CONCEPTUAL AND METHODOLOGICAL DEVELOPMENTS IN INNOVATION

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Abstract

In this paper, I use an autobiographical approach to tell the story of innovation and its changing fortunes and uses. I have lived through the major approaches and perspectives in the past 50 years and have played some role in them myself. The paper starts off with my early days with the diffusion of innovations and the agricultural treadmill in the Mid-West of the US where those theories emerged and became dominant. I then turn those ideas around by reporting on my involvement in a test of a not-for-profit marketing approach to innovation in Kenya that featured Innovating Laggards. A further turn-about occurred when indigenous knowledge and endogenous development became key dimensions of innovation. Farmers are the experts. I became closely familiar with attempts to foster innovation through collaboration between farmers and scientists in Participatory Technology Development. My work on agricultural knowledge and innovation systems (AKIS) made me sensitive to the Farmer Field School and Landcare. Both practically operationalised the idea, that innovation emerges from interaction among stakeholders. I end the paper with reporting on the Convergence of Sciences (CoS) Programme in which I am a member of the Scientific Coordination Committee. During its first phase, CoS established a pathway for an agricultural science that can improve the livelihoods of resource-poor farmers. But that phase also showed that technical innovation within very small windows of opportunity can only have limited impact. It further demonstrated the need for, and possibility of, institutional development. This finding allowed us in CoS2 to focus on innovation systems as an approach to institutional development that stretches the windows of opportunity for small-scale farmers.

Key Words

Resource-poor farmers; diffusion; agricultural treadmill; FFS; indigenous knowledge; innovation systems; innovation of innovation

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INTRODUCTION: FOCUS ON INNOVATION

The Innovation Africa Symposium is an important initiative because it focuses the spotlight on a subject that deserves all the attention it can get. Of course, innovation is a sexy concept that appeals to left and right, and young and old, including Mzees like myself. Innovation has promise, it sounds like a way forward. It is easy to get people behind it. But beware! The concept is used in different meanings. It can represent very different perspectives. It can lead to considerable confusion. It is a real 'battlefield of knowledge', as Norman Long once called it (Long and Long 1992). Sometimes it is in need of innovation itself!

This keynote is meant to put the subject on the map. I believe I am the right person to give it. There are few people who have fallen into more traps, and were seduced by more meanings for innovation, innovation systems, system innovations and what not, than me. It therefore seems a good idea to give the keynote overview of conceptual and methodological developments by way of an intellectual autobiography. I will use my own 'history of innovation' to take you through the minefield of meanings and perspectives. For each episode, I will zoom in on what I consider relevant for discussion during the Symposium. I will end with a number of key points.

A good thing of Africa is its respect for old people. In my own country, one tries to look as young as one can, which succeeds better in the dark. Yes, I have reached 'three score and ten' and am thankful that that phrase no longer predicts a person's lifespan. For purposes of giving an overview for this Symposium, my having been a professional and academic in the innovation business for such a long time has obvious advantages, which I am going to use to the hilt!

PhD IN THE US WITH ROGERS IN 1970

Diffusion of Innovations

I did my PhD in the US with the late Everett Rogers in 1970. I was part of his AID-funded project 'The Diffusion of Innovation in Rural Societies', which operated in Brazil, India and Nigeria. I was recruited in Nigeria, where I was working as a young lecturer in the University of Ibadan. The Project worked from Enugu. I spent two years there and two and a half in Michigan, smack on the middle of the American Mid-West where one of the most influential theories of innovation was developed.

Everett Rogers is the father of the Diffusion of Innovations paradigm, which will be familiar to most of you (Rogers 2003). The paradigm which Rogers has so successfully synthesised and promoted since his first overview in 1961 goes back to a study of the

diffusion of hybrid maize in Iowa in the early forties (Ryan and Gross 1943). Specific conditions in the Mid-West corn belt of the US in those days led to the 'discovery' of diffusion as an autonomous process that multiplies the impact of research and extension for free. But before we all get excited about diffusion as the mechanism for lifting up African agriculture, we must be aware of the specific conditions that allow spontaneous diffusion of a novel idea or technology in a community of farmers. These conditions are in themselves quite interesting:

1. A large number of farms or firms which all produce the same commodity for the same market.
2. Each of them is too small to affect the price of the commodity. Hence they all produce against the going price (price takers) and therefore seek to improve their situation by producing more of the commodity against lower costs.
3. Given the inelasticity of the demand for most agricultural products, all these farmers trying to produce more, more efficiently, exert a constant downward pressure on the prices of farm products.
4. All the farms have access to credit, fertilisers, extension, farm journals, agri-business, and are members of farmers' organisations, be it in different degrees.

Introducing a new idea or 'innovation' (note the way I use the term here, i.e. as a *noun* denoting a *technology*), such as hybrid maize in such conditions (typically called a 'recommendation domain') can lead to a wave of innovation (here used in the sense of a *process*), as individual farmers adopt. The wave of innovation is called the 'diffusion curve', which in theory is usually depicted as an S-curve, i.e. the diffusion process is expected to start up slowly, then gather momentum, and finally peter out when all farmers for whom it is relevant or feasible, have adopted the innovation.

The 'discovery' of the diffusion of innovations led to a great deal of research. At one time, it was the most popular social science research subject and more than 2000 studies on diffusion had been completed by the time I last checked (quite long ago). And one can imagine the excitement. Here was a spontaneous social process that multiplied the efforts of research and extension for free. 'Diffusion works while you sleep' (a pun on a popular advertisement for anti-rust paint that claimed the same for corrosion). Diffusion seemed key to social change and modernisation. It explained not only the spread of agricultural technologies, but also of the Hula Hoop, new medicines, and contraceptives.

The Agricultural Treadmill

It is small wonder that, at the time, when I did my PhD in Michigan, innovation could only be talked of in terms of the diffusion process. It was my main subject of study. Apart from social scientists such as Rogers, also economists looked at the phenomenon. Probably the best known of them is Wilbur Cochrane (1958) from Minnesota, who coined the phrase 'the agricultural treadmill'. He added some important components to the existing theory, which have to do with farmers' incentives.

