breeding programs could not produce the required amount of seeds or seedlings, since the number of breeders and breeding stations were few, particularly in developing countries. Second, such programs required large amounts of money which was not available in most developing countries. Third, the new resistances were too specific, i.e. against specific pests, and this did not augur well with field situations in which resistance is needed against a wide variety of pests. So breeding techniques were unable to stop the use of industrial pesticides. Additionally, the increase in resistance compromised other physiological characteristics, including the yield potential.

Another technique known as Integrated Pest Management (IPM) was introduced, which allows a minimum use of industrial pesticides. In many developing countries, farmer field schools (FFS) were established to implement this technique. In the FFS approach, farmers became researchers and their farms became research stations. Systems like Agro-Ecosystems Analysis (AEA) were developed to assist farmers to analyze their farm ecosystems before deciding whether or not to apply industrial pesticides. Though IPM aims to reduce the use of industrial pesticides for pest control, in practice little has been achieved. First, the sustainability of most IPM programs is not guaranteed, since most programs are donor-driven. Second, due to pressure from the pesticide industry, the use of the same (sometimes even higher) volumes of industrial pesticides is still common in IPM programs, leading to the situation of an "Integrated Pesticides Management". Third, the level of awareness and understanding of farmers must be high in order to implement a successful IPM program. Farmers need to know why to adopt IPM and how to adapt it before they can change their farming practices. This has not always been the case in many IPM programs. Usually the ministries of agriculture develop a policy and supportive legislation that farmers have to comply with. Fourth, a successful IPM program will be achieved only when all farmers in a particular area have converted from conventional agriculture to IPM. When only a small fraction of farmers have converted to IPM while the majority has not, the success of IPM programs is put at risk or even doomed to fail. This is a dilemma in most IPM programs since most farmers are risk–averse. They take time to adopt new and uncertain ideas, and this gradual shift does not harmonize well with the concept of IPM.

Another problem with IPM is that in many developing countries, its practicability is very limited under large–scale farming systems. The difficulty of applying an integrated approach in large-scale farming has discouraged the adoption of IPM. For example, the integrated approach requires several measures to be taken, e.g. biological control, farm hygiene, etc. Some of these measures are not practical under a large-scale farming system. In many developing countries large-scale producers are regarded as change agents; for example, in Tanzania, large-scale private and state farms have considerable influence on small-scale farmers. Whatever is practiced in large-scale farms is nearly always adopted by small farmers. Thus the non–adoption of IPM by large farms has discouraged small farmers from changing to IPM themselves.

Organic agriculture (OA) has also grown recently due to consumer demand for pesticide–free food and concerns about environmental and human health. Organic agriculture is a zero-tolerance technique which does not allow any use of industrial pesticides. This zero-tolerance philosophy has posed many challenges to farmers, particularly in developing countries. Farmers in OA have to try to maintain a healthy balance between pests and their predators. But the longtime use of industrial pesticides has created new pests, and increased the resistance and resurgence of old pests. It has also eliminated many of the natural predators of crop pests. Ecosystems can no longer control pests as they used to do before the introduction of industrial pesticides. For organic farming to succeed, the ability of the natural ecosystem to control pests needs to be restored, but unfortunately many years of a pesticide-free environment are needed to restore this ability. Hence, most organic producers face pest problems in the first few years of production and some are forced to use industrial pesticides to control pests during that time. Also, to compensate for lower yields, a market system that allows farmers to get premium prices for organic products is needed; but in many developing countries such market systems are not in place. Consumer awareness is critical for a successful organic farming program, but this is often lacking in many developing countries, contrary to the situation in ‘developed’ countries. There is little demand for organic products in Africa, and most farmers are not interested in organic farming because it does not seem to be a profitable business for them- which may not be true.

