The evolution of national systems of innovation in agriculture and resulting prospects for Sub-Sahara Africa: Lessons learned

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Paper presented at the Innovation Africa Symposium,

Kampala, Uganda, 21 – 23 November 2006

1 Introduction

1.1 The Green Revolution

This chapter is seeking to describe in a first step the importance of agricultural modernisation for SSA. In a second step follows an investigation of the core reasons why it is especially difficult to modernise African agriculture, with a focus on agricultural research and development (R&D) and its promising rates of return, leading over to the second chapter which tries to give some proposals of how to improve the performance of agricultural R&D by reforming the National System of Innovation (NSI)[1].

Africa and especially SSA is getting more and more within the focus of international donors. If prevailing trends persist SSA is expected to miss every single of the 18 targets of the Millennium Development Goals (MDG) (figure 1). This is especially serious for the important MDG number 1 "Eradicate extreme hunger and poverty". Regarding the often quoted target number 1 "Halve, between 1990 and 2015, the proportion of people whose income is less than 1 Dollar a day" it is obvious that SSA is far from reaching it. Actually, the proportion of people living from less than 1 Dollar a day has increased between 1990 and 2001. In fact, in 2001 46.4% of SSAs population lived in extreme poverty. Though this proportion is expected to decline in the coming years the decline can only be denoted as marginal as the expected value of 38.4% in 2015 is far from the set target of 22.3%. Furthermore, the absolute number of extreme poor is even expected to rise, from 313 million in 2001 up to 340 million in 2015 (figure 2).

In 2000, about 56% of Africans depended on agriculture for their livelihoods (FAO (2004)). It is becoming more and more acknowledged that the modernisation of the agricultural sector is a crucial precondition for the modernisation of the African economy as a whole. Yang and Zhu (2004)[2] quote that *"without agricultural productivity, a traditional economy cannot overcome the fixed supply of natural resources and thus, cannot generate sustained economic growth"*.

Despite its potential the agricultural sector in Africa, especially in SSA, has made little progress within the last 4 to 5 decades. In fact, Africa is the only region in the world where agricultural production per capita has declined over the past 40 years (figure 3, 4) as little improvements reached in agricultural productivity were offset by the rapid population growth especially in rural Africa. Total food production increases annually at about 2% while population growth amounts to 3%.

In many developing countries, the intensification of management on agricultural land, accomplished through the use of high-yielding crop varieties, chemical fertilizers and pesticides, irrigation, and mechanization can be subsumed under the general heading of "the Green Revolution". It started in the 1960s with the transfer and dissemination of high-yielding seed which, combined with a varying innovation package composed of the mentioned

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[1] For this study the definition of Metcalfe (1995) as quoted by Chema, Gilbert and Roseboom (2003) is utilised, defining NIS as *"that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store, and transfer the knowledge, skills, and artefacts, which define new technologies. The element of nationality follows not only from the domain of technology policy but from elements of shared language and culture which bind the system together, and from the national focus of other policies, laws and regulations which condition the innovative environment."*

[2] Quotation in Diao et al (2006).

components, boosted grain yields by shortening the growing season for irrigated crops, allowing farmers to harvest twice or more times a year (Matson et al (1997)). As a result, basically rice, wheat and maize yields more than doubled within the period from 1960 to 1990 in Asia and Latin America. The importance of the Green Revolution[3] is reflected by the fact that it has been the starting point for economic boom and hence the position of points to overcome poverty in many developing countries.

Intensive green revolution technologies provide increases in average cereal yields of about 75 kg/ha/year whereas agriculture without utilisation of external inputs (i.e. extensive agriculture) leads to increases of less than 10 kg/ha/year. These two growth rates hold true worldwide (Breman and Debrah (2003)). Though success stories do in fact exist in SSA (Gabre-Madhin and Haggblade (2003)), the pervasive impact of the Green Revolution failed to appear. The question is: why didn't agricultural research lead to a Green Revolution in SSA? First of all, the developed revolutionary high-yielding varieties are often dependent on irrigation so that arid and semi-arid regions have not benefited from the improvements. As only 7% of Africa's arable land is irrigated, compared for instance to 37% in Asia (FAO (2005)), it is not surprising that SSA's inadequate water supply rendered a benefiting from the achievements of the Green Revolution difficult for most parts of the region. Second, the Green Revolution did not occur in countries with very low levels of rural infrastructure (Spencer (1994)) like it is the case in most of SSA. For instance, SSA has to undertake great efforts even to reach India's rural road network in the fifties (table 1).

However, limited relevance of hitherto existing innovations, underdeveloped rural infrastructure and insufficient irrigation systems are not the only reasons for the underperformance of SSAs agricultural sector which indeed is influenced by a huge variety of complex systems (figure 5). For instance, World markets and international trade politics (e.g. WTO) have a strong and increasing influence on the agricultural sector world-wide, much more than they had in the time when the Green Revolution in Asia and Latin America took place. Due to the proceeding globalisation, international events like shocks, climatic changes, international trade policies, currency fluctuations and many other factors have an influence on the national agricultural sector. National factors influencing the agricultural sector range from public policies and programmes over private reactions in non-agricultural sectors to the reactions of every single farmer. Hence, agricultural research, the focus of this paper, is not the only identified bottleneck responsible for the poor performance of the agricultural sector of SSA. However, as will be discussed in detail in the following chapter, rate of return analysis suggest that agricultural R&D is indeed among the most important.