When a new technology begins to be adopted, it allows the ones using it to produce more, or more efficiently, against the going price, which is initially still determined by the old

state-of-the-art. This means that those few early adopters make a windfall profit. They really benefit from the innovation. But as more farmers adopt (seeing the good results of the early ones), the state-of-the-art changes. Total production increases. Prices start to drop. People who have not adopted the innovation yet see their incomes drop, even if they work as hard as before. Price squeeze finally forces them to also adopt. Hence the diffusion process is *propelled by market forces*. This is called the 'treadmill', the benefit from innovation is a positional good. Farmers who are too small, too old, too sick, or too stupid to keep up, eventually drop out. Their resources (such as land) are taken over by the 'stayers'. This process is called 'scale enlargement'. In a country such as my own, the Netherlands, scale enlargement started as early as 1960 (Van den Ban 1963). Since then, about 2% of farmers have given up annually. Those who survive in 2007 usually have large enterprises, a good education, an enormous working capital (tractors, buildings, livestock, etc.), they are highly organised, and they are embedded in a network of supporting institutions and organisations, including input service cooperatives, farmers' unions, truckers, processors, retailers (e.g., supermarkets), vets, and so on. Ronald Havelock from Michigan (1973 and 1986) was one of the first to focus on this configuration of institutions as an essential counterpart to treadmill innovation.

The birth of a policy model: transfer of technology
When it works, the diffusion process and especially the market-propelled treadmill have important consequences at the *macro* scale:

1. Labour moves out of farming. In industrial countries only 3% of the working population might still be farmers, even if 10% is employed in agriculture-related activities.
2. Farmers cannot hold on to the benefits of technological innovation. Global food prices have continuously declined over the past 40 years.
3. A country becomes more competitive in the world market as its farming industry becomes more efficient.
4. Farmers do not complain or rebel. The front-runners who capture the windfall profits and benefit from scale enlargement are the ones who hold the positions of power in farmers' organisations.

Evenson et al. (1979) established that investment in agricultural research and extension, the perceived drivers of innovation (given the conditions I have enumerated), has a high internal rate of return. This high rate of return can be explained by the multiplier effect of diffusion and by the macro benefits from the market-propelled treadmill.

At this point we make an important observation. Diffusion of innovations was a *research tradition* based on *empirical* studies that looked at what had happened in the *past*. But the macro benefits of the treadmill, as perceived by economists, transformed the research tradition into a *policy model* for what is desirable in *future*. This model emphasises *technology transfer (technology supply push)* and *free markets* as recipes for agricultural development. That is, the treadmill became the dominant guideline for how innovation *should be* promoted. Often this guideline is called 'the linear model': innovation is the end-of-pipe outcome of a linear process, that runs from fundamental research, via applied

and adaptive research, subject matter specialists, extension, and contact farmers, to widespread diffusion among 'follower farmers'. The Training and Visit System (T&V) of extension tried to operationalise this linear model all over Africa. The WTO advocates a global treadmill, in line with the Washington consensus. In most of Africa, the technology supply push model, which is the simplified version of the treadmill, often is the only theory of innovation around. In fact, most policy makers, ministry officials, research administrators and managers, economists, and agricultural researchers cannot imagine any other theory of innovation than the linear model and continue to adhere to it, even after years of failure in situations where it does not apply. To be sure: diffusion can be observed *after* it has taken place. But so far, it has not been possible to predict whether a technology *will* diffuse or not. The production of agricultural technologies by agricultural research, even if they 'work' in the experiment station, is absolutely no guarantee for diffusion.

Implications for Africa
Using the treadmill as a policy model in Africa has major shortcomings:

1. The conditions in which the treadmill works usually do not apply. The proverbial political, social and ecological diversity in Africa allows no easy identification of recommendation domains. Most African farmers do not operate in well-developed commodity markets and do not have access to the information, inputs, credit, etc., required to capture the benefits from technologies that are externally introduced.
2. Forcing people out of agriculture is not such a good idea when alternative employment is not available. Even in the US and Europe farm subsidies were introduced to lessen the effects on farmers' incomes of unfettered treadmill impact.
3. The treadmill forces farmers to externalise social and environmental costs (pollution of groundwater, destruction of natural resources and bio-diversity, human health impacts of pesticides), especially in conditions of weak legal and other institutions.
4. The global treadmill means that African farmers have to compete with farmers in industrial countries who have benefited from sixty years of efficiency gains and scale enlargement. Even if farmers in industrial countries earn 25 times the income of farmers in African countries, their labour productivity is 32 or more times higher, so they can out-compete African farmers anytime (Bairoch, 1997). Note that this effect is only amplified by the subsidies that farmers in Europe and the US receive. Maize can now be imported into Kenya at 20% below the cost price of the best Kenyan farmers (Cyrus Ndiritu, pers. com., 2002). Of course, some governments (e.g., Ghana) love the cheap imported food because it keeps their urban electorates happy, but that seems a short-term consideration that could have negative long-term repercussions by destroying local food production capacity.

I cannot but conclude that the global treadmill prevents African farmers are from making a contribution to global food security, and African countries from gaining food sovereignty. On average already 20% or more of African food grain requirements are now imported. These are serious issues given a future that is marked by insecurity as a result of climate change, population growth, political instability and increasing costs of fossil energy.

Box: Recent examples of technology transfer as the recipe for African agriculture

1. Last year, the Bill and Melinda Gates and Rockefeller Foundations teamed up to make available 150 million dollars over five years to fund the development and distribution of seeds that are 'suited to sub-Saharan Africa's parched climate, denuded soils, and stubborn pests' both through research and distribution (*Economist* Sept. 16-22, 2006:90). But African farmers themselves are exceptionally good in managing agro-biodiversity as a means of coping with a variable and risky environment, as some of the papers for this Symposium attest.
2. In a paper called 'Development perspectives for agriculture in Africa', Bindraban and Rabbinge (2005) write: 'In combination with close and remote sensing, geographical information systems and robots, the progressive precision in agriculture increases the efficiency of productivity and mono-crop 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'. They admit that African agriculture is difficult to fit into this model. Nevertheless, 'where the aim is to increase productivity of complex farming systems, new technologies are required'.
3. When he was DG of WARDA, Dr Monty Jones, received the World Food Prize for the development of NERICA, New Rice for Africa. The prize was based on the discovery that Riza sativa (Asian rice) and Riza glaberrima (African rice) could, after all, be hybridised, which allowed the development of crops with the advantages of each. The award assumed that WARDA had developed this cutting-edge breakthrough. In reality, farmers in Sierra Leone had discovered natural hybridisation in their fields. This was in turn discovered by a Sierra Leonean researcher, the late Malcolm Yusu, which eventually led to WARDA getting the prize and the recognition (pers. com. Paul Richards).

