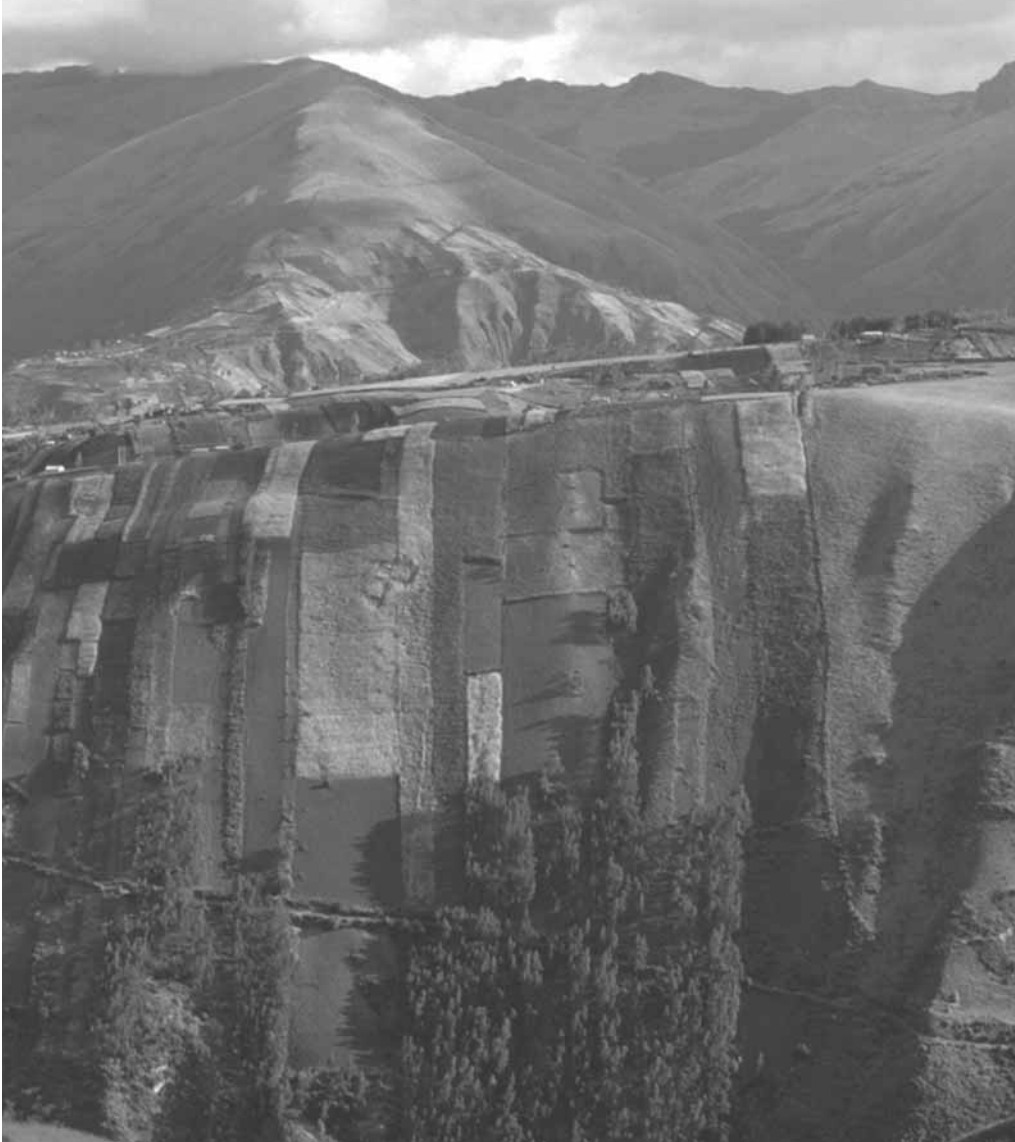


Agriculture and food production: Quo vadis

Dr Hans Rudolf Herren



Why should we be concerned about the agricultural production base? First, the world population continues to grow: from less than 3 billion in 1950 to 4 billion in 1975, reaching 6.4 billion in 2006, and we expect it to be about 8.5 billion in 2050. Meanwhile, the area of farmland has remained roughly stable, as land lost to degradation and desertification has been made up by clearing forests and bringing land under cultivation through irrigation. But the future of food production remains uncertain, especially in view of global warming: much of the productive agricultural land in coastal areas is predicted to disappear. And more people means diminishing cultivated land available per person for food, fodder, fuel and fibre, so the pressure to increase the productivity of every hectare to achieve the same production levels remains high. Yet that comes at a cost.

In an ideal world, a well articulated understanding of pressures, drivers and appropriate responses would foster a decision-making arena in which national governments could work to increase or maintain agricultural productivity while conserving environmental quality. Between policy and farms, however, there exist a number of problematic “disconnections” that hamper good policy making.

Disconnections

Of the several disconnections in our systems we will discuss those between agriculture and the environment, between producers and consumers – or, in another sense, between rural areas and cities – and then between policies and expectations.

Agriculture and the environment

No matter how well we manage our agriculture, we are interfering with natural cycles. Contemporary farming methods in particular – with level fields, reduced biodiversity, no rest periods and the use of toxic chemicals – involve managing land in ways that conflict with the healthy functioning of ecosystems. Yet agriculture depends on healthy ecosystems for its water supply, for the cycling of nutrients in soils, and for pollination and pest control. We know all this, but rarely work to promote them. Some are trying: a number of farmers are moving to organic agriculture, sustainable agriculture, or ecoagriculture – whatever we call it – but this is only a tiny proportion of what is happening in agricultural production today. In contrast to the growing need for a system that works and will continue to work in the future, we are actually destroying it.

