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North-South Discussion Papers 2005-1

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Development perspectives for agriculture in Africa – Technology on the shelf is inadequate

Food is the most basic human need, and as such requires continuing attention. In the first world we have more than enough food, although this has not always been the case, and the battle for sufficient food for all has not yet been won. The availability of food per person has increased worldwide in the last forty years by an average of 30%, but in the same period, Africans South of the Sahara have seen the amount available to them decline by an average of 12%.

The harrowing images of acute food shortages are symptomatic of a continent in decline. The tide can only be turned by implementing measures simultaneously in a number of areas, including those of science and technology. As far as agricultural development is concerned we argue that the currently available technologies are not sufficient to ensure sustainable development that will benefit the majority of Africans. A more effective strategy is required, and is quite conceivable.

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The North-South Discussion Paper series provides a platform for contributing to topical discussions in the field of agricultural development in the widest sense. The content is the responsibility of the authors, and does not necessarily represent the view of Wageningen UR.
Editors of this series: Niek Koning, Niels Louwaars

Fundamental differences

Lagging agricultural productivity in Africa is analysed from the perspective of successful increases in productivity in other parts of the world. A combination of technological innovations and favourable institutional and economic conditions, created by the government, formed the basis for increases in productivity in the successful areas of the world. Given the badly functioning governments in Africa, the conclusion is quickly drawn that even in this continent agricultural development will get going once good governance is implemented. This would imply that the currently available technologies are sufficient to ensure sustainable agricultural development in Africa. However, production systems in Africa are fundamentally different and as a result the available technologies are not tailored to the specific forms of agriculture on this continent. African agriculture will have to be developed in phases, in which not only suitable technology is developed but also specific market conditions are created, similar to the current developments taking place in multifunctional and organic agriculture in the well-off countries.

Productivity development during the green revolution

Breaking out of the low productivity trend in the first world ……

After the Second World War food availability was placed at the top of the political agenda in the first world. Conducive market conditions were created for farmers, including minimum price policies, guaranteed prices for agricultural products and input subsidies. The development of institutions such as research institutes and extension services was heavily supported. Wageningen University and Research Centre, now one of the largest agriculture and nutrition institutions in the world, is a shining example of this.

In the period following the Second World War a huge increase in agricultural productivity took place. A cohesive package of technical measures lay behind this departure from previously low yields. Artificial fertilizers, irrigation, crop protection using biocides, improved crop varieties and mechanisation were the main technologies that were implemented in combination and had a strongly reinforcing effect on each other. The increase in productivity that occurred was a result of both the technological innovations and the creation of favourable external conditions.

….. was copied by receptive developing countries ……

In the 1960s the strategy of a comprehensive technology package was also applied in developing countries. This approach, helped by receptive governments and systems of cultivation that were suitable for the technology, did indeed lead to increases in productivity, particularly in rice, maize and wheat; at least in all continents except for Africa.

International research institutes were set up, the CGIAR institutes, including the International Rice Research Institute (IRRI) in 1961 in the Philippines, and the International Maize and Wheat Breeding Institute (CIMMYT) in 1963 in Mexico. These institutes started by providing improved varieties and later turned their focus to optimising cultivation methods. There are now some 15 CGIAR institutes throughout the world. It is important to note that rice, maize and wheat form eighty percent of the diet of the inhabitants of Asia. These are also the crops that directly or indirectly in the form of animal feed, also form the majority of the diet of people in developed societies. Two-thirds of the diet of the inhabitants of Latin America consists of these cereals. These crops, however, form less than 30% of the diet of Africans. Also important was that it was easy to transfer knowledge on cereal crops and their cultivation in the first world to developing countries.

…… *partly as a result of the similarities in the production systems*

The success of the technology transfer depended heavily on the way in which the cereal crops were cultivated during the introduction period. The high population pressure, especially in Asia, meant that land was already intensively used, with much focus on increasing yields through high labour input. This resulted in a relatively high degree of control over the factors of production, such as good water management in rice growing and intensive weeding practices. The introduction of technologies such as artificial fertilizer, crop protection measures, improved crop varieties and mechanisation were easily adopted, certainly when productivity increases per unit of land, labour and other inputs were achieved. The advantages quickly became clearly visible in many developing countries. In the above description of agricultural development it is the technology that provides the kick-start to the motor of general agrarian development. Then it is necessary to create the right economic and institutional conditions to keep the motor going.