Conclusion

In all, I came away from doing my PhD in the American Mid-West thoroughly imbued with diffusion of innovations and treadmill thinking, but also all too aware of the need to innovate this model of farm innovation. Looking back, I can say that a good part of my professional life has been devoted to attempts to find alternatives to the treadmill and technology push. Dr Daniel Benor, the father of T&V, used to say to me: 'Show me an alternative that works'. I have persisted in the quest to find alternatives, if only because technology push and T&V so obviously failed. Meanwhile the treadmill is increasingly running out of steam in industrial countries, as the externalities become politically unacceptable and as agriculture shifts from producing commodities to producing ecosystem services, such as drinking water, CO_2 sequestration, the closing of nutrient cycles, biodiversity, health, and yes, food, fibre and fuel.

The relatively large part of this paper that I have devoted to the linear model is justified in my opinion. The box gives some examples of how strong the linear supply-push of technology still is worldwide. Without understanding it thoroughly, it is impossible to move on.

THE SPECIAL RURAL DEVELOPMENT PROGRAM (SRDP) IN TETU, KENYA

The marketing approach

In 1971, I joined the Institute for Development Studies of the University of Nairobi to carry out post-doctoral research with a friend and colleague from the days at Michigan State, Dr Joe Ascroft from Malawi. He had been a market researcher in East Africa and was, for example, the originator of the Coca Cola Barometer, a tool to monitor sales. In Tetu Division, Central Province, Kenya, Ascroft was designing a project using the marketing approach to agricultural innovation. This fascinating project turned diffusion research on its head.

The marketing approach (see e.g., Kotler and Andreasen 2003) is all about the exchange of values between market partners, usually the exchange of goods and services for money. But not-for-profit marketing applies the approach to the exchange of other values. Thus an extension service can apply a marketing approach to the way it designs its services for different publics. Marketing research provides insight into the composition of the likely markets: which categories of clients or customers require which kinds of offerings? Based on what it can provide and on its objectives, an extension service can then make decisions about the nature of the customers it seeks to target and the kinds of offerings it needs to design for them, or perhaps even with them (In those days, we distinguished between DO TO, DO FOR and DO WITH). Usually, markets need to be segmented into homogeneous categories or 'target groups' for which one can design specific bundles of offerings (services, products, messages).

Targeting the segment of 'Forgotten Farmers'

In our Tetu project (Ascroft et al. 1973; Röling et al. 1976; Röling 1988), we targeted 'the forgotten farmers', i.e. we deliberately chose to offer opportunities to the segment of farmers that is likely to drop off the treadmill. In other words, we turned around the usual 'progressive farmers' approach, which heaps riches upon riches and went for what Rogers used to call the 'laggards'. We segmented the Tetu farmers on the basis of natural cut-off points on an index for 'innovativeness', i.e. and index based on the number of innovations farmers had already adopted, and then deliberately chose the segment of those that had adopted *least* innovations. Together with agricultural specialists, we then designed a hybrid maize package for a quarter of an acre that seemed suited to the conditions of these 'laggards'. We made sure that the farmers had access to a sufficient quantity of hybrid seed (which required repackaging), 50 kg of fertilisers, pesticides and a loan to purchase these inputs. We also designed a 2.5 days training course at

Wambugu Farmer Training at Nyeri for 25 farmers (M/F) at the time. In all, we trained a few hundred farmers across Tetu division. The training was the condition for farmers to receive the package. The whole field experiment was carefully monitored and evaluated.

The results were astounding. Virtually all the 'laggards' who had passed through the course adopted the hybrid maize, many of their neighbours did as well, and repayment of the loan was over 90%. It was very clear that even so-called laggards were innovative if they were offered the right conditions and opportunities. What is difficult for the people who used to be called laggards, but who can better be called resource-poor, is to create the conditions and access the resources, which allow them to become innovative.

A farmer with one quarter of an acre needs a large part of that land to produce the food for family consumption. In order to be able to purchase fertilisers, the farmer needs to produce a certain surplus for the market. The size of that surplus depends on the price of fertiliser. If that price goes up, the surplus needs to be higher, and the risk of failure as a result of dogs or thieves eating your maize, of crop failure in a dry year, or of needing the money from the surplus for a burial, also becomes greater. Our careful quantitative study of the adoption of hybrid maize by resource-poor farmers in Tetu made these mechanisms very clear. They raise serious questions about using high input technologies for poverty reduction in highly diverse, risk prone and variable conditions (Chambers and Jiggins, 1983). It is such insights that led to the founding of the magazine ILEIA, where LEIA stands for Low External Input Agriculture.

Implications for Africa

(1) Developing technologies and 'releasing' them to farmers, or 'delivering' them to 'ultimate users' has not, on the whole, been very effective in Africa. In fact, the impact of agricultural research on small-scale farmers had been remarkably limited. This is partly due to the fact that formal research has paid so little attention to the (very) small windows of opportunity within which farmers can actually innovate. Much research output simply is not appropriate for farmers conditions. From a marketing perspective, one could say that agricultural research has produced goods and services for which there is no market. Stronger, agricultural research simply does not engage in marketing research of its customers to see what those customers need and are able to use. If a technology is more productive than another in the experimental station, it is assumed good enough for 'release'. An important reason why agricultural research in Africa has been able to maintain such practices for decades is that small-scale farmers are not organised and have no political clout.

