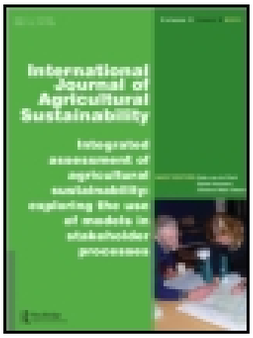

International Journal of Agricultural Sustainability

ISSN: 1473-5903 (Print) 1747-762X (Online) Journal homepage: https://www.tandfonline.com/loi/tags20

Can convergence of agricultural sciences support innovation by resource-poor farmers in Africa? The cases of Benin and Ghana

A. van Huis , J. Jiggins , D. Kossou , C. Leeuwis , N. Röling , O. Sakyi-Dawson , P. C. Struik & R. C. Tossou

To cite this article: A. van Huis , J. Jiggins , D. Kossou , C. Leeuwis , N. Röling , O. Sakyi-Dawson , P. C. Struik & R. C. Tossou (2007) Can convergence of agricultural sciences support innovation by resource-poor farmers in Africa? The cases of Benin and Ghana, International Journal of Agricultural Sustainability, 5:2-3, 91-108, DOI: 10.1080/14735903.2007.9684816

To link to this article: https://doi.org/10.1080/14735903.2007.9684816

Published online: 08 Jun 2011.

 www.earthscanjournals.com

Can convergence of agricultural sciences support innovation by resource-poor farmers in Africa? The cases of Benin and Ghana

A. van Huis[1], J. Jiggins[2], D. Kossou[3], C. Leeuwis[2], N. Röling[2]*, O. Sakyi-Dawson[4], P.C. Struik[5] and R.C. Tossou[6]

[1]*Entomology, Wageningen University, The Netherlands;* [2]*Communication and Innovation Studies, Wageningen University, The Netherlands;* [3]*Department of Crop Production, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, Bénin;* [4]*Department of Agricultural Extension, University of Ghana, Legon, Ghana;* [5]*Crop and Weed Ecology, Plant Sciences Group, Wageningen University, The Netherlands; and* [6]*Department of Economics, Socio-Anthropology and Development Communication, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, Bénin*

The article introduces the *IJAS* special issue on the Convergence of Sciences (CoS) research programme that took place in Benin and Ghana between 2002 and 2006. CoS sought to develop pro-poor pathways of science. Starting initially from the assumption that science impact could be improved by developing farm technologies that are appropriate for the circumstances of resource-poor farmers, the nine researchers soon ran into the very limited windows of opportunity that the farmers face. Improving productivity at the farm level is thwarted by limited access to markets, infrastructure, inputs, credit and services, and by cheap imports. Farmers have no political clout, and agriculture is a source of rent for a host of actors including local and national governments. In these conditions, poverty reduction requires institutional change rather than participatory technology development. All nine researchers tried in their own way to deal with the institutional dimension. This special issue reports on these attempts. The introductory article provides background and context for understanding the institutional issues involved.

Keywords: Benin, Ghana, resource-poor farmers, agricultural science, institutional factors, windows of opportunity

Introduction: focus on the pathways of agricultural science

This special issue is devoted to Convergence of Sciences (CoS), a research programme (2002–2006) that has been executed by a consortium of the Université de d'Abomey-Calavi, Benin; the University of Ghana at Legon, Ghana; and Wageningen University in The Netherlands.[1] At the core of the CoS programme were the research projects of nine doctoral students, four from Benin, four from Ghana and one from the Netherlands. The eight African students each worked with a group of farmers who, often on behalf of their community, and always with wider stakeholder involvement, developed technologies in such areas as land use and soil fertility, weed management and plant genetic diversity for food crops, and integrated pest management (IPM) for the cash crops cotton and cocoa. They also experimented with ways of improving the framework conditions for technological innovation. Each of these doctoral projects had been set up so as to optimize the likelihood that the technology developed makes a contribution to poverty reduction. The ninth student sought to

*Corresponding author. Email: n.roling@inter.nl.net

draw comparative lessons from the eight farmer–scientist interactions, so as to throw light on research procedures, methodologies, and processes that were assessed for their effectiveness in improving the livelihoods of small-scale farmers.

Many agricultural universities have departments that deal with agricultural extension education but very few have departments devoted to the topic of how to organize agricultural research and innovation in different contexts. We believe that the effectiveness of agricultural research is far from being self-evident and that the lack of impact of agricultural research cannot be explained only by failures of research 'delivery' through extension. The nature of technology development itself is highly contentious and requires careful research and development to make it 'right', especially when it comes to poverty reduction strategies in Sub-Saharan Africa (e.g. Stoop, 2002).

The central issue addressed by CoS was the need to increase the impact of agricultural research on the livelihoods of resource-poor farmers in Sub-Saharan Africa. This issue has become highly topical. The Inter Academy Council (IAC) (2004), the UN Millennium Project (2005), and the Commission for Africa (2005), have called for new investment in agricultural R&D, especially in Africa. 'To transform itself, Africa recognizes that it needs to harness the power of science and technology'.[2] These reports assume a key role for agricultural research in achieving the Millennium Development Goals, but this call for new investment has not been accompanied by greater insight into the way by which agricultural research could help improve the lives of resource-poor African farmers. In fact, the *pathways* by which agricultural science could make such a contribution are largely unknown, or worse, are assumed to be the same as those that supported agricultural development in industrial countries and in Asian developing countries during the Green Revolution. It is against this background that CoS very deliberately has experimented with ways of carrying out agricultural research that increase the likelihood that the research will benefit resource-poor farmers.

CoS embraced 'convergence' in three ways: (1) among disciplines; (2) among scientists, farmers, and other stakeholders; and (3) among organizations. First, it was assumed that research that is effectively responsive to farmers' problems requires fostering inter-disciplinarity. Different natural and social sciences must collaborate and integrate their work, rather than staple autonomous contributions together after the fact, because innovations have technical, social-economic and institutional dimensions. Second, it was assumed that research that is relevant to resource-poor farmers requires the involvement of non-academic stakeholders, especially farmers (trans-disciplinarity). Farmers must be able to exert effective control over the research and the disciplines involved in it. Third, it was assumed that innovation emerges from multi-stakeholder processes that occur not only at the field and farm level, but also at the higher organizational levels where all-important framework conditions are set. The replication at a larger scale of effective multi-disciplinary and interactive research with farmers and other stakeholders often falters because organizational actors at higher scale levels refuse to create the appropriate framework conditions. A typical example is the failure of scientifically proven methods of farming that do not rely on pesticides to become widely adopted as a result of the effective lobbying of pesticide industries with policy makers (Sherwood, in prep.).

This special issue of *IJAS* presents articles by the CoS researchers and their supervisors that deal with the social and institutional dimensions of agricultural technology development. At the time of writing, analysis of the more purely technical results of the agronomic fieldwork and participatory technology development was being finalized. Therefore, this special issue will not focus on the quality of the technologies that were developed. The concluding article of this special issue is based primarily on a comparative study of the methodologies that the researchers used, and formulates initial generalizations from research on agricultural research.

In this introductory article, we frame the nine studies in terms of the pathways of agricultural science. In doing so, the article goes beyond the familiar study of the diffusion of innovations (Rogers, 1995), technology transfer (Havelock, 1986), and treadmill propulsion (Cochrane, 1958) of agricultural development. We pay particular attention to the social, and especially institutional, dimensions of agricultural innovation. The following specific subjects are addressed.

First, we try to specify what we consider innovative about the CoS approach, and how it adds to other better-known approaches, such as farming systems research and participatory technology development. We then consider the context within which research must make its mark, that is a context with very small windows of opportunity for farmers. These conditions make special demands on designing 'pathways of science' that lead to outcomes that are appropriate and feasible in resource-poor farmers' conditions. We then pay attention to the all too often neglected institutional dimensions that circumscribe the impact of technological innovation, including a brief excursion to Patrimonialism. We conclude by giving an overview of the special issue and giving a brief glimpse of how CoS as a research programme could evolve to address the issues that remain unresolved.

What is innovative about CoS?[3]

CoS is not the first approach designed to make science relevant for resource-poor farmers. Well-known predecessors include Farming Systems Research (FSR) (e.g. Collinson, 2000) and Participatory Technology Development (PTD) (e.g. Van Veldhuizen *et al.*, 1997). CoS draws and builds upon FSR and PTD in ways that both resemble and differ from them.

As in FSR, the CoS programme works with conventional science institutions, and aims to combine scientific endeavour and indigenous understanding to achieve development objectives. CoS also has adopted FSR's broad systems perspective and tries to increase understanding of complex inter-relations among natural, social and technical phenomena in specific contexts by integrating insights from a variety of natural and social science disciplines.