Agricultural development in Africa

Bad governance is blamed, but .....

The successes outlined above have not taken root in Africa. Only sporadic increases in productivity have been achieved. The discrepancy with the rest of the world is attributed to a wide range of factors, of which only a few are directly related to agriculture itself. Increasingly it is the lack of good governance that is blamed for the lack of improvements in Africa.

Governments are supposed to devote themselves to road building, providing education and public health, supporting research and maintaining public order. Looked at from this perspective, good governance will create the conditions that make agricultural investment attractive, and as a result markets will function well. Only if this happens is development possible.

However valid these arguments may be, they lead to the perception that agricultural development in Africa will only take place if favourable political and socio-economic conditions are created.

An often-heard remark is that the technological expertise and know-how that we already have available is sufficient to get agricultural development going in Africa. After all it was the same technology that spurred agricultural development in other parts of the world! The current overwhelming focus on social, institutional, economic and political aspects obscures the possibility that existing technologies might not be suitable for African agriculture.

..... *the kick-start is missing* .....

The possibility that the kick-start for agricultural development in Africa is missing is, however, very real. The agricultural production systems on the African continent differ fundamentally from those of other parts of the world. In the areas where the bulk of the world's food is produced, mainly monocrops are grown, arising from the need to increase efficiency per unit of land, labour and inputs. Our technologies have been developed to increase the efficiency of monocrops.

..... *because the production systems in Africa are fundamentally different*

African cultivation systems, however, still consist primarily of mixed systems in which as many as 15 to 20 different crops are raised together, sometimes also in combination with animal husbandry. These systems are geared towards getting the most out of the scarce natural resources, the availability of which is unreliable. The African continent is not richly endowed with favourable farming conditions. It is an ancient continent, with large areas of old, heavily eroded soils whose fertility is low. The amount of alluvial soil, such as is formed by rivers laying down sediments, is low, as is the amount of fertile volcanic soil.

The total amount of water available is high, but is concentrated around the great lake area in the humid tropics. The use of these water resources is also hampered by the diseases in these humid regions, which are fatal for both humans and animals. In the large semi-arid areas dependency on rainfall is high. The erratic and unpredictable rainfall can however completely destroy crops. As a result, farming systems have necessarily been developed that reduce the risks of production losses. Nomadic pastoralists that 'follow the rains' with their livestock, and growing several different crops at once to reduce the effect of unreliable rainfall, are very effective systems under the prevailing bio-physical conditions.

The relatively high availability of land and a low population has led to the maximisation of production per unit of labour. This has led to relatively extensive forms of agriculture in terms of unit of land and inputs.

The limits of African farming systems have almost been reached

It is easy to see that these kinds of systems show a relatively high level of resilience from the point of view of needing to survive under marginal conditions, largely because they provide low but relatively stable yields. The carrying capacity of these systems however is limited. Their intense vulnerability has also become clear in the face of the increased demand for food production as a result of the population growth. Whereas there were only some 300 million people in Africa in 1960, today the continent numbers about 800 million and has the highest population growth rate in the world.

With an average of less than 10 kg of artificial fertilizer per hectare applied each year, the already poor soils are rapidly becoming exhausted. In almost the whole of sub-Saharan Africa the nutrient balance is negative; more nutrients are extracted from the soils than are added. This extreme soil degradation through exhaustion is lowering the productivity of the land. Rehabilitation is a long-term process in which the yield-improving effects are unprofitably low in the short term.

Without ways of restoring and maintaining the nutrient balance and fighting soil degradation, the population is being dragged down in a negative spiral of unsustainability.

Development pathways of production systems in developed countries

Far-reaching improvements in efficiency .....

In specialised farming systems, which dominate in the developed countries, and Asia and Latin America, the bio-physical conditions are adjusted according to the requirements of the crop being grown. We apply water and nutrients in the form of fertilizer to the crop or animal and we protect it against disease and pests. These measures decrease the production risks in comparison with systems that are left to their fate at the hands of a hostile nature.

..... *are favourable in ecological terms* .....

Our understanding of the functioning of plants, soils, weather and other organisms such as pathogens, pests and weeds has increased enormously in the last decades. The development of crop-growth simulation models using the rapidly developing information technology has made a considerable contribution. These developments help us to regulate production systems even more precisely. For example models can be used to determine what artificial fertilizer application regime is best suited to the nutrient demands of a particular crop. Finer adjustment reduces the environmental impact: losses are reduced as efficiency increases. Modelling can also help in the search for minimal application of crop protection measures, determining optimal planting dates and many other cultivation practices. Crop characteristics desired for specific conditions can also be determined, helping breeders to improve plant varieties and animal breeds.