(2) On the whole, there is nothing wrong with small-scale African farmers. They are not traditional, stupid, uneducated, backward or what have you. They have only very few and small opportunities. The notion that African agriculture is stagnant because no great advances in agricultural productivity have taken place is wrong to my opinion. African agriculture is incredibly dynamic. Small-scale farmers are innovating and adapting all the time in order to cope with changing circumstances. African farmers

have, on the whole, been able to keep up food production with the very rapid growth of the population. They have done this without much use of external inputs or science-based knowledge, without much support from government (in fact, agriculture is a source of revenue for most African governments), and in the face of imports of cheap food, a changing climate, and conflict and disease. Hounkonnou (2001) has called these rural dynamics the most hope-giving element in an otherwise pretty dismal landscape.

(3) It is possible to design opportunities for farmers that allow them to innovate. The Kenya Tea Development Authority (KTDA) has for years provided small-scale farmers with a set of services, inputs and supervised credit (a package) that has allowed small-scale farmers to benefit from the export opportunities for tea. The various production societies for cotton in West Africa have also been a huge success in creating income earning opportunities for small-scale farmers. A key point has been the supervised credit: the exporting organisation can deduct the credit from the farmer's revenue. Since farmers cannot eat tea, cotton or cocoa, such mechanisms work. Such schemes as KTDA are among the most successful approaches to large-scale innovation in rural Africa.

(4) Governments, on the whole, have not been very capable of creating opportunities for small-scale farmers and government-run supervised credit schemes soon become vehicles for revenue raising, rent seeking and patrimonial benefit. I myself learned that it is dangerous for a research project to create artificial conditions for farmers (as we had done in the Tetu project) because most public agencies are not capable of replicating these conditions within their means and their bureaucratic systems.

BOARD MEMBER OF THE CENTRE FOR INDIGENOUS KNOWLEDGE FOR AGRICULTURAL AND RURAL DEVELOPMENT (CIKARD)

After my PhD and post-doctoral research, I became an academic, and my contact with the field became mediated through memberships of boards, supervision of MSc and PhD students, consultancy missions, scientific congresses, and so on. One of these experiences was to act as a board member (together with my wife Janice Jiggins) for CIKARD in Iowa. It had been started by the late Michael Warren, a playful, imaginative, and concerned researcher. He had worked as an agronomist for the Peace Corps in Ghana and there met his wife Mary, a Nigerian gold trader. As a result of this mixed marriage (or maybe it was an outcome, that is buried in history), Warren began to realise how much colonialism had ignored indigenous wit, technology and knowledge. He became totally absorbed by this notion and started his CIKARD as a centre to study, conserve and pass on indigenous knowledge, not only in developing countries, but also in the US. For example, Warren supported 'The Practical Farmers of Iowa', a group of US farmers who engage in their own research.

Indigenous knowledge

The linear model looks at agricultural research as the source of all innovation and is rather blind to the fact that farmers are researchers in their own right, who have to live by the results. They constantly try out things and over generations develop farming systems

that satisfy their needs. They try to make optimal use of their environmental and market conditions. Even if farmers are not 'scientists' in the sense we usually use this terms, they are extremely good at discovering what works, even if they cannot always explain why. And we are dealing with many generations, with collective intelligence and with millions of experimenters *in situ*. Indigenous knowledge is a very respectable and important source of innovation that had been seriously ignored, until people like Mike Warren brought it to our attention.

I remember visiting David Norman in Zaria, Nigeria, in the early seventies. He had just completed a study (Norman, 1974) why farmers who lived around the experiment station at Samaru had, for as long as the British and later the Nigerians had their research station there, refused to adopt mono-cropping and continued to practise mixed cropping. The careful study by Norman and his colleagues showed that mixed cropping:

(1) Creates a micro-climate, which is beneficial for crop growth;
(2) Creates crop diversity, which reduces the spread of pests and diseases;
(3) Is a clever adaptation to a variable climate: if some crops die as a result of drought, one still has something to eat from the drought-resistant crops in the mix;
(4) Optimises the use of factor labour, which is the minimum in the farming system; and
(5) Optimises the total monetary value of crop production.

The design of farming systems that work in such intricate ways is something research cannot do. Research is good at developing component technologies, such as fertilisers, and Bt-cotton. But farmers have designed systems within which these component technologies must provide a benefit. And all too often they do not, because research has not bothered to take cognisance of the systems concerned.

Farming systems research and participatory technology development
Norman was one of the first farming systems researchers, but he was not the only one. Most of you will be familiar with the work of Robert Chambers, for example. Farming systems research became quite a movement, and the International Farming Systems Association (IFSA) and its regional caucuses are still going strong. Farming systems research makes the following points:

(1) Farmers often know more than scientists when it comes to the characteristics and dynamics of the environment in which they farm, including risks of water logging, drought, pests, thieves, and so forth.
(2) Farmers know better than scientists the criteria by which innovations will be judged and the (possibly multiple) objectives the innovations have to serve. Researchers usually assume that the objective is to become more productive or resource-efficient. For farmers many other criteria and objectives pertain. Since adoption is a voluntary act by farmers, it is their opinion that should prevail.
(3) Small-scale farmers (M/F) are intelligent beings. You can ask them about things and discuss things with them, and do not have to carry out costly and time consuming extractive research to find out about something yourself. This 'insight' led to the

development of ‘rapid appraisal’ methodologies for exploring the feasibility of development approaches.

Soon the idea of doing an appraisal to provide an outsider with insights gave way to the notion that resource-poor farmers could and should be *partners* in analysing their situation and designing their future. One of the best known applications of this idea is participatory technology development or PTD, which is an approach in which scientists collaborate with small-scale farmers in field experiments to develop technologies that are needed, wanted, and appropriate to the conditions of the small-scale farmers concerned.

In this sense, insights have really changed compared to the linear model of technology supply-push. What is remarkable is that most major national and international agricultural research centres have only used these insights to a limited extent and continue to believe in magic bullets and green revolution approaches for Africa. When the chips are down, core business for agricultural research remains breeding, biotechnology, smart farming, robotics and high input agriculture, and productivity per hectare. Marketing approaches, farming systems research, and participatory research so far have had only limited impact on the dominant policy model of technology transfer. I can only explain this persistence as an outcome of the lack of countervailing power of small-scale farmers over agricultural research. Improving the impact of research is not so much a question of investing more in research, but in developing the ability of farmers to influence research.