The CoS and PTD approaches have in common that they both operate in a participatory learning and action research mode. Farmers and local communities are positioned as active partners and co-researchers in a problem solving process, with much of the research taking place on-farm. Both approaches make use of Participatory Rural Appraisal tools and principles for local-level problem identification and diagnosis of the 'windows of opportunity', the starting point for joint activity.

Yet the CoS approach also has some distinguishing features, that is

- Treating social relations and institutions as integral components of innovation, thus altering the boundaries and conditions that affect the space for change.
- Continuous diagnosis across levels and scales.
- Continuous re-orientation and flexibility.

The first of these features was deliberately designed to address the limitations of FSR and PTD, while the last two were discovered and formulated as the programme unfolded. Below we elaborate these aspects of the CoS approach in greater detail.

Treating social relations and institutions as integral components of innovation

In both FSR and PTD, the tendency has been to work on the design of new and/or more appropriate *technologies*. Although it was recognized that the uptake of promising technologies can be influenced greatly by the availability and/or functioning of input supply, credit systems, land-tenure arrangements, organization of marketing, distribution of benefits, etc., such social-organizational phenomena have mostly been considered as conditions that hamper or enhance adoption of technological innovations. In the CoS programme, such social institutions are regarded and treated as integral components of an innovation, instead of as 'external' conditions (Leeuwis with Van Den Ban, 2004; Smits, 2002). In line with this, each CoS research team (consisting of one PhD researcher and his or her supervisors) has worked not only on designing new technologies, but also on matters such as the development of (and experimentation with) alternative land-tenure contracts, novel forms of mobilizing labour, institutional innovations for the prevention of cheating in marketing chains, etc. In the innovation processes induced by CoS, developments in the realms of technical and social-organizational change have influenced each other, resulting in a continuous process of co-evolution of technology and society (see also Geels, 2002; Sonneveld *et al.*, 2004). In this way, the CoS approach seeks not just to develop 'appropriate technology' but also *to alter the boundaries and conditions that affect the space for change*.

Contrary to many research and development projects, CoS-triggered changes in the conditions that frame local innovation did not take the form of externally induced artificial circumstances (e.g. the

temporary provision of inputs or marketing opportunities), which could never be sustained in the long term. Instead, CoS facilitated farmers and other stakeholders to build and develop new institutional arrangements themselves on the basis of joint learning and interaction that enhances local innovation capacity (Hounkonnou, 2001), while making use of the normal services and channels for obtaining resources and marketing outputs. The only special conditions created were the facilitation of the innovation process by the CoS teams and the provision of research support. The challenge ahead is to ensure that such facilitation and research support become part of normal research and extension professionalism and organizational capacity.

Continuous diagnosis across levels and scales

In order to enlarge the space for socio-technical innovation, it was realized that the CoS approach should work not only at the 'local' level, but should also address and take into account constraints and opportunities at higher hierarchical levels and wider spatial scales. To identify the opportunities in the innovation landscape, the CoS programme started with so-called Technographic studies (Richards, 2001) which served to select broad themes, issues, stakeholders, locations and communities that might be involved in and/or benefit from action research. Technographic studies were designed to understand the innovation landscape and aimed to: (1) identify key actors and institutions in the innovation processes that affected a number of selected crops; (2) analyse strengths and weaknesses of these innovation processes; (3) identify unsatisfied needs of farmers; and (4) identify the gaps or discontinuities in the innovation processes studied. The main outputs of the technographic studies were the mapping of key actors and the identification of the relevant opportunities for innovation with respect to the selected crops.

CoS researchers then conducted local level diagnostic studies (Röling *et al.*, 2004), which resulted in the identification of research agendas for on-farm research with farmers in specific settings. Thus, the researchers gradually 'zoomed in' on farmers' realities and conditions at the field level. The outcomes from field-level experiments were also considered and interpreted against the background of the higher-level issues and opportunities identified. Through time, this iteration between 'zooming in' and 'zooming out' constituted a continuing diagnostic process that led regularly to a revision of research agendas as well as to an adaptation of the facilitation processes and stakeholder networks involved.

Continuous re-orientation and flexibility

Both the continuous iteration between technical and social-organizational aspects of change, and the sustained effort of 'zooming in' and 'zooming out', led to considerable re-orientation of the action research efforts even at later stages in the individual PhD research projects, thus ensuring flexibility in the face of the real world dynamic of change. This dynamic could be caused by a major change in conditions, for example when the prospect for exporting organic cocoa collapsed (Ayenor *et al.*, this issue), or by increased understanding of the 'active ingredients' in the contexts, for example when it became clear that marketing constraints severely limited the usefulness of productivity-enhancing technological innovations (e.g. Aliou *et al.*, this issue). Many conventional research and extension efforts lack such flexibility and suffer from rigidities caused by the prevailing funding, planning and evaluation procedures. We deliberately sought that flexibility, based on a conviction that change in complex agro-ecological and human systems cannot simply be designed and effectuated in an instrumental manner (Holling, 1995; Röling, 2002). It is our understanding that change processes are characterized by relatively unpredictable dynamics that emerge from place-dependent interactions among stakeholders and among people, technology and the agro-ecological environments (Leeuwis with Van Den Ban, 2004). Improving the quality of such interactions by supporting learning and increasing the transparency of systems dynamics is an important task for all those who wish to stimulate the kinds of change that aim to achieve more than simply 'doing the same things better'. If researchers want to contribute, they must actively engage with the flow of history and adapt their efforts to the process as it unfolds. In the 1980s, Simon Maxwell called this the challenge of 'hitting a moving target' (Maxwell, 1987).

CoS in all these respects has moved the debate further. But it is not alone in this quest. Ashby

(2003), for example, in her preface to a collection of studies that 'unite science and participation' makes a distinction between research *and* development (R&D) and research *for* development, in which the former is very similar to the transfer of knowledge perspective that we shall describe below, while the latter is founded on 'a participatory approach involving farmer experimentation, and building a capacity to learn about biological and ecological complexity' (Ashby, 2003: 8). This kind of research becomes 'a collective enterprise in which different stakeholders' values, knowledge and expertise are negotiated to produce results'. This process can be regarded as a democratization of science (e.g. Funtowicz & Ravetz, 1993; Pretty, 1994) that is also at the heart of the CoS approach.

Farmers' windows of opportunity

A strong correlation has frequently been found between the adoption of innovations by farmers and their wealth (Rogers, 1995). If innovations require special inputs or other conditions, rich farmers can create them more easily than poor ones. Resource-poor farmers in the high risk and diverse, rain-fed environments that do not support green revolution technology face very small windows of opportunity for innovation. This requires special attention to the design of the pathway of science so that it can deliver outcomes that are relevant for resource-poor farmers.

Agricultural pilot projects often create special conditions to enable and stimulate farmers to utilize the recommended technologies. Such special conditions might include access to subsidized inputs, guaranteed marketing of the surplus generated, the creation of special credit schemes, the availability of highly qualified advisory staff, and so forth. Invariably, such pilot projects report great enthusiasm among farmers and rapid uptake of the technologies (see, e.g. Röling, 1988). But, equally invariably, such projects turn out to leave few traces after the special conditions have been withdrawn. *Replicability* of the development gains is a key issue. The best guarantee for such replicability is to ensure that new technologies work *within* prevailing physical, socio-economic, cultural and institutional conditions and, if necessary, to stretch those conditions. This approach requires special procedures for adapting research goals, designs and processes on the basis of deliberate decision-making that is informed by an understanding of the farmers' context. These procedures have been of special concern for CoS and we have devoted a double issue of the *NJAS-Wageningen Journal of Life Sciences* to it.[4]

Small farmers in West Africa face very small windows of opportunity. The Green Revolution does not work in areas that, as Chambers (e.g. Chambers & Ghildyal, 1985) put it, are hilly, rain-fed, risk-prone and marked by high diversity. This is the nature of farming in huge areas in the developing world where opportunities for irrigation development are limited, such as the Deccan Plateau in India and most of Africa. The following specific reasons for the failure of the Green Revolution in Sub-Saharan Africa have been enumerated (De Janvry & Dethier, 1985):

- The heterogeneity of farming and farming conditions makes it impossible to develop uniform technology packages that can blanket large homogeneous recommendation domains. In industrial and Green Revolution agriculture it is possible to control the environment to fit the genotype, but in complex, diverse and risk-prone agriculture farmers need a variety of genotypes to fit the highly variable environment.
- The variability of rainfall and soil conditions makes it technologically risky to apply expensive fertilizers (fertilized crops often perish first under drought conditions), and the variability and specificity of insect problems makes it technologically risky to adopt blanket application of pesticides. Where farmers do use fertilizers and pesticides, especially when taken on credit, as in cotton production systems, crop failures often lead to financial ruin and suicide (Bertolote *et al.*, 2006).
- Prices for local food products are too low for food farmers to be able to afford chemical inputs.
- There are no major domestic marketing outlets for surpluses in countries or areas where up to 70% of the population is in farming. Urban demand is small and domestic opportunity often is pre-empted by cheap imports of agricultural commodities and food. Maize can be imported into Kenya at a price that is 20% lower than the cost price of the best local farmers.[5] In Ghana, imported American rice, subsidized to

almost 70% of the cost of production, has not only replaced locally produced rice but is also beginning to have substitution effects on other local food crops (Velthuis, 2005). Governments respond to urban electorates that appreciate low food prices. Africa today imports about 25% of its food grains (IAC, 2004: 195), not because food cannot be produced but because it is not economic for its own farmers to do so.