We are pumping water from very deep down and in many places the water table is receding below its capacity to fill up again; the cycle of nutrients in the soil is being broken because so many crops are exported far from where they are grown, with nothing being returned to the land where they are produced; we have an almost global problem in our loss of pollinators; and we are destroying the balance of natural pest control. In an environment that is functioning in a certain equilibrium, these systems operate almost without anyone noticing. It is only when changes begin to occur that we realize that something has been lost. We must ask ourselves what we want for the future. Do we want more land-degrading methodologies or do we want a sustainable approach to agriculture and food production?

Soil fertility: As we deplete soils through inappropriate practices, we have to compensate by adding fertilizers, creating new problems further down the chain because fertilizers, particularly nitrogen, have a habit of running off. The application of inorganic fertilizers is particularly heavy in highly developed areas such as North America and Europe, and usually where agricultural production is intensive. Africa in particular has not followed that trend so far, mostly for economic reasons, and that is perhaps one reason why productivity there is rather low. But across the world, soil degradation is now so severe that yields on about 16 per cent of agricultural land have diminished despite the use of optimal fertilizer rates. Soil productivity is declining in parts of India and the whole of East Asia. Again, the damage is greatest where there are major concentrations of people. Research in Thailand has shown there is no way to increase rice production with higher fertilizer application rates. The land is just exhausted, and there is a need to look at sustainable agronomic practices to maintain or increase yields. One such method, the System for Rice Intensification (SRI)¹, which originated in Madagascar and has been widely tested in Asia, takes advantage of specific plant traits to optimize growth and productivity.

Water use: Irrigated agriculture – a significant component in the productivity gains of the Green Revolution – is very important, but we need to think more about how we actually do it. Large-scale schemes often produce more food than we actually need, or produce it in the wrong places, and contribute to waterlogging and salinization, to the chemical contamination of surface and groundwater supplies, and to their untimely depletion. Such a loss of water means that there is no long-term future for this type of system. But there are better technologies, such as drip irrigation, which uses less water, helps to control weeds, resulting in lower herbicide use, and involves much less leaching of fertilizer, as water and nutrients can be directed straight to where the plant needs them. Far more must be invested in such technologies as

¹ see <http://ciifad.cornell.edu/sri/listsevs/index.html#update>

part of sustainable agricultural research; we still have more to learn to become water efficient, and we still have to value water more highly. At present water is simply too cheap to promote such investments.

Agricultural chemicals and pest control: Runoff from high-use areas generally carries heavy loads of pesticides/herbicides as well as fertilizers, polluting waterways and overloading them with nutrients. Such high chemical loads have created problems for the people who want to use the water, and have also promoted pesticide resistance. There are now more than 400 herbicide-resistant weed biotypes, 150 resistant fungi and bacteria, and more than 500 species of insect, mite or tick that are resistant to one or more pesticide compounds. So many insects are resistant that in many cases we do not know what to do next. But this could be a good thing, because there are other ways of controlling pests: we can use biological controls, we can use better habitat management practices, and we can farm using fewer monocrops and more mixed cropping, which allows natural enemies of crop pests to be part of the system and stop them getting out of control. If we have an environment that is diverse in the sense of different guilds (herbivores, predators, parasitoids), we will have fewer problems.

Pollination services and beneficial insects: Recent research has shown that the most effective pollinators (representative of beneficial insects) are the first to suffer local extinctions under systems of conventional, rather than organic, agriculture. We are losing many of our pollinators, some we do not even know about. As an example of the many pollinating insects, let us look at the honeybee. In California people are currently paying \$120 to pollinate an acre of almond orchard. Last year it was \$30. This huge increase in cost is because hives in the United States, Europe and elsewhere are dying out as a result of the *Varroa* mite, which has been carried round the world by inattentive people taking short cuts. But there are many species of wild bee that have also disappeared, or are disappearing, because we are removing their natural habitats. Campaigns to preserve hedgerows are not just important for small animals but also for maintaining pollinators. About two-thirds of our plants need pollinators, so any loss in pollinators means a huge loss in plant biodiversity. If we continue to spray chemicals and remove hedgerows and natural habitats for wild bees, we are going to run into more and deeper ecological problems.

Genetic simplification: Another reason why pests have become such a problem is the planting of genetically similar crops, so that if a crop gets a disease it can be wiped out almost immediately. This is especially true for many hybrid plants. In the United States in the mid-1970s, for example, the whole crop of hybrid

maize was lost and it was only because scientists were able to multiply new seeds off-season in South America that farmers could resume growing maize the following year. Vegetatively multiplied crops are a very strong target for cloning and tissue culture multiplication methods (e.g. bananas, cassava, many tree species, flowers, etc.). The narrower the genetic base, the more exposed the crops are and will be.

Producer and consumer

Now let us look at another disconnection, that between the producer and the consumer, or between land and cities. Consumers want perpetually low food prices (making farming a precarious business), but this is now compounded by a crisis of trust fuelled by food scares such as “mad cow” and foot-and-mouth diseases, and a sense that many supermarket foods are low on nutritional value and high on price.

In the case of “mad cow” disease, it seems clear that money was the issue behind the short cuts that created the problem. Now bird flu is coming; it is getting closer and it will be difficult to stop or even contain. The only question here is *when* it is going to happen – not *if*. And with animal-to-people transmission already occurring, it is probably only a matter of time before we have people-to-people transmission. Again the production system, fuelled by the “cheap food syndrome”, is at fault. One may wonder why food is so cheap in the industrialized countries at a time when people have more money than ever, and health problems linked to nutrition have been demonstrated over and over again.