Implications for Africa

(1) African farmers’ innate tendency to innovate in their search for ways to improve their lives is a huge asset that we have barely learned to mobilise for agricultural development. By recognising farmers as important sources of innovation, PROLINNOVA is making an important contribution.
(2) African farmers are not only innovating in terms of component technologies, but also in terms of farming systems, something scientific research finds hard to do. An example is the development by the Adja in Benin of oil palm fallow, a system of permanent land use in a very densely populated area that uses rotation of annual food crops with oil palm to restore soil fertility and suppress weeds (Imperata cylindrica, a weedy grass). The rotation is economically feasible because of the sale of alcohol from the palm wine, which is collected when the palms are cut down to make place for food production (Brouwers 1993).
(3) African farming systems are under constant pressure to innovate. One of the most important pressures is towards more permanent land use as a result of population growth. In its wake, this has brought serious problems, such as loss of soil fertility, the emergence of pernicious weeds, and small farm sizes. Technical solutions to these problems have hardly emerged and formal research has been slow to pick up on such issues as weeds, which have become an important dimension of rural poverty (Vissoh 2006). Farmers themselves have sought to solve the problem in other ways, such as the feminisation of agriculture, whereby men go off to distant cities to find gainful employment and leave the women to look after the farms. The lack of opportunity in rural areas has become destabilising in that rural youths have no future in their own communities.

(4) Experience from all over Africa shows that farmers are very quick to take up opportunities. The recent increase in the FOB price of cocoa in Ghana from 40 to 70% led to a doubling of cocoa production without any technological break-throughs. One can safely leave it to African farmers to make the best use of new opportunities provided by markets, employment generation, etc. Creating opportunity is not primarily a technical issue, but more an institutional one.

With that conclusion, we move to a new notion of innovation, from technology development to the development of opportunities through institutional change.

FARMER FIELD SCHOOLS AND LAND CARE

Being an academic in such a field such as innovation is an exercise in humility. It is very hard to actually design effective innovation of innovation. One can talk about it, develop criteria, recognise it when one sees it, and help those who do it to understand what they are doing. But to actually create an alternative approach to the linear model has remained elusive. In the eighties, I was fortunate through PhD students to come across two approaches that were based on totally different points of departure than the linear model: IPM farmer field schools in Indonesia and Landcare in Australia.

IPM Farmer Field Schools

The Green Revolution in irrigated rice production in Indonesia had been based on inputs of new varieties, subsidised fertilisers and pesticides. Careful control of market and irrigation conditions, credit packages and some strong arm tactics in the beginning led to the rapid diffusion of highly productive rice farming, typically moving from 1 to 3 or 4 tonnes per ha per crop (often farmers under irrigation can grow two rice crops and a vegetable crop in a year). Huge areas and literally millions of farmers were blanketed with the same recommendations in terms of rice variety, and type and dosage of fertiliser and of pesticides.

In the eighties, a serious problem emerged. A small insect, the Brown Planthopper that had never been a problem before started to cause serious damage and threatened rice harvests across huge areas. This was a political issue of the first order. Suharto, who was the President at the time, had been able to take over from Sukarno because of rice shortages. It turned out that the pest problem had been induced by pesticides: the insects had become resistant while its natural enemies had been destroyed. Hence it could resurge very fast after each spraying and more, and more potent, pesticides were required each time to control it (‘pesticide treadmill’). Suharto reacted by banning 57 broad-spectrum pesticides, by removing the 85% subsidy on pesticides and by asking for an extension campaign on Integrated Pest Management (IPM), which emphasised control through natural enemies, growing a healthy crop, and use of pesticides on the basis of observation. The extension campaign that used mass meetings, posters, and T&V was a downright failure. IPM is too complex a message for this approach. It was then that the FAO staff and their Indonesian colleagues in the IPM programme designed the Farmer

Field School (FFS) as a radical alternative (Pontius et al., 2002). I became involved through a PhD student who evaluated the approach (Van de Fliert, 1993; Röling and Van de Fliert, 1998), and had the good fortune to visit her in the field and to become a consultant to the FAO project. My main contribution was to help them understand what they were doing.

The FFS has the following remarkable principles: grow a healthy crop, use natural processes, the farmer is an expert, and research linkage. About 25 farmers meet once a week during one growing season. Their main job is to learn from experience. For this they use a field, which they divide into two: in one plot they grow rice the conventional way (i.e. with pesticides), and the other is the IPM plot. During each meeting, they split up in small groups and carefully observe a randomly selected number of rice plants in both fields, in terms of their growing conditions, health, and the insects living on them. Each small group discusses the results, makes a drawn (picture) report, and presents it to the plenary meeting. This 'Agro-Ecosystem Analysis' is the main activity during each meeting. The facilitator guides the process but refrains from strong intervention. In addition, some special subjects are introduced (e.g., the life cycles of an insect), and experiments are performed (e.g., the defoliation of rice to see how much of a rice plant can be eaten before it affects the yield). The farmers are left completely free to decide how to manage their IPM plot on the basis of the outcome of their observations and discussions. If they want to spray, they can spray. The farmer is the expert and carries out experiments.

Evaluations of IPM FFS projects tend to show that yields go up and that costs go down (especially because of lower use of pesticides). What is more, farmers learn to apply what they have learned to other crops and other situations. But what strikes observers time and again is that the FFS experience *empowers* farmers. They become opinionated, and learn to organise and to speak in public. Often FFS alumni spontaneously organise themselves to provide FFS training to other farmers or to undertake development projects. Politicians who visit FFS projects invariably are deeply impressed by the changes FFS can bring about and often want a rapid scaling up of the project because the FFS seems so promising in terms of them finally gaining an instrument to control farmers.

Alas, the effect of FFS is very sensitive to the quality of facilitation. Rapid scaling up leads to loss of that quality because there is not enough time and money to carefully train the facilitators and to create the conditions for effective farmer education. Most governments find it hard to refrain from using FFS as a vehicle for promoting government agendas and technology transfer.