1.2 Rates of return on agricultural research and extension

Baker (2000) describes cost-benefit analysis as *"attempts to measure the economic efficiency of program costs versus program benefits, in monetary terms."*[4]

[3] The Green Revolution has raised concerns especially with respect to the trend towards monocropping and the often excessive utilisation of fertilizers and pesticides, resulting in threats to health, environment and yields. However, this highly controversial discussion will be neglected as going beyond the scope of this study.

[4] For many projects, it is not possible to measure all benefits in monetary terms. For example, the benefits of a program to provide school inputs would consist of increased learning. In this case, learning achievement scores could be used to quantify the benefits. This would require cost-effectiveness analysis. The concepts for both types of analysis are the same. (Baker (2000)).

Though the internal rate of return (IRR) has some shortcomings[5], it is utilised by most empirical studies on cost-benefit analysis, perhaps because it is perceived to be more meaningful to noneconomists.

Rate of return studies suggest a surpassing positive impact of agricultural research[6]. IFPRI reports rates of return to agricultural research between 40 and 60% per year, the median rate of return to public agricultural research in Africa is typically believed to be 36% (IAC (2004)). Block (1994) compared econometric estimates of Total Factor Productivity for SSA between 1963 and 1988 and concludes that one-third of the growth in SSA's agricultural Total Factor Productivity is due to research expenditures.

However, studies vary in how they define and measure benefits and costs, thus certain characteristics are relevant as explanatory variables to account for variation among studies. These include whether underlying observations were based on real or nominal, marginal or average, ex ante or ex post, social or private values. It is this inconsistency in data and methodology which renders rate of return analysis vulnerable to criticism. To prove the validity of estimations on rates of return to agricultural R&D, Alston et al (2000) conducted a meta-analysis of all available evidence on rates of return to investments in agricultural R&D since 1953. The final report comprised 292 studies reporting 1,886[7] rate of return estimates. Of these, 758 observations had to be excluded as extreme outliers or because of a lack of information about explanatory variables, leading to 1,128 observations. Alston et al come to find that reported rates of return are distributed very broadly, with less than 25% of investigated estimates falling within the often quoted 40-60% per year range (figure 7). The median rate of return of amounts to 42.0%. The sample for Africa amounts up to 188 observations with a considerable median rate of return of 34.3%. Although precision is unlikely in most of reviewed studies, the fact that only 15% of observations provide an estimated return of 20% or less is a strong indicator that true rates are nonetheless well above the social opportunity costs of public funds which typically fall within the range of 3-5% per year (Alston et al (2000)).

Evenson (2001) reviewed more than 100 studies estimating rates of return to agricultural research to validate whether the rates are consistent with the economic growth experience. While regarding the highest estimates inplausible, Evenson comes to the conclusion that average estimates are not inconsistent with actual economic growth experience and therefore plausible.

A comparison of rates of return to other investments reveals that rates of return to agricultural R&D are surpassingly high. For instance, Psacharopoulos (1994) calculated expected rates of return to investments in education at primary, secondary and higher level for various countries. Rates of return for SSA range from 24.3% for primary, 18.2% for secondary to 11.2% for higher education (table 2) – below the rates of return to agricultural R&D[8].

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[5] The IRR criterion is inapplicable for decision making whenever alternatives are mutually exclusive. Further, not every project has an IRR, for instance an IRR does not exist for projects with solely positive net benefits. Additionally, projects can have multiple IRR, when net benefits change sign more than once. However, in most cases, these problems do not appear, so that in general IRR and NPV are equivalent (Belli et al 1997).

[6] Time lags of up to 15 years may exist between the investment in R&D and the responding effect on productivity (figure 6). However, after taking the effect, benefits from an innovation may persist for more than thirty years. This correlation has to be kept in mind, as the late materialising of payoffs from agricultural R&D requires a long-term view for evaluating the impacts of a certain project.

[7] These estimates can be divided into 406 (i.e. 21.5%) ex ante and 1.480 ex post observations.

[8] The underlying method, however, has to be handled with care as it estimates the BC of net wages (i.e. the difference between wages with and without the respective education), attributing all differences in wages solely to education and neglecting any other explanatory variables like economic growth, policies etc.

Accordingly, the World Bank (1994) reported average economic rates of return to infrastructure, precisely electricity and road building projects, from 1974 till 1982 and 1983 till 1992, which were with 18% and 16%, respectively likewise below the rates to agricultural R&D (table 3). Even the rates of return to irrigation projects, though clearly beneficial, range between 11% and 15%, reduced mainly by high investments costs of 4,000 to 8,000 USD per irrigated hectare (Breman and Debrah (2003)).

Fan, Zhang and Rao (2004) investigated the impact of government spending on agricultural research and extension, education, rural roads and health in Uganda. Their estimates are based on district-level data for 1992, 1995, and 1999 in 30 districts, resulting in 90 observations. The study reveals that out of the four investigated scopes expenditures on agricultural research and extension had the largest measured returns to growth in agricultural production as well as the largest assessed impact on poverty reduction[9], therefore providing a "win-win" strategy (figure 8). Although the study surely has several limitations, among the most critical data constraints, as acknowledged by the authors themselves, it nevertheless shows the potential of agricultural research and extension on poverty reduction and therefore MDG 1.