Recommendations

To best manage pests without compromising human and environmental health in developing countries, several actions should be undertaken:

1. Awareness-raising among farmers and consumers
2. Capacity building of extension staff and decision makers on IPM and OA methods

3. Adopt IPM and OA as national strategies (not donor-driven programs). Design IPM programs for large-scale farms
4. Establish a marketing system for IPM and OA products. Give incentives for IPM and OA farmers
5. Establish IPM and OA centers with training and extension, machinery service, access to credit
6. Establish FFS at village level
7. Ban extremely toxic pesticides and phase out highly hazardous pesticides- and enforce the laws!

6. How to integrate livestock with crop production?

The knowledge that animals, especially ruminants, also contribute to the warming of the earth, has encouraged many a vegetarian in technologically developed countries. These animals' digestive systems release methanol and their dung nitrogen dioxide, both extremely strong greenhouse gases (GHGs). So it is important to remember why we raise animals in the first place: to eat the most important proteins, which are found in higher concentrations in animals than in most plants; to obtain help with transport and fieldwork in poorer countries (while draft animals are replaced by global warming-enhancing machinery in developed countries); to use their manure and compost for maintaining and restoring soil fertility or as energy. Ruminants are able to use land which, due mostly to dry conditions, is not suitable for human food crops, but only as grassland as long as it is used in a rotational way. Finally, for small farmers, livestock is often a 'walking savings account' rather than daily food, used to obtain quick money for emergencies or as a dowry. The old rule is still valid: the more financial resources people have, the more they consume meat and dairy products instead of crops. The worldwide demand for animal products is growing strongly because of population increases and higher disposable incomes in many countries, especially China.

In the industrialized agriculture of the North, the mass production of animals near cities has become a problem. The animals, normally non-ruminants like pigs and chicken, are largely fed with food that is also appropriate for human consumption and so they are competing for food with humans. Their wastes don't go back to the fields to close nutrient cycles, but create problems of ground-water and river-water contamination. Disincentives for this kind of industrial animal production could be instituted by a tax on the production of climate-relevant emissions. On the other hand, most nomadic pastoralist tribes have adapted successfully to their environments, surviving and producing with their cattle and other domesticated animals by wandering from one waterhole and pasture area to another - wherever this is still possible in an increasingly settled and urbanized world. In many cases, liberalized border regulations are necessary to keep them moving and help them to avoid dependency on food aid. Nevertheless, overstocking and uncontrolled free roaming of animals has to be avoided.

In situations of high population densities and sufficient rainfall, animals should be kept in stables and food should be brought to them ('cut and carry'). This allows their manure to be saved in a highly anaerobic state that minimizes GHG releases. Food plants, including multi-purpose trees, could be planted as inter-crops, cover crops and improved fallow, and also used as mulch.

Additional minerals are necessary. Another increasingly important use of animals is via the construction of biogas plants, which use the gases from animal manure to produce energy in a decentralized and energy-positive way with fertilizer as a 'waste product'. Additionally, animals kept in stables can prevent human-wildlife conflicts with carnivores. This system also facilitates better control of infectious diseases that might be transferred from wildlife to livestock and then humans. The use of vaccination is necessary and sustainable, while chemicals may create tolerance and resistance in vectors and the causes of disease. Tick control and de-worming is easy in the stable. Many methods of adapted management exist to avoid diseases transmitted by biting flies; the use of local breeds is one. Keeping different animal species together is also helpful as 'risk insurance' and to better use resources; for example, goats can be employed to control weeds and bushes.

A rich diversity of agricultural activities, such as an integrated livestock and variable crop production system, offers opportunities for better food security and higher monetary income. A biodiversity-friendly example is rice production in fish ponds, which are fertilized by animal dung and farm-grown by-products, and in turn provide fertile mud and irrigation water.

7. Improving subsistence or cash-crop production?

Statistics show that sub-Saharan farmers are producing enough food for subsistence at low nutritional and economic levels -- not achieving stable food security, but still providing enough of a surplus in normal years to feed most of the 30% of non-farmers in their countries.