Implications for Africa

(1) IPM has become a policy model that often is implemented by replication without thinking about the need to adapt the FFS to specific conditions and needs. I have seen the rice FFS curriculum being applied lock stock and barrel to bananas.
(2) Pesticide-induced pest problems are a typical second-generation Green Revolution phenomenon, which usually does not occur in Africa. Much more often, African farmers have problems with soil fertility, weeds, and with pests and diseases that do

not come about through pesticide use. Most FFS in Africa therefore require careful experimentation and testing in farmer research groups to develop appropriate curricula for FFS (e.g., Bruin and Meerman, 2001, describing the experience of a project in Zanzibar).

(3) Powerful bosses in ministries and research stations find it very hard to understand and accept the participatory processes upon which the effect of FFS is based and are all too ready to use FFS as an instrument to control farmers or to push their messages. One of our PhD students (Nederlof, 2006; Nederlof and Odonkor, in press) observed how a carefully developed FFS curriculum was turned into a technology-push programme overnight by 'the boss'.

(4) It is difficult to scale up the FFS. Government agencies might be in the pay of pesticide companies which try to discourage IPM as much as possible (a common problem across the globe). Typically hierarchical government procedures do not fit easily with the experiential learning approach and with the type of facilitators that FFS requires.

(5) FFS typically have little spin-off to farmers who have not participated in an FFS, just as your second child cannot be expected to get much schooling from your first-born. Complex practices such as IPM and integrated soil fertility management do not lend themselves to 'diffusion'. The FFS is a form of farmer *education*. In industrial countries, farmer education and training have been central ingredients in allowing farmers to become effective partners in agricultural development. FFS also is a very good basis for building farmers' organisations and farmer countervailing power. In fact, in systems such as the Gezira in Sudan, which are strictly run on command and control, FFS were discontinued because FFS alumni started to complain abut things they did not like (Khalid 2002).

Landcare in Australia

The other innovative approach to innovation that I briefly want to mention here is Landcare (Campbell, 1994). Landcare emerged when erosion, salination, desiccation and other environmental problems, as a result of applying European farming practices to a continent to which they were not suited, created awareness that new approaches were required. These new approaches asked for land users to engage in concerted action to ensure integrated management of watersheds, vulnerable soil types, saline groundwater tables, patches of native vegetation, and so on. In other words, proverbially independent landowners in the 'outback' had to learn to manage their 'properties' in concert with others so that desirable ecosystem services of units at the landscape scale could be sustained. This required a great deal of collective action, organisation, and social learning and its facilitation. The Landcare movement pioneered methods and approaches that are now quite common across the globe, for example in the management of watersheds, communal forests, etc. I myself was an instigator of a major European project on Social Learning for the Integrated Management and Sustainable Use of Water at the Catchment Scale (SLIM) (www.slim.open.ac.uk).

Three key points emerged with respect to my understanding of innovation:

(1) Innovation can be seen as the emergent property of interaction among stakeholders in a natural resource or ecosystem service. Where the destruction or degradation of the

resource or service is the collective outcome of each stakeholder trying to satisfy his or her individual preferences, a more sustainable management of that resource or service *necessarily* must be the outcome of collective processes, such as social learning, negotiation, agreement, reciprocal sacrifice of benefits and privileges, conflict, leadership, that lead to concerted management. Technology and market incentives can play some role in achieving concerted management, but basically we are dealing with a totally different concept: innovation as the emergent property of interaction. This notion was, of course, already implicit in the FFS, but in Landcare it became explicit and a subject of study. Soft systems thinking (Checkland, 1981 and with Scholes, 1990) became an important way to understand what was happening. I contributed by formulating the notion of a platform for resource use negotiation (Röling, 1994) that was considered helpful for a while. My colleagues Paul Engel and Monique Salomon developed a detailed methodology, Rapid Appraisal of Agricultural Knowledge Systems (RAAKS), for taking the stakeholders in a resource or ecosystem service through a systemic process of reflective action research, learning and decision making that leads to the emergence of innovation from their interaction (Engel and Salomon, 1997). RAAKS is a tool to 'enhance the innovative performance of the actors in a theatre of innovation', as Engel (1995) put it.

(2) When innovation is the emergent property of interaction, the promotion of innovation becomes a matter of *facilitating the interaction process*. Of course, this was already important in such approaches as Participatory Technology Development, but where the innovation is the result of collective voluntary behaviour change (instead of technical manipulation at the farm level), process facilitation becomes a key skill.

(3) Landcare was largely run by groups of land owners facilitated by trained officers made available through state governments. But it remained a very local phenomenon. The Government of Australia did not really support it or create the conditions through policy or institutional support that allowed it to develop. Thus it petered out when local people had done what they could do in their sphere of influence and ran into bottlenecks to consolidate, scale up, or institutionalise the changes. From then on I have been very aware of the fact that institutional support and conducive policies at higher scale levels are essential ingredients for success.

Implications for Africa

(1) Once we see that innovation can emerge from interaction among different stakeholders on platforms for deciding about concerted action towards some common objective, a great deal of African innovation becomes visible. Dangbégnon (1998) describes a number of examples, such as fishermen around Lake Ahéme in Benin trying several times to take collective action to stop them from collectively destroying the lake's fisheries. Her also describes successful action among arable farmers and pastoralists to agree on the use of common grazing lands. Hounkonnou (2001) reports a number of effective local self-development actions, such as a village succeeding in stopping robberies, and another going from strength to strength in developing its agriculture and establishing an effective local health service. In all these cases, the basis for success was laid a long time ago when young people learned to trust each other, to organise and work together.

(2) The perspective on innovation through collective action opens up huge potential for change. Many of the worst aspects of poverty such as the lack of services, rent seeking and corruption, insecurity, lack of community amenities, lack of access to education, drinking water, and so forth, could all be remedied through effective collective action, as so many successful projects across Africa have shown. But the same applies to the creation of opportunities for small-scale farmers to market their products and gain access to inputs and credit.

With that, we come to an interesting point. Innovation through collective action opens a perspective on creating opportunities and conditions for small-scale farmers. Instead of trying to develop Africa's agriculture by introducing 'innovations' at the farm level, we now begin to see a possibility for innovation to create better opportunities for small farmers as a necessary condition for change at the farm level.