Industrialized agriculture is giving rise to increasing incidences of food-borne illness. We eat too much, we eat the wrong mix of food, and we get sick from our food. The concentration of livestock into factory-type feed lots, broiler sheds and massive piggeries promotes infection and spread. For example, more than 90 per cent of pig herds and 50 per cent of cattle in Denmark and the Netherlands are contaminated with *Campylobacter*, a food-borne bacteria causing diarrhoea. About half of the antibiotics used in the United States are fed to livestock, and four-fifths of these are to promote growth and suppress disease rather than treat it. Resistance to antibiotics is on the rise and, although until now we have been able to find new ones, we do not know how often we can do this or how quickly – not to mention the question of cost or who will pay for it.

As a result of these intensive methods, meat is cheap per kilogram produced, but if all the costs were factored in – water pollution, disease, subsidized transport of feed from Argentina to Europe, to the



United States or China – the meat would actually be more expensive than from a local farm with a mixed crop-livestock system. The same is often true of intensive grain production. Calculations of rice cultivation in the Philippines have shown that costs are greater, in terms of agricultural inputs involving high pesticide use, than under integrated pest management (IPM). Here too there are significant health costs, with increased incidence of eye, skin, lung and neurological disorders, not to mention costs to the environment and biodiversity. Clearly, many aspects of these food systems are unsustainable.

Policies and expectations

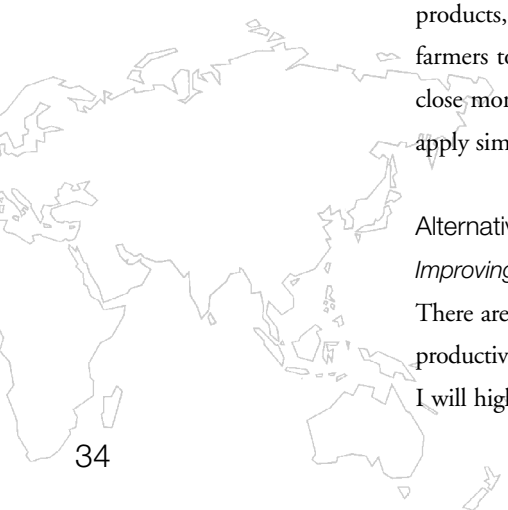
Almost every country in the world cherishes its agricultural roots, in song, picture and mythology. We believe that agriculture is a pleasant occupation and that it helps support our beautiful landscapes. But this valuation is rarely translated into policy to support the family farms that are central to any particular farming community. In many places agriculture no longer looks very nice, while in others much of the land has been filled with houses. Suburban sprawl usually takes place on the best agricultural land, and is followed by the requirement to intensify production on the remaining, poorer quality land, using more fertilizers and more pesticides, and so increasing productivity at a very high cost while also harming the environment and reducing the ecological services that a well functioning system can provide.

There are very few policies aimed at keeping good farmers on the land producing good food at prices that reflect the value we attach to safe foods and a strong rural sector. Agricultural subsidies have rightfully earned a contentious reputation, as they have too often served to support large industrial farms (certainly in the United States) and to help such producers flood developing-country markets with subsidized products, none of which achieves desirable policy aims. Moves within Europe to provide subsidies to farmers to maintain the environment rather than overproduce deserve further consideration, as well as close monitoring to ensure they are not subverted by conventional subsidy schemes. Nascent efforts to apply similar strategies in developing countries, such as Uganda, also merit close study.

Alternatives (two ICIPE approaches)

Improving the production base

There are viable options for stewarding the production base while maintaining or increasing agricultural productivity, many of which have been developed under the challenging conditions of developing countries. I will highlight two good examples of “green” but productive agricultural systems from the International



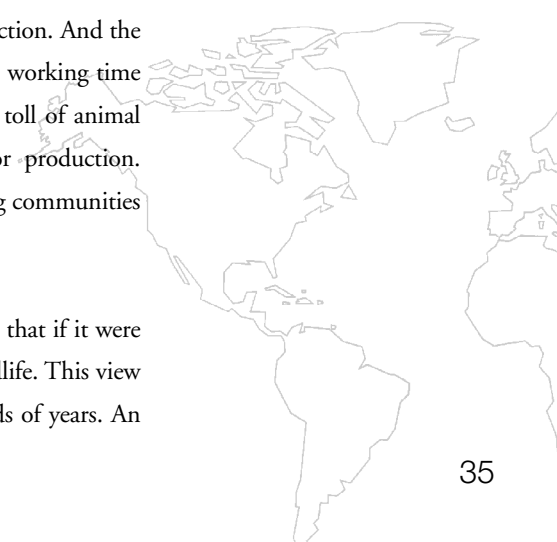
Centre of Insect Physiology and Ecology (ICIPE) in Nairobi, where I have spent the last 10 years: tsetse and trypanosomiasis management, and an integrated maize system for sustainable crop health management.

Tsetse control: Sleeping sickness, trypanosomiasis, is transmitted by the tsetse fly and affects animals as well as people, and cattle in particular. For people, the chances of getting the disease are generally very low, although in some areas of Sudan, particularly the south and a swathe through the central part of the African continent, it is quite widespread. Trypanosomiasis is not very pleasant, and once a person has it there are only very old treatments available to cure it, if it can be cured.

Nagana, as the form that has an impact on livestock is known, affects the whole sub-Saharan Africa belt. There are several species involved and the pathogens are all equally deleterious. In 1998 the Food and Agriculture Organization (FAO) of the United Nations wrote: “Nearly 100 years of control efforts have failed to curb the distribution of tsetse fly infestations or the resulting incidence of trypanosomiasis in Africa (only 10 per cent of the area reclaimed). African trypanosomiasis remains a major constraint to livestock productivity and continues to impede intensification of crop-livestock systems across vast areas of Africa that hold the greatest potential for increased agricultural production and rural development.”