Sub-Saharan farmers are poor, sometimes miserably so, and they often damage the land through fire, overgrazing of livestock on communal land, deforestation and soil erosion. However, if they are not sick and if they have enough family and/or some traction power (e.g. draft animals) to help, small farmers have the potential to produce and earn 2 to 3 times more than they do currently. They need to avoid traditional but avoidable mistakes and to apply conservation farming methods. Large-scale farmers, on the other hand, make profits on their own land, and, when they receive loans, even on newly acquired land. The difference is power, influence and skills.

In Africa, agriculture has a considerable potential to generate reasonable livelihoods even for small-scale, hand-hoe farmers with low cash income. Transport, medicine, sugar, salt, oil, drinks, batteries, maybe fertilizers, school fees, and increasingly cell-phone talk-time are the main costs to bear for most. Land, housing, energy and water are still largely free in sub-Saharan Africa.

Local markets are the best place to sell and buy things. They are found nowadays in even the smallest places. Markets in larger towns are often not accessible for small farmers because of poor infrastructure, especially during the rainy season. Dealers and traders will only come to farmers if there is a high, reliable supply of a well-priced good, and they often prefer to avoid the dangers that pothole-filled streets and rickety bridges pose for their trucks. A recently emerging danger for local price development is the poor utilization of emergency aid, an industry that has grown immensely during recent decades.

Products to be sold on the global market must also reach a connected place first. Additionally, this market is extremely unpredictable, quickly changing and may create dangerous dependencies. Finally, it is the high subsidies that developed countries pay their farmers that strongly distort the world market and destroy potential opportunities for poor farmers in the South.

Low external input agriculture with maize (corn) requires sound skills in sustainable farming like improved fallows, manure production through livestock, and crop rotation. On the other hand, maize is easy to harvest and process and offers a combination of staple food and cash-crop production. Even large-scale farmers admit that there is no economically interesting alternative to cereals like maize or (irrigated) wheat and soybeans. For a decent crop rotation in Zambia, at least three components are necessary.

The Conservation Farming Unit (CFU) therefore recommends a cereal component, a leguminous component, and a cash-crop component for crop rotation in order to safeguard soils and minimize pests. In Zambia, small-scale CF farmers grow maize (or sorghum) in the cereal phase, groundnuts or soybeans as nitrogen-fixing plants, and cotton or sunflowers in the cash-crop phase, but the latter yield very little profit and soybeans are difficult to sell in rural areas. These are the main reasons that crop rotation is unpopular and maize production, supported by subsidized fertilizers that are still expensive and often arrive too late, keeps small-scale farmers poor and dependent.

Organic farmers save money by not purchasing synthetic inputs, but rarely get any price premium and need to find uses and markets for their rotational or fallow crops. Some organic farmers produce essential oils or seeds, but this market is limited.

As food is scarce in many parts of Africa, food prices are relatively high for producers unless governments interfere to calm the urban masses. Otherwise, the difference between food and cash-crop production is not very pronounced and even commercial farms produce maize, wheat, groundnuts and soybeans. We have to remember that while high food prices are good for poor smallholders with access to a market, the urban poor suffer from them.

The current practice of allocating thousands of hectares of land for biofuel production or growing food to be exported to food-scarce foreign countries is already creating major social tensions in southern Africa and Kenya.