Due to inconsistency in methodology, data availability, local situations etc. a comparison of rates of return can only be used as one indicator. However, they show that investments in agricultural R&D are highly justified and cannot be neglected by favouring investments in infrastructure or education.

However, despite those encouraging figures public funding of agricultural research in SSA eroded over time, leaving NARIs[10] highly underfunded and hence in a quite poor status quo. As will be discussed within the following chapter, the initial institutional setup – the so called Top Down Model – has barely been effective in exploiting the potential of agricultural R&D on a large scale, not only in Africa but also worldwide[11]. Believing that without visible positive impacts (i.e. innovations contributing visibly to rural development and poverty reduction), public support for agricultural research will erode even further – despite all promising rates of return – this paper afterwards turns towards the current research reform debates, describing the core lessons learned derived from literature and complemented by two case studies of the German development cooperation. In a final step those core lessons learned will be integrated into one single model thus trying to give some impulses of how to release the identified high potential of agricultural research.

[9] It has to be noticed, however, that the fact that spending on health did not show a large impact on both agricultural productivity and poverty reduction, is in part due to difficulties in measuring some of its impacts. For instance, health investments tend to affect growth and poverty reduction in the long run, an effect which could not be captured within this model. For instance, Belli et al (1997) calculated a rate of return to a child immunization program of 98%. This high value demonstrates that this specific immunization program is probably more than competitive with alternatives in other sectors

[10] Using the description of FARA (2006), National Agricultural Research Institutes (NARI) are publicly funded agricultural research centres established by national governments and therefore the major actors within the National Agricultural Research Systems (NARS).

[11] However, because of the described special circumstances in Africa, the deficiencies of the institutional setup had stronger impacts in Africa than in the rest of the world.

2 National systems of innovation in agriculture

2.1 The Top-Down Model

The Top-down Model (figure 9) utilised a so called "pipeline" approach, in which international researchers, especially CGIAR and its Future Harvest Centres (as they are called by now), transferred generic knowledge to the respective NARIs and trained the staff how to utilise this basic knowledge to generate applied knowledge. This applied knowledge in turn was passed in form of a technology packet from the respective NARI to extension units trying to persuade farmers to adopt it with the help of the well-acknowledged T&V system[12]. In this model farmers were solely regarded as end-users of knowledge, having no influence on neither research methods nor issues.

This approach, already contested in Latin America and Asia, almost completely failed in the case of Africa. As described in the first chapter, the high yielding varieties developed by CGIAR did not fit SSA's limited irrigation potential, depleted soils and the low density of rural infrastructure with the latter one additionally hampering the T&V system. As a result, the percentage of farmers reached under T&V systems on a regular basis did not exceed 10% in most countries (Chema, Gilbert and Roseboom (2003)).

Although it is by now common knowledge among researchers that the Top-Down-Model has to be modified as it has proven to be quite inefficient, especially in Africa, little has yet been reached in implementing an alternative system linking research and extension. However, current reform debates have generated valuable lessons learned which are considered to render NSI quite effective – once they are implemented. The following chapter will summarize key lessons learned of the reform debate as well as lessons derived from two case studies of the German development cooperation.

2.2 Lessons learned

This chapter will first provide a short overview of the two case studies before summarizing the core lessons learned of the reform debate on one hand and the cases on the other.

Case study 1: AGRAN[13]: Supporting the Management of national agricultural research

The reform process of Benin's National Agricultural Research System started in 1992 with the creation of the National Agricultural Research Institute (INRAB). The first step was the participatory design of Benin's Master Plan for Agricultural Research (1994-1996) that has been supported by DANIDA.

In 1999, AGRAN started to support the operational design and implementation of the reform aiming at client orientation and more effectiveness of technology development for Benin's agricultural sector. The project has been integrated in 01/2004 in the bilateral sector program ProCGRN (conservation and management of natural resources). The scaling-up of the developed model to the national level became possible rather soon after project start with the support of Dutch and Danish Cooperation.

[12] Training and visiting (T&V) systems were strongly endorsed by the World Bank especially in the eighties. The extension units were endowed with a kind of "innovation package", including the technology to be distributed as well as a detailed description of how to use it, disseminating the technology amongst farmers and training them in application.

[13] Projet Appui à la Gestion de la Recherche Agricole Nationale

AGRAN's support focuses on the change process required to master the transition from an administrative direction of the Ministry of Agriculture to a performing public enterprise for technology development with the mandate to coordinate all agricultural research activities in Benin.

Source: German Technical Cooperation (GTZ)

Case study 2: DUNAVANT: A private sector training and empowerment project

Dunavant Zambia Ltd. is a private company and part of Dunavant Enterprises Inc. of Memphis, Tennessee, one of the largest cotton merchandisers in the world. Within Zambia's cotton industry Dunavant Zambia is the market leader, holding a market share of about 65% – at least partly due to its comprehensive distributor and out-grower network comprising more than 185,000 small-scale farmers.

Knowing that cotton is a volume business and that only a farmer who makes a profit will continue growing it, it is the strategy of Dunavant Zambia to continuously try to facilitate rising yields, thereby enhancing farmers' profit as well as their own. This is also the intention of its currently implemented training and empowerment project in Zambia which is co-financed by the German Investment and Development Company (DEG) and lasts for two years (10/01/2005 – 09/30/2007). The precise objective of the project is to offer up to 128,080 small-scale farmers training and assistance to apply and adopt the programme "5 Key Basic Cotton Growing Practices"[14].