Tsetse flies breed in the undercover of bush. In the colonial period, control was undertaken in many regions of Africa by whole-scale bush clearance. This made it possible for farmers to raise cattle without high levels of tsetse, but after independence, when clearance was stopped, the land went back to bush and the tsetse flies returned. This has made it very difficult for farmers to farm, because they have no tractors and very little mechanical energy, so are dependent either on human labour or animal traction. And the problem is exacerbated by malaria, which leaves people too weak to work. A third of the working time of an average African is lost to malaria, amounting to losses of \$12 billion a year. This toll of animal and human disease leaves many African farming systems with very little energy for production. Mechanization has been advocated, but is usually beyond the resources of African farming communities – and judging by current oil prices, will continue to be so.

Tsetse has sometimes been called a “blessing” to wildlife conservation, with the claim that if it were eradicated, cattle would wander everywhere and there would be no national parks or wildlife. This view rather fails to understand that cattle have been a part of African landscapes for thousands of years. An



integrated approach, that seeks to manage rather than eradicate tsetse fly populations, is far more desirable than either continued high losses or old bush-clearance control systems.

There are a number of possibilities. One control method, the sterile insect technique, has been tested by the International Atomic Energy Agency in Vienna and by FAO. In this approach the tsetse flies are multiplied in the lab in their millions and sterilized with a cobalt radiation source. Once released into the wild, the sterile males copulate with the feral females with the result that there are no offspring. This has been carried out successfully on the island of Zanzibar in a forest of about 16 square kilometres, albeit at a cost of something like \$30-40 million. Some think we can now do the same on the continent, but, taking an area such as that from Dakar to Maputo, many thousand times the size of Zanzibar, the cost would be somewhere around \$10-20 billion, even if it were feasible.

Rather than trying to eradicate the tsetse flies, scientists at ICIPE have taken a bottom-up approach – and one that is sustainable – by enabling farmers to manage fly populations using traps and repellents, assisted by computer simulation models to identify where the traps should be placed. It so happens that flies are very much attracted by cobalt blue colour and so they come from far away and land on the trap, a piece of blue cloth with a plastic bag on top. The flies are trapped in the bag and die, frying in the sun, and the traps are then emptied by ants that like to eat the flies, making it a self-sustaining system.

This “pull” method – of attracting the tsetse – was not always sufficient by itself, so ICIPE developed a “push” or repellent technique. When thousands of flies were checked to see what blood they had taken, traces from elephants and every other kind of animal were found, but never any from a waterbuck. The scientists set about finding out why, especially as there are often more waterbucks than any other animal in the bushy riparian areas where tsetse flies breed. Waterbucks turned out to be highly repellent to tsetse flies. So the odour of the animal was synthesized in the lab, and the cattle now wear collars with dispensers that make them smell like waterbuck. Flies simultaneously avoid the cattle and get caught in the traps under what is called a “push and pull” system.

This all sounds very simple, but are farmers actually doing it? We tried it with the Masai and others, and found that as long as scientists were there to help they were happy to maintain the system but, a year or two after the scientists left, when the traps grew old and the farmers had no money to buy new ones,

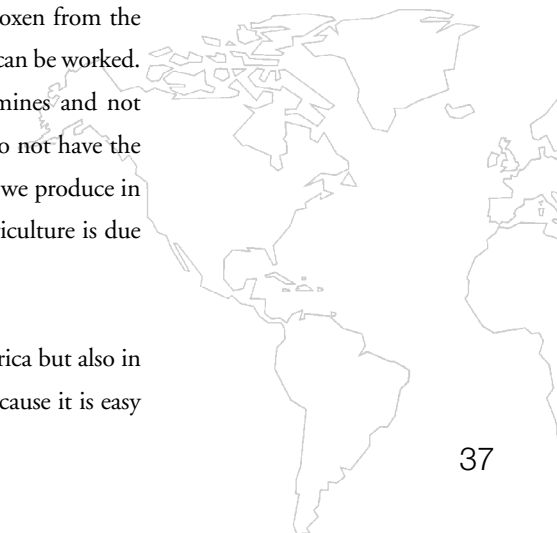
the system faltered. (In addition, people like to use the blue cloth for shorts and shirts, and they also make very good school uniforms.) However, when the farmers later realized that the traps had actually reduced cattle mortality, they began to put them out again.

People have been taught to make the traps themselves, but they still cost around \$5 or so each for the cloth and so on, and this for many farmers is quite a large sum of money. Until recently, ICIPE recommended using one trap per square kilometre, which was successful, but generated a lot of work for the farmers who had to go to many places on foot. To reduce the number of traps, and so the costs and time burden, ICIPE developed a computer model to assist in the trap layout scheme. Control or monitoring traps from which the farmers collected data biweekly were placed in the target control zone. The resulting data were then processed and the computer model indicated where traps should best be placed to guide control operations to the predicted hotspots.

The number of traps used to limit tsetse flies is now down to a quarter of the earlier number, at levels manageable for farmers. Those involved in the project in the Ghibe Valley of Ethiopia are very enthusiastic, and the project has also attracted farmers from a neighbouring valley who requested training in the deployment of the traps. We call the system adaptive management, and it involves the farmers with the scientists and the extension specialists from the outset of the implementation process. They are taught how to place, monitor and control the traps, and eventually continue with the work on their own.

The project has now been going for three years with no outside interference: milk production has increased fourfold and ploughed land sixfold. In the past, most farmers had to get new oxen from the government almost every season, but now that cattle survive and do well, much more land can be worked. These are important implications for places like Ethiopia, where there are frequent famines and not enough food is produced, and where it is impossible to improve the situation if people do not have the energy to work and there are no animals to replace or help them. How much food would we produce in the industrialized world if we had to do it all by hand? Much of the efficiency of our agriculture is due to increased energy input.