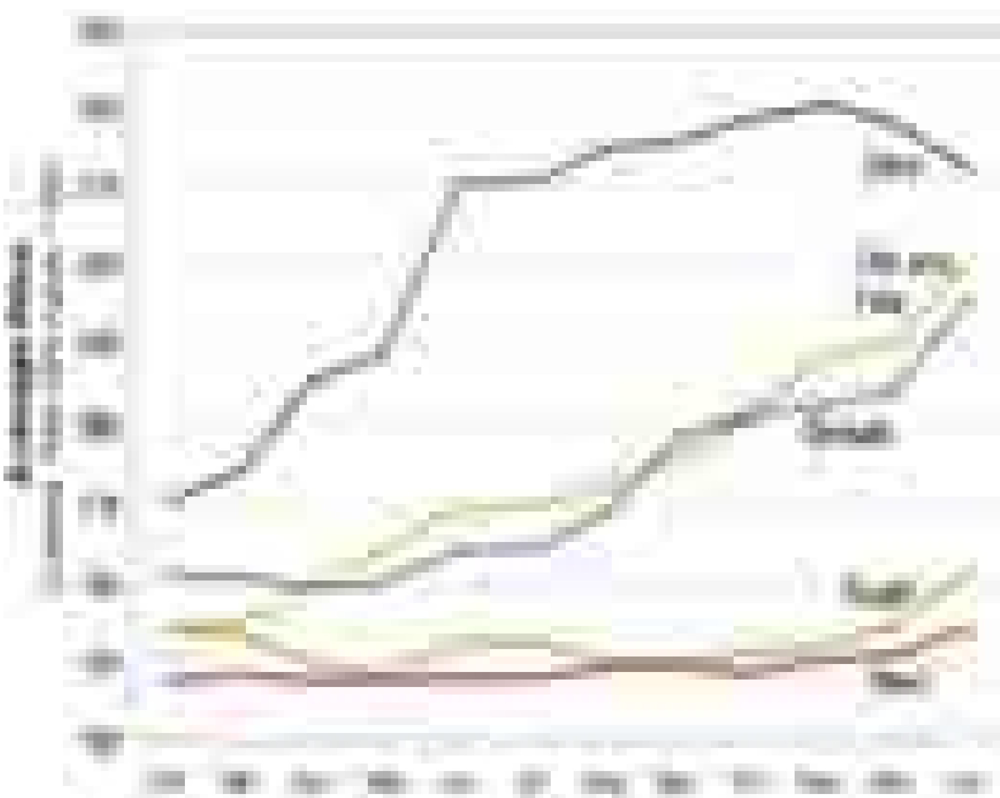
While some massive land-holdings do not produce anything at all, the yield of many large farms in Southern and Eastern Africa is quite low, often below that of small-scale farmers. Still, those farms can play important roles for the economy, employment and even conservation. Many large-scale Zambian farmers are turning towards more sustainable land-use practices due to their economic advantages. More farms that are larger than a few hectares are needed, but their development should be driven by the local population and not from overseas. It must be a process of inclusion and not one that increases unemployment and rural exodus.

It is necessary and unavoidable to intensify agriculture in Africa. Parliamentarians and civil society organizations should raise an outcry when governments and local authorities allocate arable land to international enterprises. Instead, they should facilitate a smooth transition from environmentally degrading small-scale farming towards income and employment-generating medium-scale farms that are run responsibly and sustainably.

8. Does biofuel production compete with food production?

Biofuels include wood, charcoal, straw, dry grass (all solid), biogas, and the liquids biodiesel, vegetable oil and ethanol out of energy plants. The CO^2 that is emitted by the burning of biofuels was previously removed from the atmosphere by the plants themselves. Preconditions for the sustainability of production are standards like those for organic agriculture or the FSC standard for forest management.

So-called agro-fuels, being cultivated on agricultural land, are different. If the land was used for food production before, then these fuels are competing with food production. The situation is also determined by the cultivation practices. Are tillage, fertilizers, pesticides, long transport or irrigation water being applied? If yes, then agro-fuels are competing with food crops for the same resources – in a hungry world.



Percent increase of food prices in 2008. (Sugar, cereals and oils are also used for agro-fuels.)

Meat is produced with soybean as fodder, while soybean oil is used for biodiesel production. There is a clear correlation between “food for fuel” production and prices for human food, whether food is burned directly or the prices of synthetic inputs increase because of intense conventional agrofuel production.