Based on the results of a successful pilot project run by Dunavant Zambia in 2004 the project is expected to increase the cotton yields of participating farmers by at least 59% on average hence leading to a substantial increase of cash-income. Moreover, as the essential agricultural techniques of the programme can also be applied towards growing food crops like maize the project is expected to enhance the self-sufficiency of farmers and eventually provide additional income from sales of surpluses.

Source: German Investment and Development Company (DEG)

From these case studies as well as from relevant literature valuable lessons learned will be drawn in the following four subchapters.

2.2.1 The role of the national government in R&D

Agricultural research has long been automatically considered a government responsibility, which let to a rather supply-driven research, with the public sector financing for all kind of research activity (Beintema and Roseboom (2003)).
One suggestion of the current reform debate is that African governments should differentiate agricultural research more carefully into activities with strong and weak public good character[15] to make their funding decisions. Whenever the public good character is weak, agricultural research should be privatised[16] or at least jointly funded to free up resources for those parts of research having a strong public good character. One important way to achieve a satisfactory level of private research investment is to introduce and implement Intellectual

[14] Timely and appropriate land preparation, early planting at correct depth, early thinning and gap filling (optimal plant population), ongoing weeding, pest management by applying integrated pest management.

[15] The public good character in the classical Samuelsonian sense consists of non-rivalry and non-excludability. However, few investments come within the limits of pure public goods in that sense. Instead the typical case is that some users cannot be excluded for some uses of the goods/services produced. Hence, the common differentiation is between goods with strong and weak public good character.

[16] If the public good character is strong, it is even with IPR very difficult to avoid strong underinvestment.

Property Rights (IPR)[17]. Otherwise privatisation will lead to underinvestment, despite a weak public good character of the privatised research activity. Furthermore, private research organisations will tend to refuse research cooperations and limit employment as an attempt to protect research results. Research with a strong public interest, like innovations yielding to enhanced food-production, however, has either to be excluded from protection, which will yield to a partly withdrawal of private engagement for this kind of research, or to be combined with a purchase option for the government. In general, basic research is more insecure than applied research and therefore more likely to be public responsibility. The long-term objective is a complete withdrawal of governmental funding for agricultural research without either having a strong public good character or being of strong public interest.

2.2.2 Management of financial resources for R&D

One of the main obstacles on the way towards an effective NSI is the lack of adequate funding. A general rule for the combination of research funding forms has been developed by Kremer and Zwane (2004). The idea is to classify agricultural research programs into "push" and "pull" interventions. Push programs subsidise research inputs whereas pull programs pay for research outputs. It is shown that push programs (e.g. grant schemes) typically provide the best way to stimulate basic research since the main objective of basic research is to provide information to other researchers rather than to develop specific products. Pull programs (e.g. research contracts) should be used if policy makers can identify a specific desired technology and its social value, meaning that they will pay only for concrete research outputs that meet pre-specified criteria.
With the objective to strengthen and diversify the financial base of African agricultural research and natural resource management institutions, SPAAR, USAID and the World Bank in the early 1990s founded the Sustainable Finance Initiative promoting experimentation with new financial mechanisms and partnerships with clients. Funding instruments generally comprise surcharges (e.g. levies), voluntary contributions, research contracts and matching grant schemes[18]. The most attended idea of the initiative, however, has been the generation of competitive research funds. Beneath the increased efficiency and effectiveness the major advantages of these funds include enhanced implementation of research priorities on sub national, national and regional level as well as the enhanced cross-institutional and cross-national collaboration. There exist also possible disadvantages, inducing that governments should only be encouraged to foster the implementation if the economies of scale are high enough[19]. However, FARA (2006) states that less than 20% of the NARIs surveyed have

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[17] Kremer and Zwane (2004) quote that *„the experience of countries with strong IPR for plant breeders supports the notion that these legal incentives do lead to more private R&D and greater technology transfer (Diwan & Rodrik, 1991; Pray, 1992; Swanson & Göeschl, 2000)."*

[18] Simple matching grant schemes are quite common, with governments paying for fix costs like salaries and infrastructure while a third company (commodity boards, FBOs, NGOs or donors) pays for all operating costs (Chema, Gilbert and Roseboom (2003)).

[19] Regarding the small size of most funds transaction costs can be very high. Gill and Carney (1999) state that *"there are clear diseconomies of scale in management and administration: while funds in the larger countries cost 5-6% to manage, some of the smaller ones cost 36-43%."* Furthermore, competitive research funds do not operate well in small research systems due to a lack of capacity and competition. Another disadvantage is that the majority of competitive research funds can only provide a maximum of three years funding, which distorts the portfolio towards short-term issues, regardless of the countries needs and priorities and the fact that most R&D investments face a relatively long time delay between their generation and their implementation.

established Agricultural Research Trust Funds as part of World Bank loans which would enable them to set up competitive funding – and that no African government to date has contributed to them[20].
However, beneath the selection of adequate financial instruments an efficient fiscal and human resource management has to be implemented. AGRAN, for instance, enhanced the management of INRAB by introducing regularly generated financial reports, establishing analytical accounting, registering overall workforce and last but not least setting up a schedule for future personnel development. Furthermore, an organisation manual has been compiled describing tasks, jobs, responsibilities and codes of conduct.