CONVERGENCE OF SCIENCES PROGRAMME (CoS)

My most recent involvement with innovation in Africa has been the Convergence of Sciences Programme (CoS) in West Africa. During its first phase (2002-2006), it worked in Benin and Ghana. In its second phase it will also work in Burkina and Mali. For me, CoS has stretched the concept of innovation a great deal and has provided concrete grounds for moving in the direction of innovation systems, which I had been working on theoretically for many years. CoS brings together a number of the issues I have presented above.

CoS1: the first phase

CoS1 addressed the problem of the low impact of science on the livelihoods of resource-poor farmers in West Africa. The Cocoa Research Institute in Ghana, for instance, has observed that cocoa farmers have adopted only 3% of the technologies it has developed (Ayenor, 2006). West Africa's small-scale farmers have on the whole ignored the technologies for improving agricultural productivity at the farm level that have been developed by agricultural scientists. The response by scientists has been, and continues to be, more of the same: investment in research, in training of scientists, and in other ways of improving the supply of technologies. Technologies by themselves are expected to generate opportunity: by increasing productivity at the farm level, they are supposed to allow farmers to sell more and to increase their income. But the impact has been low. CoS1 tried to break through this impasse by developing a new 'pathway of science'.

To achieve this, CoS1 experimented in the field through the projects of eight African PhD students, supervised by mixed social and natural science teams of both African and Dutch supervisors. The ninth PhD student tried to draw the comparative lessons from the experiments of the others. The 'pathway of science' that CoS1 tested featured (1) a 'technography' for exploring the innovation landscape across the CoS themes (IPM, soil fertility and crop biodiversity) and across a number of crops and farming systems (cocoa, cotton, cowpea, and the sorghum and cassava/maize systems); (2) diagnostic studies by each of the students to zero in on farmer communities with whom they would collaborate, and on concrete research issues that farmers considered relevant; (3) collaborative field

experiments with farmers, and (4) platforms for discussion and learning composed of researchers, extension workers and others. Most PhD students also created (5) forums of villagers not directly involved so as to monitor and learn from the work.

CoS1 showed that it is possible, through technography and diagnostic studies, to identify niches within which a contribution of agricultural science to participatory technology development is very useful. In all CoS1 case studies, the research groups developed low external input technologies that build on a combination of farmers' knowledge and practice and scientific input.

CoS1 thus started off with an emphasis on technological research and the technography and diagnostic studies had made it possible to zero in on the small windows of opportunity that farmers have for beneficial technical change. But during CoS1 the need to stretch up those opportunities made itself felt.

Adjei-Nsiah (2006) and Saïdou (2006) provide an example. After initially pursuing purely technical avenues to improving soil fertility management, they found that tenure contracts between land owners and immigrants created conditions in which the latter could do little else but knowingly engage in practices that were detrimental to the long-term sustainability of land use. The researchers subsequently facilitated the renegotiation of tenure contracts as the key intervention needed to improve soil fertility management. This in turn created room for technological change.

Institutional innovation
In common parlance, the words organisation and institution are used interchangeably. For instance, 'institution building' typically refers to individual organisations such as universities, government departments, research organisations, etc. This concept easily leads to the idea that development requires strengthening the intervention power of *individual* organisations, agencies or institutes.

But institutions can also refer to the rules and agreements that reduce uncertainty in human interaction (North, 2005). In other words, the focus is on *interaction* and on realising the poverty reduction that can be captured from the *interfaces* among important actors in rural development. This might include improving service delivery, reducing rent seeking, strengthening mutual claim making, enhancing interdependence, and empowering resource-poor farmers to have voice in theatres of innovation. This interactive approach to institutional development fits with the innovation system perspective that I shall introduce when talking of CoS2.

An illustrative example of institutions, as defined here, is the 'Plimsoll Line' (Jones, 2006). In the nineteenth century, many lives were lost at sea because of unscrupulous ship owners whose greed drove them to overload their ships. This caused many accidents and shipwrecks. It is thanks to a committed philanthropist, Mr Plimsoll that a legally binding agreement was eventually reached about the safe maximum to which ships could be loaded. This maximum is marked on the hull of the ship and to this day is called the Plimsoll line, although few people nowadays remember the achievement of Mr Plimsoll

in forging this life-saving institution as a normative agreement, backed by improved scientific understanding among stakeholders.

In developing countries, in accordance with the Washington Consensus and the supremacy of methodological individualism and rational choice economics, the focus is almost exclusively on competitive technological change at the farm level as the main driver of rural development. The institutional development in the public sector, such as veterinary services, extension agencies, cotton campaigns, agricultural education, marketing support schemes, etc., has been weakened or even abandoned by governments under direct pressure from international institutions, in a process euphemistically called 'structural adjustment' (e.g., Stiglitz 2006). Even Farmer Field Schools, with their proven ability to educate and empower small farmers, are rejected by some as being 'fiscally unsustainable forms of extension' from this myopic perspective (Feder et al. 2004a,b).

An example from CoS1 underscores the importance of institutional development in the sense discussed here. Dormon (2006) worked with cocoa farmers in Southern Ghana on Neem as an effective control measure against Capsid bugs. Given the recent high prices for cocoa paid to farmers, there was a keen interest among local stakeholders in this technology. But it soon proved difficult to access and process Neem seed, which is supplied from Northern Ghana. As a result, Dormon and his farmers had to develop local capacity to purchase and process Neem seed. This required organisation and management beyond the level of the individual farmer and the involvement of a wider set of stakeholders who could develop income opportunities around this enterprise.

Figure 1 shows institutions and technology as two dimensions of innovation. It is the nature of their combination that requires attention. But institutions have been badly neglected in African development.