Even if economically viable in the short-term, all plantation-like production of agro-fuels in the tropics has had considerable side-effects , always in the ecological sense, but also socially in form of slave labor, resettlement, expulsion and social unrest. New problems are emerging with the cultivation of agro-fuels on so-called marginal land, which mostly turns out to be mixed woodland or forest in Africa. Big investors and their allies are not really interested in truly marginal land - meaning marginal production - and often declare uncultivated land to be marginal.
Driven by misunderstandings and misguided international policies like production subsidies in Europe and USA, big land-grabbing has occurred from a combination of ruthless investors and corrupt land authorities. In Africa, these flourish due to the existence of parallel, often contradictory land legislation: the traditional and the 'modern' one. Existing gaps are exploited by foreign countries, which target the poorest of continents also to grab land for food crops as a way to improve their own fragile food security.

Conflict is increasing between food and cash-crop production through the use of food for biofuels, often by the use of so-called marginal or under-utilized land for jatropha-based biodiesel production. Large-scale jatropha production has so far used only arable land also suitable for crop production. D1, a venture of BP with a history of being active in Tanzania and Mozambique also, has already received 174,000 ha from the Zambian Government for intensive jatropha plantations in high rainfall zones. Similarly, in Tanzania, important rice-growing areas for local consumption were converted to jatropha.
Though this is advertised as a climate-saving activity, the carbon balance is actually negative especially when the sites were previously under woodland/forest cover. Suede (2007) calculated a payback time of 20 years for the resulting carbon debt. But this optimistic calculation supposes substitution of fossil fuel only for the jatropha oil and not for the whole forest. Considering the annual increment of the forest, the pay-back time is indefinite. The amount of carbon embedded in the wood and soil of the forest plus the yearly increment can never be reached by a jatropha plantation. A calculated advantage of jatropha after 20 years is based on the incorrect assumption that production from the destroyed natural forests was not itself a bio-fuel. But closed Miombo forests in regions receiving more than 1000 mm of annual rainfall, like those being presently destroyed by some enterprises in Zambia, yield biomass as fuelwood, charcoal (thin trees), building material (oldest trees), meat, mushrooms, herbs, fibre, etc. The costly substitution of these products will require large amounts of fossil fuels. The misleading assumption with "marginal land" is that where there is no (monetary) market, there is no production. More than 10 MT/ha/year of Carbon are produced by these forests !

Carbon debts of at least 440 MT CO^2 were calculated for those forests and a payback time for fossil fuel substitution of at least 44 years. Currently, the competitive price of agro-fuels compared to fossil fuels is due mostly to the absence of taxes and the presence of subsidies. The use of forests for the livelihoods of local people, and the value of its biodiversity, climate and water regulation functions, are not being included in the calculations.

But carbon debt and the competition with food production can be reduced through measures that reduce the input of agrochemicals and increase carbon sequestration. Sub-Saharan Africa has the highest potential worldwide for an increase of food production by using more land resources without destroying intact natural landscapes. But even if no new land was brought under cultivation, the potential for an increase of production to a reasonable level is considerable.

Jatropha curcas and other potential energy plants offer some opportunities for a local cash and energy market. They can be beneficial also to small-scale farmers as long as:

- 80% of the farmer's production consists of food crops
- No natural vegetation is cleared to plant it
- It is planted as hedges
- No fertilizer is used
- No annual tillage is applied
- No pesticides are used
- The oil is used locally or regionally, but not for the world market
- The cake or the ash of the cake is fed back to the soil

Jatropha is a perennial plant suitable for agroforestry that is more environmentally friendly than annual crops. Integrated into permaculture and conservation farming/organic systems, it has a high ecological and economic potential. It can be useful as living hedge, protecting fields from livestock and wildlife. Its oil can be used locally for generators, pumps, tractors, lamps and soap, and even to feed decentralized energy platforms.