2.2.3 Responsibilities and networks within R&D

It is by now a well established fact that a separation of knowledge generators and users like it was done in the Top-Down Model is detrimental to effectiveness. Participation is one of the major lessons learned and a strong issue in all reform debates, the utilisation of indigenous knowledge has been strongly demanded. However, stakeholders are not solely farmers though discussions tend to focus on them as the primary beneficiaries of agricultural research. To substantially and sustainably enhance the performance of the agricultural sector other stakeholders like the private sector (i.e. traders, exporters, processors), consumers, NGOs, extension services and civil groups must not be neglected. Nevertheless the representation of the Boards of NARIs is usually dominated by scientists, policy-makers and academics, while other stakeholders are generally poorly represented – a remedy of the Top-Down Model (FARA (2006)).
Although guidelines for establishing partnerships and linkages between NARIs and universities and NGOs have been developed through Memoranda of Understanding, NARIs recorded weak linkages with local (65%) and foreign (34%) universities; 58% do not implement any or only few joint projects with NGOs. Except for South Africa and Mauritius private sector participation in agricultural research in SSA is still classified as insignificant by 77% of NARIs. Linkages with FBOs and community-based organisations (CBO) are weaker than expected: over 30% of NARIs report weak linkages, 31% implement few joint projects. Linkages with sub-regional research organisations like CORAF and ASARECA are weak for 35% of NARIs (FARA 2006).
A special focus should be laid on private sector engagement, which is particularly promising[21]. One example is the floriculture industry in Kenya. Monty Jones (2005) states that in just 11 years the cut flower industry has become the biggest export earner of Kenya, accounting for 23% of export revenues. The main contributions of the private sector in R&D comprise contract research and voluntary contributions. However, little has been achieved so far to strengthen the role of the private sector in Africa, which faces the greatest obstacles to doing business world-wide (Doing Business Report 2006).
While participation as such is by now a commonly acknowledged concept there exist diverse opinions concerning the optimal degree of participation. Generally, participation can take

[20] Governments typically have to borrow money even to pay for current expenditures and investments and will be more than reluctant to pay future expenditures out of current revenues.

[21] Despite the great advantages of private sector engagement for SSA it nevertheless has to be assured that research activities are not biased towards those considered to be more able to contribute to research funding, with little researchers willing to work for government financed research on issues of public interest like the enhancement of the situation of small-scale farmers. Setting the right incentives to avoid such a bias will be an important task for the respective governments.

place on at least five levels, research funding, setting research priorities, conducting research, disseminating research results, monitoring and evaluating research results.
AGRAN emphasizes participation, more than 2,100 farmers are involved in participatory on-farm trials and diagnostic research, more than 1,000 farmers and 750 female farmers participate in gender sensitive on-farm research. The greatest achievement of the project is the development of a complete management cycle with key constituents involving the priority setting in collaboration with farmer organisations, peer review of frequently inter-institutional research proposals, evaluation of research results, publications and decision making concerning the transfer of research results to extension[22]. Approach and tools are documented in detail in a handbook. The experience since 2000 proves that scientific quality has been enhanced, the sophisticated management cycles have proved extraordinarily effective in:

- Focussing research on needs of resource poor farmers and their professional organisations in different eco-regions and value chains,
- improving the scientific quality and efficiency of technology development: strategic elements are peer reviews of research proposals, M&E during implementation, training courses and on-the job training,
- fostering networking between governmental and non-governmental service providers as well as producer organizations of the agricultural sector with focus on applied agricultural research and transfer of results and
- last but not least, the production of performing and mainly bankable information relevant for extension and credit.

Additionally, AGRAN supported INRAB in developing a conceptual model for the institutionalization of demand-driven agricultural research in Benin (figure 10) which could according to Arodokoun (2002) easily be split up in:

- 15 local committees, having acquired experience in the cooperation with agricultural research. They facilitate constraint analysis and priority setting with the villagers, help researchers to coordinate on-farm research and organize annual evaluation sessions. Since 2002, they participate in the meetings of the regional committees.
- The regional committees, plat-forms for agricultural research, extension, producers and representatives of their associations. At this level, local research priorities are aggregated, discussed, completed and up-dated. Research results are evaluated and decisions on the research activities of the following year are made.
- The national committee, having an analogue mandate at the national level. It has been designed at the beginning of the reform process and met unfortunately only once in 1995. Taking into account the evolution of the regional committees that took place since 1999, the mandate of the national committee and the composition will have to be reviewed according to the principle of decentralization and subsidiarity.
- The West African Council for Agricultural Research (CORAF), constituting the sub-regional interface for NARS in the area. Its main task is to promote the exchange of experiences and to foster cooperation and labour division among NARS. It is thus a potentially important partner for international agricultural research centres being active in West Africa.

[22] Extension tools are adjusted to the requirements of a frequently illiterate target group. Explanatory texts are completed by pictures. To avoid ambiguous or even false interpretation every single picture is reviewed by researchers, producers and representatives of the respective target group. Documents also contain a calendar indicating the relevant processing periods as well as calculations of the expected costs and yields. In all cases documents contain the gross margins estimated at different interest rates with the latter additionally facilitating the borrowing process. The bulletins are sold to the target group and rural development projects at an affordable price. A tracing of the documents offers a possibility to estimate their impact.