- The majority of farmers are not well organized, have no political clout and cannot exert effective demand on agricultural research and policy-making.
- Given that agriculture in many African countries is the major source of wealth, national and local governments, traders, police departments (through road blocks) and other rent seekers raise revenue from agricultural products. Export crops such as cotton, cocoa, oil palm, coffee, etc., support large unproductive populations of officials and feed corrupt networks.
- Public service delivery and input provision have all but collapsed as a result of structural adjustment. They probably did not contribute much to agricultural development anyway, since they reached only a small proportion of the farmers. Their virtual absence stands in sharp contrast to Green Revolution areas where input and service provision plays a crucial role.
- Given the poor rural infrastructure, road transport is expensive and unreliable. This point is also emphasized in the IAC report (2004).

These conditions have not substantially changed over the past decades. In all, the windows of opportunity for agricultural development are very small. Yet, over the years, millions of farmers have tried to make the best of it. Professional observers often call Africa's agriculture 'stagnant' (e.g. IAC, 2004: xviii) and observe that food production per caput in Sub-Saharan Africa has gone down by 0.2% per year over the past 20 years – although the last 10 years has seen a slight reversal, to an annual per capita increase of 0.3% (IAC, 2004: 9). However, throughout this period, the population grew by more than 2.5% per annum. In other words, far from being stagnant, African agriculture has largely kept up with rapid population growth, notwithstanding major impediments, such as war and civil strife, the HIV/AIDS pandemic, and the droughts that threaten agricultural production over large areas. The expansion in output has largely occurred without the aid of fertilizers and in the face of reduced labour availability as rural populations have shifted to the towns and cities.

It is often suggested that farmers have managed to keep up with population growth in the face of institutional and trade disadvantages by 'mining' agricultural resources and extending the area cultivated, rather than by innovation and increasing productivity per hectare or per unit of labour. From all parts of Africa farmers indeed are reporting loss of soil fertility, if not 'comatose' soils (Brouwers, 1993; Stoorvogel & Smaling, 1990); they report increasing drought stress, as soil organic matter and hence water retention decreases under permanent cultivation (e.g. Kudadjie *et al.*, 2004); and they report extra costs and drudgery, if not crop failure, as a result of invasions of pernicious weeds and other pests that never were a problem under slash-and-burn cultivation and ample fallow periods (Vissoh *et al.*, 2004). But there is also evidence that farmers are adapting to changing conditions by developing their knowledge, applying their science and technology in new ways, changing their practices, using different combinations of crops, developing other land and water use systems, re-organizing labour allocation, and working harder (e.g. Brouwers, 1993; Jusu, 1999).

Mortimore and Harris (2005) tested the hypothesis that nutrient depletion scenarios should be reflected in the long-term agricultural performance of West African farming systems at macro-, meso- and micro-scales, and found that the scenarios have less predictive capability than macro-economic policy and demand-side factors. 'The dominant narrative of soil fertility in Africa therefore needs revision. The best policy strategy for African soils is to create an enabling environment for private investments – by small holders – across the range of their natural resource-based livelihoods.' In this sense, small-scale African farmers can be considered innovative and creative, given the right policies. It is high time that small-scale farmers receive some recognition and help instead of active predation and exploitation in their national contexts, unfair competition from industrial countries, and misunderstanding in development agencies.

This recognition is urgent. Young rural people increasingly are fed up with the lack of opportunity

and the small incomes from agriculture. Many no longer have access to land, and otherwise are beyond the social control of the institutions that traditionally govern rural societies, giving sustenance to the brutal conflicts in Sierra Leone, Liberia and Ivory Coast. African export crops face increasing competition and adverse terms of trade. The stranglehold of exploitative patrimonial networks and urban elites gives little space for a renaissance, while industrial country governments and their private industrial sectors combine to exploit whatever opportunities emerge.

Research by Van Haaften (2002) has established a very high correlation (0.90) for West African villages between (1) an index of environmental degradation (loss of soil cover, erosion and soil exhaustion), on the one hand, and (2) an index of psychological stress and alienation, on the other. The debilitating consequences of land degradation do not leave people with the resilience required to do something about their situation. More and more rural people in West Africa are facing this situation. For European countries, these adverse developments in Africa's rural areas are a reason for worry. They do not want desperate illegal African migrants to flood into their countries.

In all, it is time for (international) agricultural research to carefully examine why formal agricultural research has played such a minimal role in the dynamics that have marked African agriculture during the past decades – exemplified, for instance, by the slow reaction of formal agricultural research to the emergence of weeds, as reported by Vissoh *et al.* (this issue). The design of innovation for resource-poor farmers cannot be technology-driven. It must try to fit innovation within the small windows of opportunity that these farmers have and/or stretch the windows of opportunity through institutional change. And that requires a different pathway of science.

Pathways of agricultural science

African farmers have frustrated the efforts of CIMMYT, IITA, WARDA and other international and national agricultural research institutes to create a Green Revolution in Africa. These institutes are receiving dwindling donor support because they have not been able to show sufficient impact in Africa (Conway, 1997: 67). Now we have a new call for massive investment in agricultural research and for creating centres of excellence for African research (IAC, 2004). But our insight in how we can make science work for resource-poor farmers in Africa has not changed. Acting on the strong feeling that we *do* have the technical answers and that we *must* do something, and therefore *will* do more of the same, is likely to leave us as frustrated as before, as farmers yet again refuse to follow our expert advice. The issue of the pathways of agricultural science could not be more relevant.

'How do I get them to see it my way?' That is the question asked by all those experts and specialists in international and national agricultural research institutes who believe they are right, but who fail to be taken seriously by African farmers. A typical example is the issue of soil fertility in West Africa. Scientists are convinced that the successful efforts of African farmers to keep up with population growth have, in fact, mined West African soils of minerals and nutrients (Stoorvogel & Smaling, 1990). This soil mining has become the dominant narrative (Mortimore and Harris, 2005), emphasizing that problems in African farming emanate from the supply side. For soil scientists, the answer is clear: soil organic matter must be restored by green manures, and depleted minerals by fertilizers (Breman, 2003). The biomass needed for building another pathway is simply not there. However, time and again, African farmers who have been confronted with this knowledge, who have discovered for themselves that green manure and fertilizers 'work', and who have followed the advocated practices for some time, fall back on their unsustainable soil mining ways when the project conditions are removed. They have their own good reasons: they do not have enough land and labour for producing green manures that do not immediately yield a useful product, they do not have access to fertilizers and cannot afford to buy them, and they cannot sell their surpluses for a price that is worthwhile (e.g. Nederlof & Dangbégnon, 2007). The scientists are still right – but obviously the farmers are also right, and what is more, they have the power *not* to adopt scientists' technologies. During the last decades they have exerted that 'veto power' on a massive scale.

The three models of the pathways of science that inform us at present have been shaped by the

experience of the development of agriculture in the US during and after World War II, especially the experience in the American mid-west, with its vast uniform agricultural industries. The first model is the *diffusion of innovations*. The classic study was published in 1943, based on the rapid autonomous spread of hybrid maize among farmers in Iowa (Ryan & Gross, 1943). For some time, the diffusion of innovations became the most popular subject for empirical social science research, even after the late Everett Rogers (well-known for his classic overview of research on the diffusion of innovations, e.g. 1995) himself spoke of the 'passing of a dominant paradigm' (Rogers, 1976). Autonomous diffusion among farmers firmly lingers on as one of the pillars of our understanding of the pathways of science impact. And in Africa, the rapid and autonomous spread of cassava, maize, beans, cocoa and many other crop species and cultivars is testimony to the power of unaided diffusion processes to change the face of agriculture. The point is that diffusion is not automatic. It cannot be relied upon as a strategy. It can and does happen, but cannot be commanded at will. What is crucially important is that the conditions for using an innovation are in place. A typical example is the availability of under-utilized resources as a condition for the rapid diffusion of cocoa in Nigeria in the first half of the last century.