9. Which are real and expected impacts of climate change on agriculture ?

The largely man-made warming of the earth has started to show results and challenges our ability to change behavior. The results will get stronger, their effects are different in different places, but overall more are negative than positive. Most changes are too rapid for nature to adapt successfully. Besides saving energy, mitigation measures and using more energy-efficient technologies, adaptations in land use practices are of the utmost importance world-wide. It is interesting to see that climate change will create few new problems-if any- but exacerbate many existing ones. This gives us hope that some adaptive methods are already in place, at least in an early stage.

Activities related to agriculture and forestry including land use conversion contribute about 1/3 of greenhouse gas production world-wide, often in the form of methane or $CH4$ (ruminants, rice production) and nitrous oxide or $NO2$ (fertilizer production and use). But land conversion to agriculture is the largest emitter. The resulting warming of the climate is impacting the environment through the shifting of natural vegetation belts and agricultural opportunities. Additional heat and droughts will change the agricultural potential, and some current cropland will be only suitable for livestock in the future. Rainfall will be less predictable, sometimes more torrential, and some already wet areas will have even more rain. Nothing is simple here: hotter weather means less clouds, which means less water and also more insects. Pesticides act more quickly but also deteriorate more quickly, fertilizers will be adsorbed even more easily, but their loss of nitrogen gases (a contributor to warming) will be greater. For large areas of southern and eastern Africa, more droughts are foreseen, making soils more vulnerable to soil erosion and the loss of soil organic matter. The latter leads to a loss of nutrients and water retention capacity, which could lead to a collapse of soil structures. This is also aggravated by heavy downpours and excessive tillage with heavy machinery which may cause water-logging. All of these processes lead to diminished returns on investments and growing food insecurity.

Adaptation methods include all of the organic matter-centered agricultural methods mentioned in Question 1. Still existing pristine landscapes should left untouched as carbon sinks, and burning should be avoided. Management of the micro-climate becomes extremely important in agriculture. Early seeding and weeding, covering the soil with cover crops at all times, intercropping and growing trees and bushes between crops, minimum tillage along the contours, and water harvesting are all methods that support agricultural sustainability in difficult areas. Some ‘thirsty’ crops will have to be replaced by ones that are better adapted to a drier climate, like maize by sorghum. Reserve fields for subsistence needs that are planted with hardy plants like cassava will become more important. Rice producers need systems with less water use (like SRI: System of Reduced Irrigation), also because higher water users produce large amounts of GHGs. The entire complex of storage technologies will gain importance. Wetter weather will bring more weed growth and fungus problems, thus raising the question of effective, costly and environmentally acceptable control methods.
The flooding of coastal plains and ground-water intrusion by salt water requires protecting and replanting mangrove belts, and the use of more salt-tolerant plants.

In animal production (see also Question 6), the emission of GHGs cannot be totally avoided. Nevertheless, in small mixed-cropping systems, ruminants should be kept in stables and food brought to them. Their dung should be used in the fields and gardens after some maturing time. The higher amount of organic material in the soil will also support the process of sequestering carbon there. High animal concentrations, like feedlots, should mainly use grass and hay and minimize the use of high-energy fodder like cereals and soy. Although there is some evidence that animals that are fed high-protein plants produce fewer GHGs, methods of establishing new production sites (such as rainforest clearing in Brazil and Indonesia), producing and transport are likely to cancel out these savings. Manure should be collected in order to use it on fields or in biogas plants. Pastoralists should return to their old or alternative new ways of wandering with their herds, and respect the carrying capacity of what land is available. As an area becomes drier, there is a marked shift of animal species from cattle to sheep to goats to camels, and an increased preference for locally adapted breeds; thus showing the overall importance of genetic variability. The tse-tse fly belt (which harbors a dangerous disease) has so far prevented cattle herding in some semi-humid areas, and this may also shift under the influence of climate change.

The introduction and further distribution of agriculture that focuses more on the production of organic matter and minimizes carbon losses may even be eligible for carbon credits for above-ground (trees, cover crops) as well as underground carbon sequestration – at least when it is done and certified on a large scale.