This elaborated concept could easily be utilised for the extension process itself as can be seen by comparing its structure with the training structure DUNAVANT developed to reach the majority of its collaborating small-scale farmers. A Yield Programme Manager has been employed for the project implementation and is assisted by two Zonal Managers responsible for the Eastern and the Central-Mumbwa-South Province, respectively. The main task of the Zonal Managers is the training, mentoring and monitoring of the 15 (24 in year 2) employed Area Coordinators in three workshops as trainers of the described programme. The Area Coordinators in turn are mainly responsible for the training, mentoring and monitoring of 289 (465 in year 2) Site Coordinators in another three workshops who themselves run One-Day-Mobilisation-Workshops for their respective group of 10 Lead Farmers to assist overall 2,890 (5,115 in year 2) Lead Farmers in applying and adopting the programme. The Lead Farmers finally train their respective group of about 15 collaborating farmers in the same programme. Hence, a total of 43,350 (76,725 in year 2) collaborating small-scale farmers shall be reached. Additionally, training materials (including a video tape) were provided to all participating farmers, and farmer exchange visits were organised to stimulate the sharing of experiences and an interactively learning process. The Site Coordinators as well as the Lead Farmers are not employed, instead they were paid according to an incentive scheme which depends on their measured performance. Each Site Coordinator receives a first incentive "package" containing a bicycle, an overall and a raincoat (worth US$ 85) and, depending on his performance, up to US$ 200 in cash. Lead Farmers receive as first incentive a work overall (worth US$ 10) and may earn an additional US$ 33 in terms of subsidised inputs, provided their mentored collaborating farmers attended the training sessions and started applying the programme.

2.2.4 The geographic setup of R&D

An important step to achieve increasing stakeholder participation and more adaptive research is seen in the concept of decentralisation. One issue is to create a tiered research system, with local research focusing on adaptive research and national research concentrating on upstream applied, strategic and basic research. Finding the right degree of decentralisation is somewhat tricky as there exists a trade-off between both approaches. Centralisation of the already limited research capacity increases its efficiency while decentralisation increases its relevance. Furthermore, decentralised research facilities are often established in regions with lower living standards, safety issues and ICT facilities which makes the recruiting of qualified staff quite difficult.

2.3 An integrated Model

The identified lessons learned are generally able to substantially enhance the performance of NSI, yet until now they have not been implemented on a broader level. The main objective of this paper is to design a model which converts the core lessons learned on a superordinate level, meaning that it would have to be adapted to the very conditions of the respective country applying it (figure 11).
To implement the requested decentralisation approach this paper seizes the suggestion to set up centres of excellence (CoE) in the different agro-ecological zones which are responsible for the research on their very zone, supporting farmers to effectively response to its special features. Although the decentralisation approach of the current reform debate goes further than this proposal with some countries setting up CoEs for each district, the question is whether this high decentralisation is required and affordable for the majority of small and poor developing countries. It has to be considered that the establishment of the centres is

costly as equipment, infrastructure, ICT and personal is needed. Additionally the existence of too many centres hampers the building of linkages to other research organisations, national and international.

The CoEs should be managed by a Board comprising all stakeholders of the respective agro-ecological zone. The composition of the respective Boards should vary from zone to zone, a process of fine-tuning the degree of participation should take place. In less favoured areas it should mainly smallholders who as the target group dominate the Board and consequently the setting of research priorities for their specific agro-ecological zone. In contrast, in more favoured areas[23] target groups comprise plantation owners as well as the private sector (i.e. traders, exporters, processors)[24]. With the distinction between high and low potential agro-ecological zones and the respective responsibilities there is a chance that research will satisfy both better-organised and market-oriented farmers as well as the millions of subsistence-oriented farmers. The management cycle of INRAB could provide an example of how the research within the CoEs could be effectively designed. Additionally, an intelligent mix of push and pull interventions and adequate financial instruments has to be chosen (cp 2.2.2) and an efficient fiscal and human resource management has to be implemented for each CoE.

The CoEs should build up strong linkages to those centres in neighbouring countries responsible for the same agro-ecological zone. This collaboration should not be limited to a simple exchange of information as it is at present. Joint research projects yield to a more effective and efficient application of limited resources and should be implemented whenever the benefits of sharing scarce resources (e.g. funds and staff) outweigh collaborating costs. To achieve such a strong networking it will be crucial to establish and maintain mutual trust, one task will be to introduce IPR on a national as well as on a regional level[25]. It is because of this required regional networking going beyond the scope of NSI why the suggested approach can rather be referred to as Regional System of Innovation (RSI).

The centres should be coordinated on national level by a so-called Apex body. While it is the responsibility of the CoEs to conduct adaptive research for their special agro-ecological zone it lies within the responsibility of the Apex body to provide research on the national level which is consequently more upstream applied, strategic and basic. As a result, responsibilities of the Apex body include the definition of the national overall strategy and the collaboration with the respective government in its function as a stakeholder. The collaboration between policy-makers and Apex body should be facilitated by the creation of a consortium. For not only does the proposed approach suggest a strong regional orientation of the research system, it also proposes a well-established inter-sectoral orientation, with close linkages to all organisations engaged in agricultural R&D. For this reason, various policy-makers are affected, e.g. the ministry of agriculture, education, finance, trade, environment etc. The consortium should meet on a regular base to discuss and reach trend-setting decisions concerning national and regional R&D. It will be the task of the Apex body to assure that the respective needs of the different CoEs are sufficiently accounted for while simultaneously supporting policy-makers with research results relevant for agricultural policies and

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[23] More favoured areas are characterised by at least some of the following conditions: relatively favourable climate and soil, existence of irrigation systems, relatively good transport and distribution system and access to local, regional and / or international markets (compare Breman and Debrah (2003)).