In the same mid-western US, this time in Minnesota, the second model, the *agricultural treadmill* was elucidated (Cochrane, 1958), based on the neo-classical assumptions that farms are basically small firms, that all produce the same commodities, and that each is too small to affect the commodity price. Hence farmers are price-takers and, in making rational choices, they seek to produce as much as efficiently as possible against the going price. A new technology that is introduced into this situation leads to a wave of innovation. The first farmers who adopt it capture a windfall profit because they can now produce more – or more efficiently – than indicated by the prevailing price. However, soon others follow. Since farmers cannot hold on to the rewards of technological advance, the price starts to drop. People who have not adopted the innovation see their incomes drop although they are working as hard as before. They must now also adopt the innovation or leave farming. Moreover, once on the treadmill, no one can afford to absorb the environmental or social costs of increasing intensification within the farm enterprise. In this manner, very specific market forces operating in agriculture propel the diffusion of innovations and the externalization of social and environmental costs. Farmers, who cannot keep up eventually drop out. Larger farms absorb the land and market share that become available, thereby feeding a process of scale-enlargement. But the treadmill has not been able to sustain incomes in agriculture in industrialized countries, notwithstanding the unsustainable amount of regulation and subsidy.

The third model is *technology transfer*, clearly formulated in the sixties by people such as Havelock (1986), Lionberger (1986), and others closely associated with Land Grant Universities in the American mid-west. This model operated on the assumption that the integration of research, extension and education at a relatively small cost could feed the treadmill and lead to 'development' in a number of ways: the number of farmers becomes smaller, the average farm operation becomes larger, farming becomes more efficient and more competitive in international markets, and prices of agricultural consumer products decrease over time. Hence investment in agricultural research, education and extension was shown to have a high internal rate of return in specific conditions and historical periods (Evenson *et al.*, 1979).

The Green Revolution in Asia followed the mid-west American framework that integrates the three models discussed above. International Agricultural Research Centres developed varieties of grain crops that allowed farmers in huge, relatively uniform, recommendation domains to increase their yields substantially. These varieties, and improved ways of growing them, were delivered to farmers by centrally-funded public extension services, forging a series of hierarchical relationships among researchers, extensionists and farmers that were later formalized in the 'Training and Visit System', that provided a smooth pathway between research and the 'ultimate users'. Delivery of fertilizers and pesticides on credit was carefully organized. And it worked: the Green Revolution in Asia turned around the food insecurity situation that had seemed intractable only few years before. 'The Green Revolution provided a special type of growth in family farm productivity. It not only increased the supply of locally available staples but also the demand for farm labour, wage rates,

and thus the work-based income of the dollar-poor' (Lipton, 2005).

Given these powerful, interlinked and experiential models, it stands to reason that the development and transfer of technologies to feed the agricultural treadmill and reliance on autonomous diffusion processes are the dominant frame for thinking about, and investing in, the pathways of agricultural science. Science produces the innovations, extension transfers them, and farmers are the 'ultimate users'. Although it has regularly been relegated to the dustbin (e.g. Chambers & Jiggins, 1987; Röling, 1988), this dominant frame has some powerful allies: researchers and research institutes embrace it because it gives them their contract with society, and the treadmill fits hand in glove with our currently dominant way of thinking about ourselves, our society and the design of the future: neo-classical economics.

The power of the dominant framework is evident in the IAC Report (2004) to Kofi Annan about realizing the promise of African agriculture. It focuses on developing the best technical means as the road to agricultural development, and uses crop growth and yield per hectare as performance indicators, a focus contested by for example Lipton (2005). The focus of the IAC report is further evidenced by its call for 'a market-driven agricultural productivity recovery' (Lipton, 2005: xxvii) and for investing in centres of excellence. The Report does not acknowledge the generally accepted notion that innovation is not produced by research, but emerges from interaction among stakeholders in agricultural knowledge and information systems (AKIS) (Chema *et al.*, 2003; Engel & Salomon, 1997; Leeuwis with Van Den Ban, 2004; Röling, 1988; Röling & Wagemakers, 1998). Instead, all we read is advocacy for more of the same.

Improving the pathway of science must abandon the focus on technology-driven approaches. It must take into account that farmers have good reasons for doing what they are doing, and that they have the power to make their logic stick. Hence the pathway of science must start from where farmers are and deal with *their* reasons, however 'wrong' they might be deemed to be. Such research design will, therefore, have to move beyond crop ecology and neo-classical economics, and incorporate analysis of human behaviour and institutions. And that raises the question how agricultural research can be best designed if it is to contribute to the livelihoods of resource-poor farmers in Africa.

Institutions

If we are to make headway in understanding the pathways of science in Africa, we could do worse than ask ourselves why African small-scale farmers have been forced to operate within very small windows of opportunity and why it has not been possible to extend these opportunities significantly. We offer three preliminary explanations that, in our view, all have to do with institutions in the sense of 'sets of rules that exist to reduce uncertainty in human interaction' (North, 1990: 17). Hence science, justice, and the equitable distribution of power can be seen as such sets of rules, but the same goes for legalized oppression and exploitation.

Small-scale farmers are not important as electorates

In a country such as Indonesia, rice self-sufficiency is a primary political issue. President Sukarno lost his presidency when he could not provide it, and his successor, Suharto, learned his lesson: he promoted the Green Revolution. And when pesticide-induced resistance and resurgence of the Brown Plant Hopper threatened rice harvests, he was very quick to ban 57 broad-spectrum pesticides and end the 80% subsidy on pesticides, even though his family was heavily involved in pesticide interests. In Africa, such a direct influence of farmers on politics does not exist. Horrible famines come and go, but African presidents remain, often benefiting substantially from the food aid. The electorates that seem to count in Africa are urban. And they want cheap food; the emerging urban middle classes increasingly rely on supermarkets stocked with imported food that can be supplied more cheaply and efficiently by industrial countries than by African farmers – so long as the food does not reflect the true costs of transport. Given that the rural population is powerless, African political elites have nothing to gain from developing African food production.

Commodity markets do not work

The treadmill requires commodity markets, that is large-scale markets for uniform products in which the price is determined by farmer efficiency and competitiveness, so that the market drives the search for productivity gains. Africa has many small niche markets that are not connected. Market information is not freely available so that prices are set locally and rather arbitrarily given the actual relative scarcity. More often than not, market prices are determined by vagaries of weather, transport, monopolistic traders, and so forth. An important factor is also the rent-seeking behaviour of national and local governments, police departments, chiefs and others who raise levies on produce at any occasion that presents itself. Our experience in CoS is that any small surplus of cassava or maize that our farmers have produced leads to the collapse of the price in the local market and to the accusation that researchers do not do enough to help market the surplus their intervention has generated (Saïdou, pers. com., 2004). The experience is typical: as soon as one solves a technical problem, one runs into an institutional one.

An important factor for the lack of commodity markets is that the urban demand is largely usurped by imports from industrial countries. This is not just a question of 'dumping', that is flooding African markets by the surpluses that have been generated in Europe and the US as a result of market-distorting subsidies. Bairoch (1997) has shown that the productivity of farmers in industrial countries is so much higher than that of African farmers that it easily offsets the African 'advantage' of lower labour costs. In this light, it is little wonder that 25% of Africa's food grains, as well as most of the broilers, peanut butter, candy, and so on are imported from abroad. Hotels in Ghana, for example, do not provide real coffee that is locally produced. One gets Nescafé instead and it does not seem to bother anybody.

Absence of effective marketing chains

A marketing chain can be seen as a multi-stakeholder network that is highly integrated and shares a common perspective or goal: to deliver a product as cheaply and efficiently as possible to the consumer. Increasing the efficiency of the whole chain is in the interest of all stakeholders, whether they are farmers, processors, transporters, retailers or others. Threat of competition leads chain partners to be highly aware of the 'competitive position' of their chain *vis-à-vis* others. This awareness leads to 'chain thinking'. For example, Dutch butter producers who initially used to insert stones in the vats of butter they brought to market, gradually learned that this behaviour only hurts themselves in the long run. But it took quite a bit of education and effort to make farmers see this.

Creating such 'chain awareness' has not happened yet in Africa. Two examples suffice. In Benin, a large number of unproductive people 'eats' from the export earnings of the cotton produced by small farmers. For example, Sinzogan *et al.* (this issue) report that pesticide salesmen in Benin refuse to sell effective but cheaper pesticides that are available and that could reduce farmers' pesticide costs substantially, simply because that would cut the salesmen's profits. The salesmen get back their invested capital and profit even when farmers do not get paid for their efforts (Tossou, 1995). The pesticide business in Benin, as elsewhere, is highly linked to the political elite. In other words, these elites behave as Dutch butter farmers of old to the detriment of the efficiency of the chain and the competitive position of the Benin cotton industry on the world market.