The diverse African landscapes, with their various microclimates and weather patterns, will see equally diverse symptoms of climate change that do not allow for a ‘one-size-fits-all’ response, but will require many different measures adapted on a small scale to relatively small and vulnerable places. (This is not necessarily in contradiction to the possibility of measuring carbon sequestration on a wider landscape scale.) Climate changes that are beyond our control will continue, uncertainties will prevail, and in order to avoid risks African societies will not only have to follow more practices of adaptive management, but may also consider the introduction of innovative insurance systems.

10. How to improve land and labor productivity?

Here we come back to the basic idea of three different farming methods, as discussed under Question 1, "conventional, conservation and organic farming." While there is little doubt about the high land productivity of eco-oriented methods, it is the prevailing perception that this requires too much additional work to be economically advantageous.

As Sachs (2008) admits, the greatest potential for world food supply lies in production improvements in small-scale farming, as its highest potential is far from being reached and significant increases in both production and productivity are possible with relatively simple and cheap measures.

Conventional farming, on the other hand, suffers worldwide from high input costs per ha, which reduces the profits per ha and makes small-scale conventional farming meaningless in most of the tropics. Nevertheless, large-scale farming can cut input costs and reduce the labor volume considerably through the use of conservation farming methods. Approaches like direct sowing with permanent traffic rails (the machine wheels are always in the same track, leaving most of the field un-compacted) makes energy-, material-, and time-intensive plowing and harrowing obsolete. Permanent crop lines concentrate soil disturbance and inputs on 10-12% of the field's surface. Cover crops save labor by suppressing weeds and do not reduce the main crop yield; they even supply extra yields during the dry season and increase soil quality for the coming season.

Organic farming, especially with heap compost, ridging and trenches, needs more labor for soil preparation; but only without cover crops and permanent furrows/basins, it needs a great deal of labor to control weeds. Organic farming needs considerable skills to achieve the optimal nitrogen level for annual crops, especially without livestock or improved fallows. The transition from conventional to organic farming begins with economic losses, while the benefits only come later.

Many rural development organizations working in Africa have demonstrated the feasibility of considerable improvements in rural livelihoods. What rarely works yet happens too often is, among many others, indoor workshops for farmers, group training without individual follow-up, and the use of government departments as trustees of funds.
The principles that work well are always the same:

- Highly qualified experts with international experience are
- training trainers practically in the fields of the farmers, with the farmers and through the farmers;
- local support structures are solidified, and lead farmers trained and supported;
- the government is involved through their local extension officers;
- there is personnel continuity and
- a long-term approach is followed.

New Green Revolution methods and inputs as used in Europe, North America and Australia, may be appropriate anywhere if there are good soils, sufficient water, farmers educated in modern ways, and nearby markets. They are less suitable for poor small farmers in the tropics to fight hunger and exclusiveness on highly diverse, mostly poor soils, nor to reduce poverty in an unpredictable environment of changing climate patterns and frequent socio-economic and political disturbances.

The anwers 1,2,3,4,7,8,10 were prepared by Martin Bertram, 6 and 9 by Reimund Kube, and 5 by Yahya Msangi Khamis.

This report was produced by the Poverty and Environment program of WWF's Macroeconomics for Sustainable Development Program Office (MPO) thanks to the financial support given by the Swedish International Development Agency (SIDA).
Based on decades of learning and experiences, the authors express here their own opinions.

The authors are Reimund Kube, Program Officer at WWF-MPO in Washington DC,

Martin Bertram, Research and Organization Development Officer at PELUM (Participatory Ecological Land Use Management) in Lusaka, Zambia,

Mohammed Awer et al., Director of Goodstuffinternational Africa Limited in Nairobi, Kenya, and

Yahya Msangi Khamis, National Coordinator of TAPOHE (Tanzania Association of Public, Occupational and Environmental Health Experts) in Dar-Es-Salaam.

All photos are by the authors or the Conservation Farming Unit in Zambia.