[24] There should be a strong engagement of high-calibre managers of the private sector, not only because of the disposition of the acquired skills and know-how but also because such members could identify innovative mechanisms for sourcing non-traditional funding and promote public-private partnerships (FARA 2006).

[25] Kremer, M. / A. P. Zwane (2004) quote that *„for example, an improvement in cassava productivity that is useful in Uganda may be useful in Nigeria and many other countries as well, leaving inadequate incentives for protection of IPR by Uganda alone."*

regulatory measures. It should particularly assist the government in creating an enabling environment for the private sector and retreating by degrees from research without either having a strong public good character nor being of strong public interest, starting in those zones already endued with a relatively well-established private sector[26].
Another important task comprises the implementation of close linkages to national, regional, and international research organisations and consultants. Most of the countries in SSA do not have the capacity to cover all possible research issues so that the Apex body in particular has to build strong linkages to those regional and international institutions with research activities in areas not covered by the national research as well as to national or international consultants being experts for the respective agro-ecological zones. Hence the Apex body has to be quite solid to avoid that the whole research system will fragment into various isolated entities.

3 Summary and conclusions

Africa's agricultural sector has been identified in many instances as the potential engine for economic growth and the most promising way to reduce the wide-spread poverty. However, in many cases the identified potential has not been released until now. A huge variety of factors influencing the agricultural sector have been identified, addressing each of them being a condition for the modernisation of the sector.
With a median rate-of-return well above 30%, public agricultural research in Africa is supposed to have a particularly strong impact on both agricultural productivity and poverty reduction. Despite its potential, government spending for agricultural R&D is astonishingly low. This is at least partly due to the long-used but inefficient Top-Down Model. As a result, SSA's NARI struggle to survive financially, reflected in poor salaries, lack of training, skilled staff and ICT. A current reform debate is addicted to the issue of how to enhance the performance of NSI. The lessons learned presented in this paper have been derived from the corresponding literature and complemented by two case studies of the German development cooperation.
In a final step, this paper has developed an integrated model approach as one possibility to convert the core lessons learned on a broader level. In consideration of the threats of scarce resources and the opportunities of neighbouring countries sharing the same agro-ecological zones, the model approach proposes to set up centres of excellence for the different agro-ecological zones. Whenever the benefits of joint research outweigh collaboration costs, strong regional linkages should be established between the centres of neighbouring countries responsible for the same agro-ecological zone. The centres should be managed by Boards consisting of the stakeholders (e.g. NARIs, universities, NGOs, policy-makers, consumers and last but not least the agribusiness) of the respective zone, including high-calibre managers of the private sector. On the national level, a so called Apex body should be established. While it is the responsibility of the centres of excellence to conduct adaptive research for their specific agro-ecological zone it is the responsibility of the Apex body to provide research on the national level which is consequently more upstream applied, strategic and basic. Hence the Apex body has to be quite solid to avoid that the whole NSI will fragment into various isolated entities. Additionally, a consortium of policy-makers (comprising inter alia the

[26] One example of a successful strategy is provided by China's "responsibility system" implemented in 1980-81, which linked productivity to material reward and proved to be highly effective: 78% of the increase in the Chinese agricultural sector output of over 61% between 1978 and 1984 has been attributed to the responsibility system and the remaining 22% to higher prices for crops (FAO (2001)).

respective ministry of agriculture, of trade, of education etc.) should be established and meet with the respective national Apex body on a regular base to discuss research relevant issues.
Because of its strong inter-sectoral and regional linkages this concept transcends the concept of NSI and should thus be referred to as Regional System of Innovation (RSI). Yet the RSI presented in this paper is just one suggestion of how to implement some of the core lessons learned drawn by the current reform debate. It does not claim to be complete nor elusive, yet it provides some impulses for a more effective and efficient design of innovation systems. Furthermore, it represents an idealised concept, which would have to be adapted to the very conditions of the respective country adopting it.
However, if this kind of concept shall work, it will be essential to address the following five issues:

1. The reversal of the proceeding retreat of national governments from providing funds for agricultural research,

2. the creation of potent FBOs, able to communicate their needs with an adequate representation of small-scale farmers,