In Ghana, the Cocoa Marketing Board (COCOBOD) is directly involved in pesticide production. The same COCOBOD has introduced mass spraying of synthetic pesticides by hired spraying gangs. All this is paid for by the revenues from small farmers' cocoa exports, over which COCOBOD has control. COCOBOD has, so far, not cooperated in the certification of organic cocoa, which would undermine the rationale for mass spraying of synthetic chemicals (see Ayenor *et al.*, this issue, on the impact of mass spraying at the local level).

The evidence of the CoS studies suggests that in Benin and Ghana, two countries which together with Nigeria were cited in the IAC Report (2004: xvii) as making dramatic progress in reducing malnutrition in recent years, public agencies seem to have no concept of the marketing chain and of improving the competitive position in the world market of their main export commodities.

Patrimonialism or the Big Man Syndrome: prominent African institutions

Africa is not 'institutionally underdeveloped' – as it was called by a Deputy Minister for Agriculture at a recent CoS workshop. In fact, Africa has very strong and enduring institutions of its own. And one of these, patrimonialism, has been particularly important for agricultural development and for the pathway of agricultural science.

Patrimonialism is 'a system of governance in which management personnel is responsible only to the political leadership, and where government jobs are treated as income producing personal assets' (Brinkerhoff & Goldsmith, 2002). 'A patrimonial elite controls the state apparatus and fails to enforce law and order and to provide basic socio-economic functions' (Peppelenbos, 2005: 51). 'Many observers are struck by how few resources trickle down through patronage networks in African countries, and how many resources remain in the hands of a select minority at the top' (Van de Walle 2002, in Brinkerhoff & Goldsmith, 2002). Most readers will be familiar with the many forms in which the 'big man' who is the centre of a patronage network appears in different African contexts. Bwana Mkubwa is the kiSwahili version, although Wa Benzi is also used, to indicate that the big men drive Mercedes Benz. In Francophone countries, one speaks of the 'Grand Patron' or 'Grand Chef'. Patrimonialism seems to influence the institutional landscape in a very fundamental manner that is hard to understand if one applies the methodological individualism of neo-classical economics and actor sociology (Peppelenbos, 2005).

A cosmology to underpin the big man syndrome

Millar (2005) reports on interesting work that brought together representatives from various African countries in an effort to understand African cosmology. The central notion of this cosmology, they decided, is perhaps best expressed by what is called 'Ubuntu' in Eastern and Southern Africa, the notion that 'I am because we are'. Ancestor-centrism seems to be the key element in this cosmology. The 'Ultimate Chief' creates a world inhabited by the unborn, the living and the dead. The dead, especially children and insignificant people become spirits, but others become ancestors. These re-enter the world of the living through re-incarnation. Hence the ancestors provide a route to life and to the maintenance of the lineage. It is easy to see how being a big man in this life is a route to becoming an ancestor in the afterlife. Accepting a patrimonial form of governance perhaps requires a set of common rules shaped by ancestor-centrism.

Big men, at all levels of aggregation, seem to work in the same manner. They develop patrimonial networks or coalitions of patronage, allegiance, interest and accumulation. Once they are installed, they are difficult to dislodge. Sometimes, such patrimonial networks work closely with corporations from industrial countries, whether to sell slaves to the Dutch (to which Elmina Castle in Ghana stands as a haunting witness), or to import pesticides or subsidized American rice.

The importance of checks and balances

Between 1965 and 1967, one of the authors used to regularly visit a village called Umuabi, just outside Enugu in the heart of Igbo land in Nigeria, with his friend Joseph Ogbatta. Umuabi at the time was a modernizing village, with a Catholic and a Church of England faction (based on rivalry between traditional groups), a Progressive Union of 'sons abroad', and so forth. But it also had strong traditional institutions, with old priests making their sacrifices to the ancestors and the ancient gods, and powerful masks representing these holding sway at certain times of the year. The village also featured a 'Chief' although theoretically this is seen by anthropologists as an impossibility in acephalous (lit. 'headless') Igbo society. He was, in fact, a 'Big Man', a former keeper of the supply store of a coalmine in Enugu who had retired in the village and become a typical patron. He provided villagers with advice about the world outside, performed services in linking the village to that outside world, and received a great deal of service, esteem and status in return. He was, for example, the representative of the village in the County Council.

The story is about a scholarship for secondary school that the Council awarded annually in turn

to the villages in the Council. When the turn came to Umuabi, the Chief appropriated the scholarship for his daughter. But the clerk of the Council also came from Umuabi and reported what the Chief had done. The village then called a village-wide contest of all children eligible for the scholarship. The daughter of a poor widow won and the Chief's daughter came second. When asked why the Chief was still there, enjoying his patron status, Joseph Ogbatta laughed. 'We would have all done the same thing.' In other words, we are all crooked, but rely on checks and balances to maintain justice. However, the checks and balances that exist at the local level often have not as yet emerged at higher levels, leaving the big men to create their patrimonial networks.

Hounkonnou (2001) describes a number of such 'checks and balances' in Benin and Ghana in which groups of young people, for example through their membership in a village sports or music club, develop mutual trust and bonds (the 'cradle') that they build on later to collectively challenge the restrictions to village development imposed by big men, and so to set the community on a path of self-help and self-organization.

For establishing checks and balances, it is not enough to install, say, an Audit Committee in an agricultural cooperative. Vodouhé (1996) describes how such an Audit Committee is an anomaly in African rural reality. The leaders of the cooperative are the Big Men or Patrons to whom all members in the cooperative are linked through ties of allegiance, loyalty and obligation. Membership in an alien institution such as an Audit Committee is underwritten by these invisible ties and thus such a committee cannot be expected to guarantee accountability of the cooperative's leadership to the members or to the rules. Indigenous mechanisms are required to secure accountability, as those in Umuabi.

It is, similarly, not enough to create a farmers' union as a way to give farmers countervailing power. It is all too easy for the Big Men who emerge as they create the union to become enrolled in the very networks of power that exploit the main source of wealth: the farmers.

The examples also make abundantly clear why donor governments, such as the Netherlands, should not give the bulk of their aid in the form of budget support as they do at present. This only strengthens the centre and the ability of Big Men to consolidate and seek rent (Toulmin, 2005). For the same reason, the so-called 'centres of excellence' that the 2004 IAC Report recommends to realize the promise and potential of African agriculture seem not to be such a good idea. One of the authors recalls how, on a mission to review the Dutch biotechnology policy, he discovered that the funds for 'client-oriented' research were being used by a Big Man to set up a research institute for himself. The tissue culture lab provided with Dutch funding was being used to produce sweet potato cuttings which farmers could buy at two cents a piece. Since seasonal drought usually killed off the sweet potato in most of the area, this was a lucrative business. Instead of supporting the Big Men, it seems worth looking for ways by which donors can scale up the checks and balances from the village to higher levels, and support local organizations and decentralized R&D (e.g. Bigg & Satterswaite, 2005).

Overview of the special issue: CoS moves beyond developing technologies that fit the windows of opportunity

As we have seen, for an important part of its initial activities, CoS has opted to develop technologies that work within the small windows of opportunity that African small-scale family farmers face. To this end, CoS has developed participatory procedures and approaches to make 'pre-analytic choices' and carry out on-farm experiments that generate technologies that small-scale farmers are able to use, want to use and know how to use, and that actually work in their conditions (Nederlof *et al.*, 2004; Röling *et al.*, 2004; Tekelenburg, 2002).

CoS can, however, not stop there. Helping farmers to adapt to restrictive conditions does not sound like an adequate strategy to reach the Millennium Development Goals. On the other hand, creating artificial conditions in pilot projects that collapse as soon as the props are removed, as has happened so often in Africa, is not helpful either. What seems required is a stretching of opportunity. This is not a question only of developing 'the best technological means', but also of institutional analysis and experimentation, in close coordination with technology development. What

is a very exciting part of CoS is the deliberate diagnosis of, and experimentation with, the institutional constraints that farmers face, within the context of technological development. This is the reason why this special issue is devoted to this work.

Each of the eight individual research projects that constitute the CoS Programme consists of several phases, including technographic and diagnostic studies (their results have been published in the *NJAS-Wageningen Journal of Life Sciences* 52 (3–4) (2004): 209–448), an analysis of specific technologies, creating space for innovation, joint learning with farmers, work on institutionalization, and a reflection on the CoS approach. The ninth project is a comparison among the eight, so as to draw lessons from research about agricultural research.