Integrated maize cropping: Maize cultivation is expanding worldwide, very much so in Africa but also in Asia. Even though it is not a particularly good human food, it is replacing other crops because it is easy



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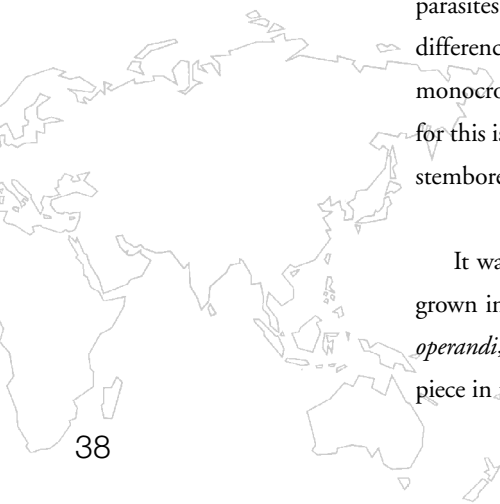
to grow, easy to consume, and requires little energy to cook. However, there are still some problems, including many species of stemborers, which attack the plant's stem so that it falls over or produces very little. Such attacks can reduce the maize crop by 15-40 per cent.

There is also a problem with striga, a major weed. The landscape looks very beautiful when covered with purple striga blooms, but the plant is a parasite that takes all the nutrients from the maize. This happens almost throughout Africa: it has been a major problem in the west, centre, east and south of the continent. The average reduction in yield is 10-20 per cent, but in many areas the loss is much greater, sometimes wiping out the whole crop, particularly in places where the soil is poor or the water balance is upset. Lately, Africa has experienced many droughts, compounding the striga problem.

ICIPE has been working with the Agricultural Research Institute in Rothamsted in the United Kingdom to look at ways to control both the stemborers and the striga. In the first stage the scientists were looking at the preference of *Chilo partellus*, a stemborer accidentally introduced from India, for laying its eggs either on the native African Napier grass or on maize. The finding in five different locations from Uganda to the Gold Coast was that more than 60 per cent of *C. partellus* preferred to lay eggs on the grass, even though larval survival is much lower than on maize: less than 20 per cent of larvae survived 30 days from hatching on Napier grass, compared with more than 70 per cent on maize. This finding provided us with our first piece of the jigsaw puzzle.

A second piece of the puzzle was that a much higher proportion of stemborers was affected by parasites when maize was intercropped with *Melinis*, a fodder grass. Although there was a significant difference in parasitization between the two study areas, in both cases it was lower in the maize monocrop than in maize intercropped with *Melinis*, whatever the ratio of maize to *Melinis*. The reason for this is that *Melinis* attracts beneficial insects into the maize field, particularly the parasites that attack stemborers.

It was also discovered that if *Desmodium* – a legume widely grown by farmers as a fodder crop – is grown in a maize field there is almost no striga. Although there are still questions regarding the *modus operandi*, the germination of striga is highly affected by the *Desmodium*. This provided us with yet another piece in the puzzle.



ICIPE scientists now needed to rearrange the pieces of the puzzle to improve matters. The proposed management system for maize cropping involved both push and pull elements. Around the field Napier grass was planted as a trap crop to attract the *Chilo partellus* moths. Inside the main crop rows, the role of *Melinis* was to repel moths and attract natural enemies. When the stemborers land, they prefer to lay their eggs in the trap crop, and the few that get to the main crop are pushed out because they do not like the smell of the fodder crop. Even if a few manage to stay in the main crop area they have little chance of surviving because natural enemies are being drawn in from outside to attack them. Meanwhile on the striga side, the *Desmodium* makes sure it does not suppress the maize.

The result of ICIPE's crop management system in 10 districts in Kenya and Uganda was that the maize yield was superior in all cases, and sometimes double, when measured against control plots. Some farmers actually increased maize production by five to ten times on very small farms – a huge difference. In addition, the farmers have fodder, so they can keep more cattle, thereby increasing milk and meat production. These extra benefits make a substantial difference to most of the small farmers, especially the milk production, which brings in cash every day.

Lessons learnt

There are several lessons to be learnt from this.

1. Invasive species can be a major threat to food security. The stemborer from India is only one of a number of insects that have been brought in from other countries, often by scientists.
2. It pays to have access to biodiversity. One day we may need to go back and find beneficial insects or pathogens to control pests, and if we lose biodiversity we may well find we have lost those too.
3. Strategic research in support of applied and adaptive research is a necessity. Knowing the characteristics of plants helps to understand how systems work and how to make them sustainable without the need for external inputs. Production systems that produce fertilizer in the form of nitrogen, create organic matter in the soil, attract natural enemies and maintain the water balance are part of the process of sustainability.
4. Capacity and institution building have contributed to successful programme design and implementation, all as a result of training people who then go on to work in national research and extension systems. Farmers need access to information and that is usually obtained through people, not through research reports, as important as these are.



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5. International cooperation can be a key factor for success. It is especially important in science and greatly benefits research.
6. Involving communities, farmers, policy makers, researchers and extension specialists is essential. Policy makers are especially critical for creating a policy environment conducive to sustainable production, affecting issues such as subsidies for fertilizers and pesticides, land tenure and farmers' access to credit, as well as marketing and distribution.
7. Adaptive participatory management methods are required – a vital link between communities and farmers.
8. It takes time and patience to achieve success. Some project examples indicate that it may take ten years to achieve results, but at present the average grant lasts three years. As there are few unrestricted funds available for investigating new avenues, all the money for projects has to be found from grants, usually hard to get and often directed to very specific activities defined by the donors rather than the needs of the end users.
9. There are alternatives to the conventional industrial agriculture model that are sustainable and work (i.e. can feed the world). It is therefore important to consider these alternatives in research, capacity building and extension. It has been said that if all farming were organic we would be unable to feed the world. But the records and data that ICIPE and many other research institutions have published demonstrate that organic and sustainable agriculture can be as productive or more so than conventional methods, particularly bearing in mind the reduced input costs and the assurance of long-term productivity of the land. More research still needs to be done on how these systems can be improved further, to provide not only the food but also the many ecosystem services that are expected from agriculture, such as clean water, air, carbon dioxide sequestration, recreation landscape, pollination, pest control, etc. This again links into appropriate policies.