In combination with close and remote sensing, geographical information systems and robots, the progressive precision in agriculture increases the efficiency and productivity of monocrop cultivation. In an increasingly liberalised world this far-reaching specialisation, accompanied by increases in scale, would appear to be the only economically feasible development trajectory. The environmental impact of this system is low per unit of produce and, as such, environment-friendly.

…… *but is increasingly rejected by the public* ……

Public acceptance of these farming systems, however, has recently started to decline dramatically, especially in European countries. In response to this development, there is increasing public demand for agriculture to also undertake other functions such as the maintenance or development of a more natural landscape and more animal-friendly production systems. In this form of 'multifunctional' agriculture, i.e. farming that does not exclusively focus on food production, an attempt is made to realise different functions simultaneously. An example of such measures is the establishment of wide strips of uncultivated land along the edges of crop fields, in order to maintain biodiversity or to provide nesting space for birds. A complication in this kind of system is that compensation for production losses is not always forthcoming from consumers.

Similar problems arise in organic agriculture. These forms of agriculture and land use are only economically feasible if they are subsidised, therefore if society is prepared to pay through taxes or other means for additional functions such as care of the birds and the bees in the meadows.

…… *and makes market support for alternative systems necessary* ……

In short: there are two development paths taking place in western countries. One is the worldwide system of extreme specialisation in the face of increasing globalisation and liberalisation. The other is the increasing demand for more 'natural' production systems. Without subsidies to safeguard the revenue for the other functions, however, these systems are not economically competitive in a liberal world.

Development pathways of production systems in Africa

Productivity increases by transfer to global systems…

Productivity increases in Africa in the last few decades have mainly taken place in systems of mono-cultivation, for example of irrigated rice and commercial cereal production. To be able to use the currently available standard technology packages, the mixed systems have been transformed into mono-systems. This development is in line with the trend towards global production systems where extensive mechanisation increases land and labour productivity. These developments serve a number of purposes, such as ensuring the production of bulk crops and generating foreign exchange through export.

…… *are not feasible for 90% of the population*

As many as 90% of the farmers in Africa, however, as described above, farm a variety of crops, sometimes in combination with animals. These systems safeguard the food security of the vast majority of the population. Available technologies, such as harvest machines for single crops but also application strategies of artificial fertilizers and pesticides, are not appropriate for these systems. It is hardly surprising that African farmers have not embraced existing techniques unconditionally and that productivity in the current mixed systems is stagnating.

Few successes in African farming systems .....

Attempts have been made to increase the productivity of mixed farming systems in the last decades, and there have been some successes. Productivity increases however, are often still low in absolute terms, even though some have led to a doubling of yields in relative terms. These improvements are of course very welcome, and can guarantee the security of farming families at least for a little while longer. The question remains, however, whether these improvements are enough.

The current measures taken to achieve these improvements make virtually no use of advanced technological expertise. A specific crop sequence that diminishes disease chances, the introduction of legumes that improve the nutrient balance, planting in specially shaped holes, using ground cover or building ridges to improve rainwater infiltration – all these techniques are possible and could contribute to increasing productivity. They are all measures that can be significantly adjusted according to local conditions, and most of them make use of locally available resources and means.

..... *as a result of insufficient understanding of how systems function and of tailored technologies*

Labour productivity remains low, however, partly because these methods are not mechanised, which limits their adoption. Mechanisation is often impossible or little short of that. There simply are no machines that can harvest different crops at once or can pick out just the ripe crop from a mixed crop stand. A number of aspects of mixed farming have not been developed.

There are possibilities however. The characteristics required of a maize plant that is to be grown in a mixed maize-groundnut system are likely to be different from those of a maize plant that is to be grown as a single crop. Upright leaves instead of ones that hang down cast less shade on the groundnut plants, enabling them to grow better. Other properties, such as the height of the crop, its rate of growth after germination, its root growth, shooting and so on can be adapted to the requirements of mixed systems.

The requirements and use of water and nutrients in a mixed system are influenced by the mutual competition or by changes in availability of nitrogen, for instance in systems with leguminous crops. Similarly, there are indications that, disease pressure may be lower in mixed systems because of reduced spreading.