This special issue of the *International Journal of Agricultural Sustainability* deals with societal and institutional aspects of relevant agronomic-technological problems. A selection was made to illustrate the different ways in which these aspects emerged and were dealt with by the researchers in the three main management domains of the CoS programme: soil fertility, biodiversity and biological stress (including weeds, pests and diseases).

Zannou *et al.* (this issue) analyse the socio-cultural aspects of yam and cowpea plant genetic diversity in Benin. It is clear that agricultural innovations have dimensions that Leeuwis with Van den Ban (2004) aptly call their hardware, software and orgware.[6] Zannou *et al.* have focused on the software through an anthropological analysis of the social and cultural embedding of the plant genetic diversity that male and female farmers create. The authors make clear that the on-farm management and conservation of genetic resources is a social construct and is affected by the agronomic-technological suitability of a variety (how it fits in the continuously changing farming systems and how it fulfils the diverse needs of a household), market demands, its capacity to contribute to food security, and its social values. Strategies for on-farm diversity management take all these factors into account.

Vissoh *et al.* (this issue) deal with the herbaceous weeds that emerged within living memory as a constraint to family farming when the rapidly increasing population density led to more permanent land use. This historical trajectory allowed Vissoh *et al.* to analyse how different stakeholder groups, farmers, administrators and agricultural researchers, 'socially constructed' weeds, that is recognized and named the phenomenon, invented names for weeds, and developed technologies, labour regimes, land values, etc., in accordance with the new phenomenon. The findings with respect to the differences in social construction between these stakeholder groups are particularly interesting in the light of the focus of CoS on research on agricultural research. Weeds took a very long time to become a priority of agricultural research. The authors clearly indicate that appropriate weed management technologies need to be developed to control invasive and parasitic weeds, such as *Imperata cylindrica* and *Striga* spp.

Kudadjie *et al.* (this issue) look at the process of joint learning among scientists and farmers with respect to variation *within* sorghum varieties. This study makes clear that, far from being the 'end users' of technology transfer, farmers are effective partners in developing technology, not just through their indigenous knowledge, but through their indigenous capacity for astute observation and experimentation. The authors suggest that farmers' practices to manage diversity between and within crops reflect their perception of diversity. Farmers' identification of variation is very similar to the classification systems that taxonomists use, and therefore, there is a basis for communication and joint learning. Through their research, farmers were better able to understand the different sources of variation and to link their management practices to the variation in their fields.

Ayenor *et al.* (this issue) also look at learning processes. But their focus is different, in that they do not discuss learning processes within the experimental group, but the effect of special procedures (the 'Local Agricultural Research Committee (LARC) approach', originally developed in Latin America) to include the wider community in the experimental work of the small group of experimenting farmers. The results are remarkable, especially in the light of the limited diffusion effects of linear extension approaches and of Farmer Field Schools. That is, the results show a very clear impact of membership of the LARC on knowledge and practices of cocoa farmers. The work reported here is part of a wider effort together with farmers to experiment with organic ways of controlling important pests and diseases in cocoa.

Sinzogan *et al.* (this issue), as part of a study of integrated pest management practices in cotton, report here on the diagnosis of cotton production and marketing networks in Benin and the way these create the framework conditions for small-scale cotton farmers. The analysis shows the specific ways in which the self-serving interests permeating the reformed cotton organizations undermine the development of an effective cotton production and marketing networks that might begin to enhance the competitiveness of Benin cotton in the world market. Some farmers have created alternative institutional relationships based on an improved pest management technology that frees them from reliance on high use of pesticides and hence on the credit that entangles them in the conventional networks. But their efforts to break away are being thwarted by the determination of the conventional input suppliers not to lose the income from pesticide sales. Farmers continue to produce cotton, despite very small profit margins (if they get paid), because of the access provided by the institutional arrangements to fertilizer that they can divert for use on their maize and other crops.

Three articles report on experiments with alternative institutional arrangements that stretch the opportunities of resource-poor farmers.

Adjei-Nsiah *et al.* (this issue) and Saidou *et al.* (this issue), who work on soil fertility issues in respectively Ghana and Benin, both ran into the well-known phenomenon that soil fertility management is affected by land tenure arrangements. The large numbers of immigrants in the areas studied try to exploit the land as much as possible in the knowledge that the owners could claim back the land at any time, while the increasingly high rent demanded by the owners forces tenants to engage in exploitative practices. Both researchers attempted to create negotiated agreements among tenants and landlords, often in collaboration with other interested stakeholders, such as local government, that allow for better soil fertility management. Their work clearly shows that it is not enough to focus on technical factors such as green manures and fertilizers, and that it is necessary to address institutional factors.

Dormon *et al.* (this issue) have deliberately and systematically tackled the institutional constraints that they ran into in the wake of developing technological solutions for the very low yields of small-scale cocoa farmers. Thus when Neem spraying proved a cost-effective pest management practice, the absence of a source of Neem seed and of milling capacity was overcome by the stakeholders agreeing to create institutional arrangements that could provide for them. Dormon *et al.* also introduced a management strategy for tackling Blackpod disease, which involves removing all infected pods. As this is very labour intensive, it led the stakeholders to experiment with reciprocal labour sharing. Thus the article describes how the solution of technical problems created new institutional problems that required social innovations. The article represents an innovative and successful effort to stretch the limited opportunities of small-scale farmers.

The final article by Nederlof *et al.* (this issue) reports a comparative study of various aspects of the experiments with farmers from the other eight researchers. The technical results of the eight researchers are not yet available. Nederlof *et al.* can therefore not draw conclusions based on the quality of the technologies produced, according to the criteria CoS has developed (e.g. Nederlof *et al.*, 2004). But the preliminary results reported here allow conclusions to be drawn about how formal agricultural research can effectively engage small-scale farmers, and thus about a pathway of agricultural science that addresses resource-poor farmers' problems and opportunities.

The CoS research reported in this issue shows that an expanded and integrated set of functions, criteria and procedures make up a pathway of science that is likely to be more effective in contributing to resource-poor farmers' livelihoods, than the limited and often fragmented functions, criteria and procedures that make up the conventional pathway based on diffusion, treadmill and transfer of technology. The pathway explored by CoS emphasizes the need to take into account the institutional constraints to agricultural development. CoS research reported in this issue provides some examples of how agricultural research with farmers can address such constraints. What this issue does not answer is the question how this pathway can become part and parcel of mainstream agricultural research. This issue is briefly addressed in the following section.

The way forward

The first phase of CoS, reported in this *IJAS* special issue ended when, in October 2006, all nine researchers successfully defended their dissertations in Accra and Cotonou. During its next phase, CoS will continue to focus on effective pathways for a contribution of agricultural science to achieving the Millennium Development Goals in Africa. It will prioritize two issues:

- Stretching the space for opportunity for small scale farmers in an integrated approach to the 'hardware, software and orgware' of agricultural innovation with special emphasis on institutional constraints.
- Scaling up the CoS approach with a view to incorporating it into the regular procedures of knowledge institutions, such as universities and national and international research organizations.

Stretching the space for opportunity

This activity will build on the experiences with altering institutional arrangements during the first phase. It will be based on a methodology specifically designed to scope, identify and diagnose critical institutional constraints, and on experimental multi-stakeholder learning and negotiation approaches that allow innovation in concerted action. These approaches will draw heavily on disciplines that have not been involved in CoS so far, such as new institutional economics and political science. It will try to move beyond the conventional crop ecology focus on developing the 'best technical means' for assumed goals and institutional conditions, and the neo-classical economics focus on methodological individualism and market fundamentalism. Instead, it will assume that 'institutions think' (Douglas, 1986), and that 'understanding institutional diversity' (Ostrom, 2005) is a key to making headway in Africa, where the conditions that make agricultural treadmills work in industrial and Green Revolution agricultures, simply do not apply. CoS will move beyond the conventional coordination mechanisms of hierarchy (with its focus on policy and political will) and market (with its focus on market liberation as the panacea for all societal ills) and embrace network coordination (Hajer & Wagenaar, 2003; Powell, 1994) with its emphasis on social learning, distributed cognition and other ingredients of transition to concerted action [e.g. creating spaces for experiential learning at multiple scales in marketing chains (Jiggins, 2005)].

Practically, and from a development point of view, the next phase of CoS will focus on deployment of agricultural science for rural employment and income generation. Its direct aim will be to enhance the countervailing power of rural people by building checks and balances against the exploitative practices that prevail at present. It will do so by building on the widespread international experience with building local organizations (c.f. Bigg & Satterthwaite, 2005).