Vision

Main challenges ahead

- Population growth, from 6 billion to 8 or 9 billion.
- Decreasing productivity of the land.
- Water (quality, quantity, distribution and access). For many people, water may be nearby, but there is no access to it.
- Climate change. We are on a trend that is difficult to reverse. Even if all harmful emissions were

stopped today, we would still go beyond the limit that we should have met. I wonder just what it takes to convince some people that we ought to do something now, when actually we should have taken action 30 years ago when the Club of Rome produced the book *Limits to Growth*. We believed technology would be the answer to all growth-related problems – and we have indeed found some technological fixes, but that is what they are: fixes, not solutions. Agriculture in particular will be extremely affected by climate change. There is drought again this year in East Africa and it is going to happen more often. Already one year in four is a drought year.

- Biodiversity crisis. Losses of biodiversity in agricultural systems will have direct impacts on pollination and natural control of pest outbreaks. Some currently proposed solutions for pest control seek a solution in biotechnology and in genetically modified organisms (GMOs). Yet this seeks to further simplify an already dangerously simplified and uniform system. It is of course possible to add genes to crop plants to solve a problem, but the full costs of such technofixes are not yet fully accounted for and will become higher with time, just as we have seen with pesticides. We entered the pesticide treadmill soon after they were introduced, and we are about to take the same path with GMOs, since we are treating symptoms rather than removing the causes of the problem.
- Energy crisis. Again, agriculture will be very much affected, particularly in the developed countries that are using so much fertilizer and nitrogen, the production of which is linked to oil.
- Ecosystem services. We must restore ecosystems and maintain them once they are restored.
- Cheap food policies are a major issue and need to be radically and quickly rethought, as does the food system and its disconnections.

Production equity issues: Let us remind ourselves of food production over the last few decades. Taking the food production index as 100 in 1961, it reached 250 in 2003 – a considerable increase. The problem is that food production per capita, although it has risen, has not gone up by nearly as much, by less than 50 per cent in fact. Food prices, as I have already mentioned, have gone down and keep going down. It is difficult to find an explanation for this, especially at times when there has been a shortage or less food available per person. It certainly defies conventional economics. The trend in undernourished people, which had been falling since 1980, has risen again in the last few years. But we know that today there is in fact enough food in the world to feed everybody well. The trouble is distribution and access, and here may lie the explanation for such low food prices in the industrialized countries where there is overproduction, while many developing nations are hampered by underproduction.



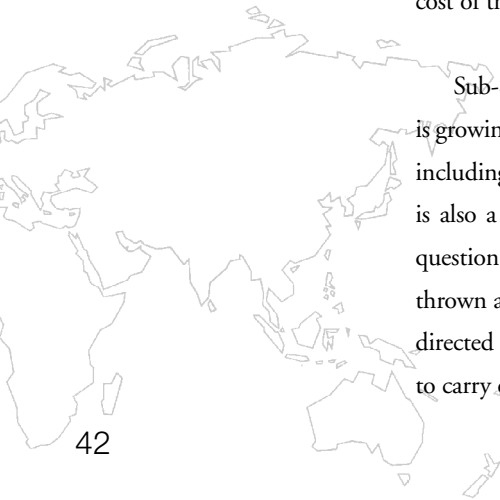
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Another problem scientists need to deal with is the gap in cereal yields between high-income and low-income countries. In developed countries productivity has increased steadily, but it is still very low in the poorest countries. Very often the variety of seeds planted, such as hybrid maize, is the same or similar, so the discrepancy is accounted for by differences in access to energy. The potential for higher production exists in developing countries, but it cannot be realized because of systemic factors, such as a lack of production resources or of the financial means to access them.

Although grain yields increased from the 1970s, particularly as a result of the Green Revolution, the trend began to flatten out in the late 1980s and 1990s. This pattern can be seen in China, India, Indonesia and the Philippines and many other countries. The increases were achieved through breeding, some better agronomy and the use of pesticides, but there appear to be limits to how much more we can produce per hectare. Cereal production, however, needs to double in the next 50 years, not because there will be twice as many people – the population will probably increase by a quarter – but because as people have more money they want to eat more, and in particular more meat. It takes a lot of cereals to produce beef.

We also need to deal with the differences around the world. The first of the Millennium Development Goals adopted by the United Nations in 2000 is to eradicate extreme poverty and hunger with a target to halve, between 1990 and 2015, the proportion of people whose income is less than \$1 a day. We are behind schedule in meeting this goal. In sub-Saharan Africa there has been little or no change and the same is true of West and Central Asia, Eastern Europe and the former Soviet Union, Oceania and many other areas. People are hungry, and they are also poor. But at what cost are they going to increase production? At the cost of the environment? Or are they going to look for a more sustainable solution?