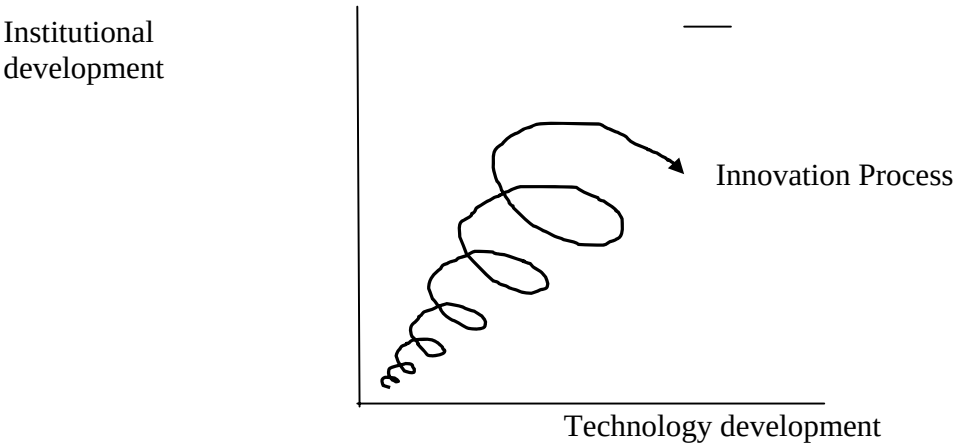

Figure 1: Innovation as a function of institutional and technical change (after Dorward, 1998)

'Much of the failure of agriculture to achieve its potential is institutional and political. Support by the state has been unresponsive to the needs of the poor and inefficient in

marketing producers' output, sometimes preventing the natural development of markets for producers. Public institutions need to be strengthened in their capacity to develop an appropriate blend of policies, regulatory frameworks and investments to re-launch the agricultural sector' (Thompson, 2006). An important promise of the Innovation Systems approach is that it able to address these institutional issues.

CoS2 and Innovation Systems

In accordance with the lessons from CoS1, CoS2 will focus on institutional development within such arenas of socio-technical change as oil palm development. It will pursue institutional change through the innovation systems (IS) approach. The notion of IS came out of empirical studies of successful development in Asia, which noted that such development can best be explained as emergent from the interaction within synergistic coalitions or configurations of key actors or stakeholders. 'An essential determinant of innovation was that suppliers of new knowledge were engaged with the users of that knowledge' (Barnett, 2006).

As happened with diffusion of innovations research, the empirical findings were transformed into a policy model. The World Bank has recently published a paper on IS (Hall et al. 2006) that has all the characteristics of a policy brief, and that therefore leaves open the possibility that IS are advocated in situations where they do not apply. The IS approach has not really been tested in African conditions. But doing so is very tempting, especially because the IS approach promises to provide a hands-on methodology for institutional development.

As a guiding concept, IS focuses on *systems*, i.e. on relationships and linkages among elements within an arbitrary boundary. In other words, we are not speaking of a given system, such as *the* Ugandan IS, but of coalitions or configurations of actors that turn out to be important within a potential theatre of innovation, such as organic coffee. As in CoS1, it will be necessary to spend considerable time and effort on technographies and diagnostic studies of such theatres of innovation, to establish the actors in them, to analyse their relationships and interdependencies, and to identify the potential contribution of synergy among them. These studies need to be participatory: the actors concerned need to gel into effective 'communities of practice' with shared goals and eventually with an ability for concerted action towards rural poverty reduction. Concretely, such concerted action will focus on provision of services, removal of rent seeking and corrupt practices, creation of markets, processing facilities and supply chains linking African farmers to emerging urban markets, etc. Greater farmer influence and countervailing power will be an essential ingredient in making sure that development is appropriate and benefits small-scale farmers.

An important aspect of rural poverty is the degradation of natural resources and ecosystem services. An IS approach allows for the multi-stakeholder negotiation and social learning required to deal with those issues, as we saw when we discussed Landcare. In fact, agriculture the world over increasingly moves away from mere food and fibre production and towards the integrated production of ecosystem services.

A final point: an IS approach needs to be applied across multiple scales. It is not enough to implement Communities of Practice at the decentralised level, say the district or *arondissement*. At the national level and international levels, institutional supports and policies need to create framework conditions, which allow IS at the decentralised levels to create realistic opportunities for small-scale farmers to improve their lives. Luckily, the Washington consensus, with its emphasis on methodological individualism, free markets, the reduction of the public sector and WTO's promotion of the global treadmill, is under severe attack.

CoS2 plans to invest much effort into learning from the experiments with the IS approach as a basis for creating a new understanding of innovation in Africa. This presentation will hopefully be continued at the next Innovation Africa symposium.

CONCLUSIONS

My autobiographic approach to the challenge of providing an overview of conceptual and methodological developments in innovation has raised a number of important points.

(1) Policy thinking about innovation tends to be dominated by the linear model of technology-supply push, partly because no other model promises such desirable macro-economic impacts. Yet the model is flawed because it has only very limited applicability in African conditions and has not led to significant development, let alone poverty reduction. The transformation of *ex-post* empirical diffusion and treadmill research into an *ex-ante* policy model has been sloppy and unprofessional.
(2) Many people who are practically involved in promoting agricultural innovation seem to have no ability to think conceptually about innovation as such. They are as imprinted with the linear model as ducklings are with the sound of their mother's call. It is essential to throw open the concept of innovation to the realisation that it can include indigenous development, social learning, concerted action and emergence from interaction. Being at the end of my career, I regret not living to see the next generation of ideas that innovate the concept of innovation.
(3) A number of important alternatives to the linear model have been developed and tested in farmers' conditions. Many of these have demonstrated considerable potential to improve rural people's lives. Some others, such as the Innovation System approach still require substantial experimentation.
(4) A clear distinction has to be made between technological change at the farm level that leads to higher productivity *within* existing windows of opportunity, and institutional change at higher system levels that *stretch* the windows of opportunity. Pushing technologies in conditions of limited opportunity is comparable to promoting a free market in a situation where essential market institutions, such as banks, do not function (North, 2005). In Africa, priority must necessarily be given to institutional change. It is not farmers, but NAROs, IAROs, local and national governments and especially international agencies that need to innovate.
(5) The Innovation System approach deserves attention because it promises to be an effective approach to promote institutional development.

(6) A key ingredient *sine qua non* in innovation is a small power differential between those who promote innovation and those who are expected to innovate. Increasing the countervailing power of small-scale farmers is an essential condition for synergy among development actors. But it holds equally for national government vis-à-vis international financial organisations. African leaders must thoroughly understand rural innovation processes if they are to stand up to misguided international policies.
(7) Without jumping off the global treadmill, it is difficult to envisage African countries acquiring food sovereignty, and African farmers making a contribution to global food security by making African land and water resources more productive.

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