Examples of the experiments that CoS will undertake are:

- A multiple stakeholder approach to social learning at multiple scales within marketing chains for export commodities.
- Creating farmer-owned integrated production and marketing enterprises for broilers and other luxury products for African supermarkets following the Development Foundation of Turkey approach (Unver, 2005).
- Deliberately using the Farming Field School experience for empowering local farmers and for creating multi-tier farmer organizations that can begin to challenge the patrimonial structures.

Incorporating the CoS approach into the procedures of knowledge institutions

The CoS workshop in Cape Coast in October 2005 with leaders from Africa's national agricultural research organizations, international centres of agricultural research, and universities showed that the time is ripe for scaling up the CoS approach. Leaders are convinced that new ways must be found to make agricultural research work. The CoS approach, and especially the work and enthusiasm of its nine researchers, appeal to them. Sub-regional organizations such as CORAF[7] wholeheartedly support the approach and recognize the need for scaling up and for incorporating it into the procedures of knowledge institutions, much as conventional Western approaches to science and

academic work have earlier been incorporated in African knowledge institutions.

To this end, CoS envisages a multi-stakeholder learning trajectory, this time not at the field at farm level, but at the level of knowledge institutions. CoS will endeavour to create 'communities of practice' (Wenger, 1998) among key representatives from knowledge institutions in a process of, first, analysis and diagnosis of own projects, and then, learning from them to collectively design new procedures, curricula, accepted research methodologies and protocols. In this approach, CoS will draw on the experience of the New Paradigm Project in Latin America (De Souza *et al.*, 2000) that worked with representatives from research organizations in Latin American countries in a similar manner.

Acknowledgement

The authors would like to acknowledge very helpful critical comments by Prof. Dr Thom Kuyper of Wageningen University.

Notes

1. The donors were: Wageningen University through its Interdisciplinary Research and Education Fund (INREF); the Directorate-General for Development Cooperation (DGIS) of the Netherlands Ministry of Foreign Affairs; FAO's Global IPM Facility (GIF), and the Netherlands Organization for Scientific Research (NWO). The Technical Centre for Agricultural and Rural Cooperation (CTA) established in 1983 under the Lomé Convention between the ACP (African, Caribbean and Pacific) Group of States and the European Union Member States, as well as the Netherlands Organization for International Cooperation in Higher Education (NUFFIC) provided support for the International Workshop in Accra in 2005 where the articles in this special issue were presented and pre-tested for an international audience. The authors gratefully acknowledge these sources of funding.
2. Sub-title of a special feature on 'Re-inventing Africa' of the *New Scientist*, 2 July 2005: 8–13. It quotes Calestous Juma, an author of the UN Millennium Project Report 'Innovation: Applying Knowledge in Development' (2005): 'We are at a critical point. At no other time has there been such awareness in Africa itself of technological development.'
3. A general description of CoS' first few years of activity has been provided in Hounkonnou *et al.* (2006).
4. Hounkonnou *et al.* (2004) *NJAS-Wageningen Journal of Life Sciences* 52 (3–4), 209–448.
5. Pers. comm. Dr Cyrus Ndiritu, Ex-Director Kenya Agricultural Research Institute, 2002.
6. Leeuwis with Van Den Ban, 2004, referring to the fact that innovation has technical, social, economic, organizational and institutional dimensions.
7. CORAF/WECARD: West and Central African Council for Agricultural Research and Development.

References

Ashby, J. (2003) Introduction: Uniting science and participation in the process of innovation – research *for* development. In B. Pound, S. Snapp, C. McDougall and A. Braun (eds) *Managing Natural Resources and Sustainable Livelihoods. Using Science and Participation* (pp. 1–19). London: Earthscan.

Bairoch, P. (1997) New estimates on agricultural productivity and yields of developed countries, 1800–1990. In A. Bhaduri and R. Skarstein (eds) *Economic Development and Agricultural Productivity* (pp. 45–57). Cheltenham: Edward Elgar.

Bertolete, J.M., Fleischmann, A., Eddleston, M. and Gunnell, D. (2006) Deaths from pesticide poisoning: A global response. *British Journal of Psychiatry* 189, 201–203.

Bigg, T. and Satterswaite, D. (eds) (2005) *How to Make Poverty History. The Central Role of Local Organisations in Meeting MDGs*. London: International Institute for Environment and Development.

Breman, H. (2003) Improving African food security. *SAIS Review* 23 (1), 153–170.

Brinkerhoff, D. and Goldsmith, A. (2002) *Clientelism, Patrimonialism and Democratic Governance. An Overview and Framework for Assessment and Programming*. Prepared for USAID. Bethesda (MD): Abt Associates Inc. On WWW at http://pdf.dec.org//pdf_docs/PNARC426.pdf.

Brouwers, J. (1993) Rural people's knowledge and its response to declining soil fertility. The Adja case (Benin). Wageningen: Agricultural University. Published doctoral dissertation. Also available in Wageningen Papers.

Chambers, R. and Ghildyal, R. (1985) Agricultural research for resource-poor farmers: A parsimonious paradigm. Brighton (Sussex): IDS, Discussion paper 220.

Chambers, R. and Jiggins, J. (1987) Agricultural research for resource-poor farmers. Part I: Transfer-of-technology and farming systems research. Part II: A parsimonious paradigm. *Agric. Administration and Extension* 27, 35–52 (Part I) and 27, 109–128 (Part II).

Chema, S., Gilbert, E. and Roseboom, J. (2003) A review of key issues and recent experiences in reforming

agricultural research in Africa. The Hague: ISNAR, Research Report 24.

Cochrane, W.W. (1958) *Farm Prices, Myth and Reality*. Minneapolis: Univ. of Minnesota Press. (Especially Chapter 5: The Agricultural Treadmill, pp. 85–107).

Collinson, M. (ed.) (2000) *History of Farming Systems Research*. Wallingford (UK): CABI Publishing.

Commission for Africa (2005). Our Common Interest. 399 pp. On WWW at www.commissionforafrica.org.

Conway, G. (1997) *The Doubly Green Revolution. Food for All in the Twenty-first Century*. London: Penguin Books.

De Janvry, A. and Dethier, J.J. (1985) *Technological Innovation in Agriculture: The Political Economy of Its Rate and Bias*. Washington: World Bank, CGIAR Study Paper 1.

De Souza Silva, J., Cheaz, J. and Calderon, J. (2000) *Building Capacity for the Strategic Management of Institutional Change in Agricultural Science and Technology Organisations in Latin America: A Summary of the Project and Progress to Date*. San José (Costa Rica): ISNAR at IICA, Proyecto Nuevo Paradigma.

Douglas, M. (1986) *How Institutions Think*. Syracuse (NY): University of Syracuse Press.

Engel, P.G.H. and Salomon, M. (1997) *Facilitating Innovation for Development. A RAAKS Resource Box*. Amsterdam: Royal Tropical Institute.

Evenson, R.E., Waggoner, P.E. and Ruttan, V.W. (1979) Economic benefits from research: An example from agriculture. *Science* 205 (14 September), 1101–1107.

Funtowicz, S.O. and Ravetz, J.R. (1993) Science for the post-normal age. *Futures* 25 (7), 739–755.

Geels, F. (2002) Understanding the dynamics of technological transitions. A co-evolutionary and socio-technical analysis. Published doctoral dissertation. Enschede: Twente University Press.

Hajer, M. and Wagenaar, H. (eds) (2003) *Deliberative Policy Analysis. Understanding Governance in the Network Society*. Cambridge (UK): Cambridge University Press.

Havelock, R.G. (1986) Modelling the knowledge system. In G.M. Beal, W. Dissanayake and S. Konoshima (eds) *Knowledge, Generation, Exchange and Utilisation* (pp. 77–105). Boulder, CO: Westview.

Holling, C.S. (1995) What barriers? What bridges? In L.H. Gunderson, C.S. Holling and S.S. Light (eds) *Barriers and Bridges to the Renewal of Ecosystems and Institutions* (pp. 3–37). New York: Colombia University Press.

Hounkonnou, D. (2001) Listen to the cradle. Building from local dynamics for African renaissance. Case studies in rural areas in Benin, Burkina Faso and Ghana. Wageningen: Wageningen University, published doctoral dissertation.

Hounkonnou, D., Offei, S.K., Röling, N.G., Tossou, R., Van Huis, A. and Wienk, J.F. (2004) Diagnostic studies: a research phase in the convergence of sciences programme. *NJAS – Wageningen Journal of Life Sciences* 52, 209–448.