Sub-Saharan Africa remains the biggest problem because here the number of undernourished people is growing. Everywhere else, except possibly South Asia, it is decreasing. The reasons behind this are many, including diseases such as malaria and HIV/AIDS, as well as the new pattern of extreme droughts. There is also a lack of investment in infrastructure, agriculture, and agricultural research. This is not just a question of money, it is also a matter of training and policy. There is only so much money that can be thrown at the problem; eventually we find it is just buried under the money. In the past, foreign aid was directed at education, universities and technical schools to produce more capable people to manage and to carry out research. Although increasing numbers of people have been trained in Africa, many of them



have left the continent. Training must be accompanied by employment creation policies, i.e. investments in the processing industry, thus creating new jobs for excess labour from the farms while also creating markets for farm products. In my view, the developed world is responsible for the current situation in Africa because of the way it has dealt with the problem: throwing money at it and thinking it will go away.

Water issues: Even in the best possible world we are going to need more water, and the only answer is to work harder to make better use of what there is. The Millennium Ecosystem Assessment (MEA) presented four different plausible scenarios for the future: global orchestration; order from strength; adapting mosaic; and techno-gardens. Under all these scenarios, global water availability increases by between 5 and 7 per cent, depending on the scenario, by 2050. But demand for water is projected to grow by between 30 and 85 per cent. Agriculture uses about 70 per cent of total water worldwide, and must be central to all efforts to use water more rationally.

A bit removed from agriculture in the narrow sense, but still an important food source, let us now briefly consider fisheries. There is a belief that there are a lot of fish in the oceans. Actually, yes there used to be, but catches are going down and will continue to do so. Marine fisheries have been declining since the late 1980s. The cod fishery, for example, collapsed in the 1990s and has not recovered. Twenty-five per cent of commercially exploited marine fish stocks are overharvested. Technology has meant that we can catch almost any fish we want. With satellite imagery, big boats, huge nets and trawlers, fishers can harvest and harvest, regardless of replenishment rates. This is a good example of how we must be more sensible about how we use technology, both in the sea and on land.

New perspectives for the future

We need sustainable food systems that:

- Play a critical role in culture and society. Food is not a commodity, but something that people eat and socialize over. Food is also a component of cultural diversity. Farming and farm products are key pillars of the economy. Our economies in both north and south depend on agriculture.
- Play a critical role in maintaining, or restoring, the substance of life. Agriculture is the steward and life support of the Earth, providing water, air, recreation and biodiversity, as well as healthy and nutritious food and an income to a large majority of the people.



If you were to take all the people, the 80 per cent living in rural poverty in Africa and Asia, and put them into cities, how and from what would they live? The food system now developing in the United States and Europe cannot be a solution for the rest of the world.

We need a vision for the future. Can we have something better? I think we can, as long as we have good science and knowledge. There is a lot of knowledge around, not yet turned into theory or written down, which must be nurtured. We also need appropriate technologies, particularly in farming where things are so delicately balanced, and where we can have such a harmful impact if we use the wrong methods. We must learn from the past, and be inclusive in terms of institutions and people. We need to put ourselves within the system much more, where there is a big job to do educating consumers as well as policy makers. We also need adaptive management approaches and constructive policies at the local, national and global levels.

One initiative that may help to provide this vision is the on-going International Assessment of Agricultural Science and Technology for Sustainable Development (IAASTD). This is an international, intergovernmental assessment somewhat similar to the Millennium Ecosystem Assessment², but looking specifically at the agricultural sector. It is financed by an international consortium of sponsoring agencies from the United Nations, the World Bank and bilateral donors, including the UK Department for International Development. Actually its name should read agricultural *knowledge*, science and technology – because it is important to include knowledge. The IAASTD will:

- evaluate the relevance, quality and effectiveness of agricultural knowledge, science and technology (AKST);
- evaluate the effectiveness of public and private sector policies and institutional arrangements in relation to AKST;
- create a common vision of the future of agriculture;
- be multi-thematic: nutritional security, livelihoods and human health, and environmental sustainability;
- be multi-spatial: global and sub-global;
- be multi-temporal: short- and long-term perspectives;
- integrate local with institutional knowledge;
- look at policy and institutional issues in light of history and plausible future scenarios.

² www.millenniumassessment.org

The starting point is the four Millennium Ecosystems Assessment scenarios. The scenarios – which have been developed using both quantitative models and qualitative analysis – represent two worlds which are reactive to environmental issues, one more global, one more regional, and two worlds which are proactive, again one more global and one more regional. The people in charge of the IAASTD, from 53 groups, countries, non-governmental organizations and the industry itself, decided that they would also like to see at least one or possibly two more scenarios somewhere in between these two extremes.

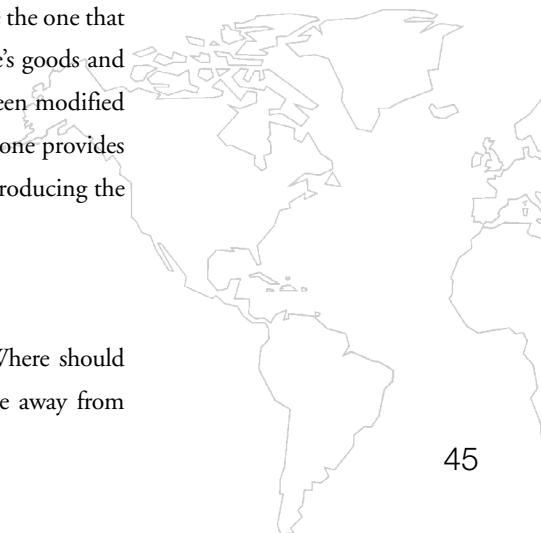
What will the world of agriculture look like in the future? There could either be big fields and machinery or farming by hand or, as I believe, something in between, with large differences between regions. Local climate, natural resource and cultural differences and preferences will play a role in the shaping of agricultural systems. The food distribution system also has to be taken into account; will it be very local or very global?