The potential advantages of African production systems can be exploited .....

Our understanding of these mechanisms, however, is still only very basic. The indication that there are potential advantages to mixed systems deserves however systematic attention. To develop relevant technologies not only requires a focus on productivity increases of land, labour and other inputs, but also a focus on stability and continuity. Production risks must be minimised, particularly in marginal areas with infertile soils and where the water supply is limited and irregular. Advanced techniques such as biotechnology and information technology can play an important role in developing these systems.

..... *by applying advanced technologies in a directed way* .....

Plant breeders have not succeeded in developing location-specific varieties on a large scale because the process of plant breeding is so time consuming. For that reason breeders have concentrated on just a few major crops, in particular cereals and varieties that give high yields when they are well cared for or where the bio-physical conditions can be adjusted to their needs.

Biotechnology techniques (not only genetic modification, although this is included) speed up the breeding process and therefore also increase the speed with which location-specific varieties can be developed. Advanced biotechnology methods can therefore transform conventional breeding and open the way for improvements to many more crop types and adapting them to locally specific conditions. Specific characteristics, such as drought resistance, leaf morphology and root growth can be introduced into new varieties.

Information technology can be used in decision-support systems for farmers. At present research is being conducted on whether by combining meteorological, hydrological and crop management knowledge, it will be possible to predict yield losses as a result of drought, and what measures could be implemented to limit losses. Model analysis can help increase our understanding of the functioning of complex mixed farming systems so that mutual adjustments to water and nutrient use can be optimised. Model analysis and other ICT-supported techniques can help in identifying the most effective combinations and crop sequences to reduce disease and pests.

Much more attention needs to be paid to increasing labour productivity. Many attempts to increase the productivity of mixed systems have run up against the limitation of high labour requirements. Mechanisation must be tailored to fit particular mixed systems. The use of robotics in mechanisation has led to more advanced solutions becoming available. Harvest robots can already distinguish between ripe and unripe cucumbers for example. These techniques can be used to develop multi-tasking machines for mixed systems.

These advanced technologies are merely aids to increasing the productivity of complex systems, where optimal use needs to be made of the advantages of combined cropping. Although the technologies described may seem to be unaffordable, they can lead to leaps in development. The dialectics of progress must be exploited. Take mobile telephones: they are already within reach of many, including poorer sections of the population.

…… *but also with market support*

Whether these productivity potentials of mixed systems will equal those of monocultures remains to be seen. High investments and obstacles to mechanisation can put a lot of pressure on the productivity per unit of capital and labour. Competition at both national and international level will have to be dealt with as the global market continues to be liberalised. If productivity lags, protective measures will be necessary to prevent mixed systems from gradually specialising and becoming monocultures.

In conclusion

Where the aim is to increase productivity of complex farming systems, new technologies are required. It is important that these are not only made specifically for the mixed systems but also that they contribute to maintaining the economic viability of these systems in an increasingly liberalised world market. If this does not happen then mixed farming systems will have to be protected from the caprices of international trade. After all, these systems serve more purposes than food production alone, as we have seen in the current developments in European countries.

This article discusses the opportunities and limitations of monocultures and mixed systems where many varieties and crop types are combined. The trajectory that can offer the best in terms of food security for Africa will have to be judged on its ecological, economic and social merits. Using the Triple P concept of sustainability should ensure that the interests of People, Planet and Profit are served in a balanced way.

The choice of development paths should be made by politicians, farmers and the public in Africa. The possibilities and limitations of far-reaching specialisation according to the dominant global model are known. Our understanding of the opportunities and limitations of mixed systems from the point of view of the three sustainability criteria is still limited. Increasing that understanding requires thorough attention and much research if African agriculture is to develop sustainably.

References

An extensive publication on the issues dealt with in this article is:
Bindraban, P.S. and R. Rabbinge, Technologies that can make a difference. Enhancing agricultural productivity in Africa. Resource document IAC study on Science and Technology Strategies for Improving Agricultural Productivity and Food Security in Africa. InterAcademy Council, Amsterdam.
http://www.interacademycouncil.net/Object.File/Master/9/055/0.doc

A publication on farming systems in the world including the unusual, mixed systems found in Africa:
Dixon, J., A. Gulliver and D. Gibbon, Farming systems and poverty. Improving farmers' livelihoods in a changing world (Rome and Washington D.C., FAO and World Bank, 2001), 412 pp.