Hounkonnou, D., Kossou, D.W., Kuyper, T.W., Leeuwis, C., Richards, P., Röling, N., Sakyi-Dawson, O. and Van Huis, A. (2006) convergence of sciences: The management of agricultural research for small-scale farmers in Benin and Ghana. *NJAS – Wageningen Journal of Life Sciences* 54(Special Issue on INREF Programmes).

Inter Academy Council (IAC) (2004) *Realising the Promise and Potential of African Agriculture. Science and Technology Strategies for Improving Agricultural Productivity and Food Security in Africa*. Amsterdam: Inter-Academy Council.

Jiggins, J. (2005). The concept of experiential learning forums (ELF). Appendix to CoS report (2005). *Experiential Learning Forums as a Tool for Capacity Building Among Stakeholders in Cotton Chains in West Africa*. Wageningen: Wageningen University, North-South Centre. Report of INREF Workshop, 10–11 March 2005.

Jusu, M.S. (1999) Management of genetic variability in rice (Oryza sativa L. and O. glaberrima (Steud.) by breeders and farmers in Sierra Leone. Published doctoral dissertation, Wageningen University, Wageningen, 198 pp.

Kudadjie, C.Y., Struik, P.C., Richards, R. and Offei, S.K. (2004) Assessing production constraints, management and use of sorghum diversity in North-East Ghana: A diagnostic study. *NJAS – Wageningen Journal of Life Sciences* 52 (3-4), 371–392.

Leeuwis, C. (with contributions by A. Van Den Ban) (2004) *Communication for Rural Innovation. Rethinking Agricultural Extension*. Oxford: Blackwell Science.

Lionberger, H. (1986) Towards an idealised systems model for generating and utilising information in modernising societies. In G.M. Beal, W. Dissanayake and S. Konoshima (eds.) *Knowledge, Generation, Exchange and Utilisation* (pp. 105–135). Boulder, CO: Westview.

Lipton, M. (2005) *The Family Farm in a Globalising World. The Role of Crop Science in Alleviating Poverty*. Washington: IFPRI, Policy Brief 74, June 2005, 2 pp.

Maxwell, S. (1987) Farming systems research: Hitting a moving target. *World Development* 14 (1), 65–77.

Millar, D. (2005). African knowledges and sciences: exploring the ways of knowing in Sub-Saharan Africa. Paper presented at *Workshop Moving Worldviews*. Amersfoort (NL): 28–30 November 2005. On WWW at www.compasnet.org.

Mortimore, M. and Harris, Fr. (2005) Do small farmers' achievements contradict the nutrient depletion scenarios for Africa? *Land Use Policy* 22 (1), 43–56.

Nederlof, E.S. and Dangbégnon, C. (2007) Lessons for farmer-oriented research: Experiences from a West African soil fertility management project. Agriculture and human values. In E.S. Nederlof (ed.) Wageningen: Wageningen University, published doctoral dissertation.

Nederlof, E.S., Tossou, R., Sakyi-Dawson, O. and Kossou, D.K. (2004) Grounding agricultural research in resource-poor farmers needs: A comparative analysis of diagnostic studies in Ghana and Benin. *NJAS – Wageningen Journal of Life Sciences* 52 (3–4), 421–443.

North, D.C. (1990) *Institutions, Institutional Change and Economic Performance*. New York: Cambridge University Press.

Ostrom, E. (2005) *Understanding Institutional Diversity*. Princeton: Princeton University Press.

Peppelenbos, L. (2005) The Chilean miracle. Patrimonialism in a modern free market economy. Wageningen: Wageningen University, published doctoral dissertation, 270 pp.

Powell, W. (1994). Neither market nor hierarchy: Network forms of organisation. In G. Thompson, J. Frances, R. Levavcic and J. Mitchell (eds) *Markets and Hierarchies and Networks: The Co-ordination of Social Life* (pp. 256–277). London: Sage.

Pretty, J. (1994) Alternative systems of inquiry for sustainable agriculture. *IDS Bulletin* 25 (2), 37–49. Special issue on Knowledge is Power? The use and abuse of information in development.

Richards, P. (2001) Technography. Notes on methods. Unpublished working paper. Convergence of Sciences Project.

Rogers, E.M. (1976) Communication and development: The passing of a dominant paradigm. *Communication Research* 3, 213–240.

Rogers, E.M. (1995) *Diffusion of Innovations* (4th edn). New York: Free Press.

Röling, N. (1988) *Extension Science. Information Systems in Agricultural Development*. Cambridge: Cambridge University Press.

Röling, N. and Wagemakers, A. (eds) (1998) *Facilitating Sustainable Agriculture. Participatory Learning and Adaptive Management in Times of Environmental Uncertainty*. Cambridge: Cambridge University Press.

Röling, N.G. (2002) Beyond the aggregation of individual preferences. Moving from multiple to distributed cognition in resource dilemmas. In C. Leeuwis and R. Pyburn (eds) *Wheelbarrows Full of Frogs. Social Learning in Rural Resource Management* (pp. 25–47). Assen (NL): Royal Van Gorcum.

Röling, N.G., Hounkonnou, D., Offei, S.K., Tossou, R. and Van Huis, A. (2004) Linking science and farmers' innovative capacity: Diagnostic studies from Ghana and Benin. *NJAS – Wageningen Journal of Life Sciences* 52 (3–4), 211–235.

Ryan, B. and Gross, N. (1943) The diffusion of hybrid seed corn in two Iowa communities. *Rural Sociology* 8, 15–24.

Smits, R. (2002). Innovation studies in the 21st century. Questions from a users perspective. *Technological Forecasting and Social Change* 69 (9), 861–883.

Sonneveld, M.P.W. (2004) Impressions of interaction: Land as a dynamic result of co-production between man and nature. Wageningen: Wageningen University, published doctoral thesis, and Wageningen: WUR, ALTERRA report.

Stoop, W.A. (2002) A study and comprehensive analysis of the causes for low adoption rates of agricultural research results in West and Central Africa: possible solutions leading to greater future impacts: the Mali and Guinea case studies. A study commissioned by the interim Science Council. Washington: CGIAR and Rome: FAO.

Stoorvogel, J.J. and Smaling, E.M.A. (1990) Assessment of soil nutrient depletion in Sub-Saharan Africa 1983–2000. Report 28. Vol. 1: Main Report; Vol. 2: Nutrient balances per crop and per land use system. Wageningen: SC/DLO.

Tekelenburg, A. (2002) Cactus pear and cochineal in Cochabamba. The development of a cross-epistemological management toolkit for interactive design of farm innovation. Wageningen: Wageningen University, published doctoral dissertation.

Tossou, C.R. (1995) People's response to policy change in agricultural development organisation: The Benin case. Koninklijke Bibliotheek, CIP-DATA. Wageningen: Wageningen University, published doctoral dissertation.

Toulmin, C. (2005) Foreword. In T. Bigg and D. Satterswaite (eds). *How to Make Poverty History. The Central Role of Local Organisations in Meeting MDGs* (pp. vi–x). London: International Institute for Environment and Development.

Unver, A. (2005) *The Road Less Chosen. A Personal Account of Rural Development in Turkey (1965–2005)*. Ankara (Kazan): Development Foundation of Turkey.

UN Millennium Project (2005) *Innovation: Applying Knowledge in Development. Task Force on Science, Technology and Innovation*. London: Earthscan.

Van Haaften, E.H. (2002) Linking ecology and culture. Towards a psychology of environmental degradation. Tilburg (NL): Tilburg University, published doctoral dissertation.

Van Veldhuizen, L., Waters-Bayer, A. and De Zeeuwn, H. (1997) *Developing Technology with Farmers. A Trainer's Guide for Participatory Learning*. London: Zed Books Ltd.

Van de Walle, N. (2002) Meet the new boss, same as the old boss? The evolution of political clientelism in Africa. Paper presented at the *Conference on Consolidation in New Democracies*, Uppsala (Sweden): University of Uppsala, 8–9 June 2002.

Velthuis, O. (2005) Criticism on government support of US farmers. Newspaper *De Volkskrant* of 11 April 2005 (in Dutch).

Vissoh, P., Gbéhounou, G., Ahanchédé, A., Kuyper, T.W. and Röling N.G. (2004) Weeds as agricultural constraint to farmers in Benin: Results of a diagnostic study. *NJAS – Wageningen Journal of Life Sciences* 52 (3–4), 305–331.

Vodouhé, D.S. (1996) *Making Rural Development Work: Cultural Hybridisation of Farmers' Organisations: The Adja Case in Benin*. Koninklijke Bibliotheek, CIP-DATA. Wageningen: Wageningen University, published doctoral dissertation.

Wenger, E. (1998) *Communities of Practice: Learning, Meaning and Identity*. Cambridge: Cambridge University Press.