There are 160 authors for the global assessment and another 200 who are writing up the five sub-regional assessments. At the global level, we are thinking about plausible futures and then trying to work out how they could be reached. We are not saying how it will be, but showing what it could be, depending on the choices people make. The main challenge will be for the authors to be really bold and to have a vision. It may be a good idea to involve the next generation in the process and to seek their views on what kind of a world they can imagine living in, as the actual vision will need to come from the dreams and ideas of the young people who will inherit the challenges we have discussed.

I have been talking about sustainable agriculture, I now owe you a definition: I shall use the one that was articulated in 1992 at the Earth Summit: “Farming that makes the best use of nature’s goods and services while not damaging the environment.” It is a short definition and one that has been modified many times since to accommodate all kinds of different wishes. I believe that the original one provides a good basis, and within this framework, there are many interesting possibilities for both producing the food we need and maintaining the production base.

Scale of research to support new visions

I will offer my own thoughts on new visions and the research needed to attain them. Where should the focus of research be to support a viable future for agriculture? There must be a move away from



Environment on the Edge

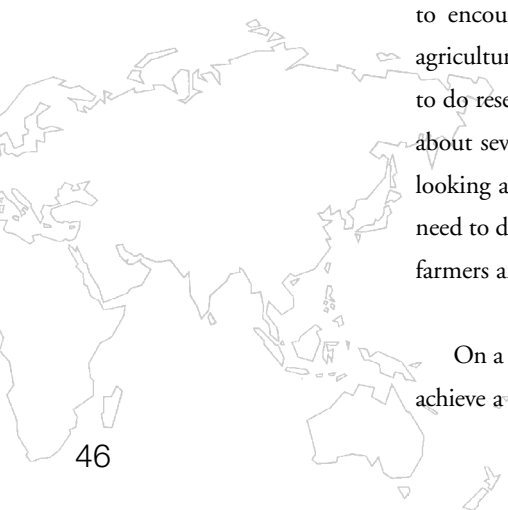
conventional agricultural research, which concentrates on crop breeding and agricultural inputs, towards research that pays more attention to the wider ecosystem and ecosystem services. The same topics reoccur: water, soil, biodiversity, human livelihoods and natural resource self-governance. At the moment research funding tends to concentrate on the molecular issues while ignoring ecology and the wider system. Of what use is a gene without a system in which it can function? Research should be integrated, from the landscape to the molecular, and it is important that everyone has a share of the research agenda.

We certainly have local and global challenges. The impetus for sustainable agriculture originated from localized site-based concerns, but concerns have widened with the realization that unsustainable practices are driving global patterns. High-input agriculture may poison soils with fertilizers, pesticides and salts left from irrigation. Irrigation practices may contribute to the depletion and chemical contamination of surface and groundwater supplies. High-input, large-scale industrial farming practices negatively impact beneficial insects like pollinators and natural enemies, and favour pest populations. There are concerns over energy, production costs, farm productivity against crop yield, and so on.

What are the most viable approaches to these challenges? The current catchphrase is “Think global, act local”, but it is arguable that it may be more relevant to “think local” – to look at the problems at the local level and support local community governance – and try to “act global” by developing the systems and policy environment to support the outcomes of research on sustainable agriculture.

What are the likely components of a research agenda for agricultural sustainability? Locally, we need to encourage more site-based research on using components of the natural ecosystem to support agriculture (including on-farm livestock), along the lines of push-pull and pollination services. We need to do research in more sites. If we look at the past, for example in Switzerland, 30 years ago there were about seven agricultural research stations, but now they have collapsed into two. So we are no longer looking at different environments, which is the opposite of what we should be doing. Locally, we also need to develop modalities for more adaptive management, to include researchers, extension specialists, farmers and consumers in the decision-making process.

On a global level, we need to use systems processes to sort out global food security issues. We want to achieve a balance, with each region producing that for which it is best adapted (grains in the north, root



crops in the tropics), while developing stronger local and regional sustainable food supply systems. We also need to combine site-based sustainability research with meta-analysis, showing trends across multiple sites.

Externalities must be taken into account in food pricing. Where do we grow our food? Which food items do we ship around and which not? And at what cost? Issues of soil fertility, water availability and access, pest control, pollination and other ecosystem services will only be resolved in the context of supportive public policies, of understanding ecological cycles, and a new approach to governance of natural resources that recognizes that they are actually limited.

The ultimate question is: Is agriculture a commodity or a culture? Jules Pretty's excellent book, *Agri-Culture: Reconnecting People, Land and Nature*³, reminds us of the importance of agriculture and culture. We have put the two parts together and forgotten about the links between them. Each country wants its own agriculture, and different systems should be maintained as part of culture. There is much to lose if agriculture were to become standardized east to west and north to south, both in terms of culture and in terms of health. There should be more diversity, not more of the same. A further point is that if we want to maintain our environment we have to use it, not for golf courses, which apply many chemicals and produce no food, but to produce food less intensively and with fewer inputs.

One way out of the cheap food syndrome would be to charge people in the cities for the water, the air, the landscape *and* the food. Farmers would be better off if they were paid for everything they produced or maintained, and we could do away with subsidies. People in the cities take their ecosystem services for granted. For cities to have water, someone has to make sure there is land, that it is open and healthy, that there are forests to allow water to drain, and that fertilizers do not pollute it. People in the cities want to spend their weekends in the countryside, so why should they not pay for the spectacle? Or for their air which comes from the forests and the fields? It is the farmer's fields and trees that sequester the carbon emitted from city traffic.

Agriculture and the way we do it have to be completely rethought: "You cannot solve the problem with the same kind of thinking that created the problem." *Albert Einstein*.

Dr Hans Rudolf Herren, President of the Millennium Institute.

3 Pretty, J. 2002. *Agri-Culture: Reconnecting People, Land and Nature*. Earthscan, London, 261pp