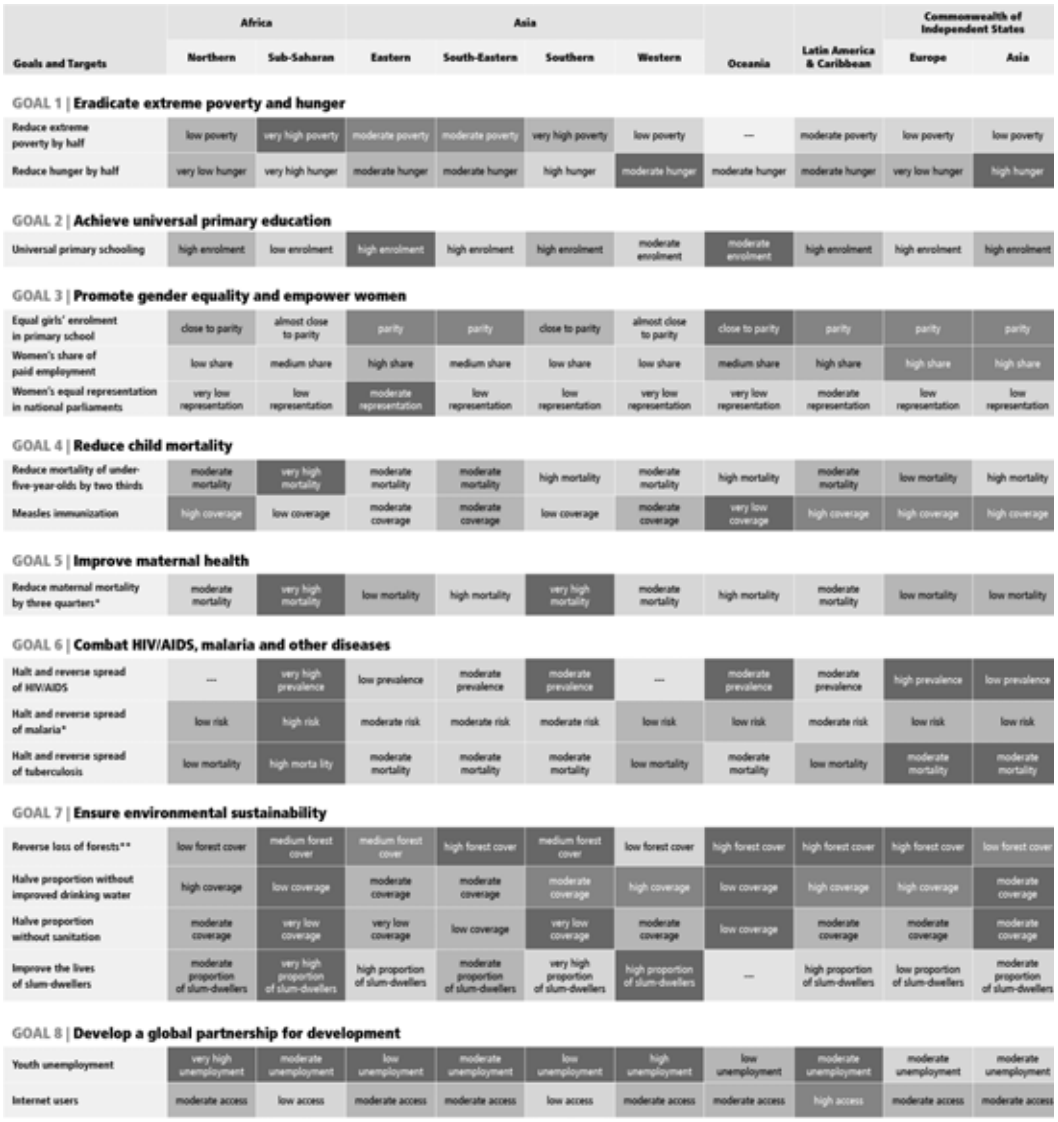
3. the improvement of innovation dissemination to reach both specialised private agents (traders, exporters, processors) as well as the millions of small-scale farmers,

4. the coordination of donor communities, committing to a joint strategy and

5. last but not least the regional harmonisation of NSI-systems by establishing comparable structures in neighbouring countries. In this context the CAADP of NEPAD could play a decisive role as “Agricultural Research, Technology Dissemination and Adoption” is one of CAADP’s four main investment pillars and the facilitation of efficient technology transfer across countries one of the improvements aimed at.

4 Annex

Figure 1: MDGs 2006 progress chart

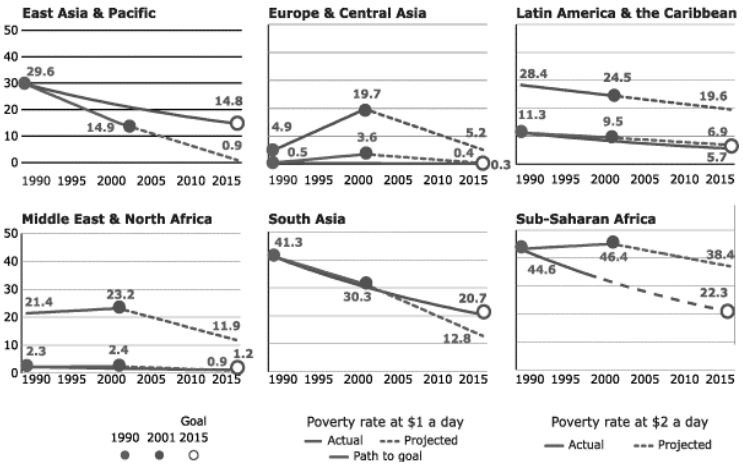


Goals and Targets	Africa: Northern	Africa: Sub-Saharan	Asia: Eastern	Asia: South-Eastern	Asia: Southern	Asia: Western	Oceania	Latin America & Caribbean	Commonwealth of Independent States: Europe	Commonwealth of Independent States: Asia
GOAL 1 | Eradicate extreme poverty and hunger										
Reduce extreme poverty by half	low poverty	very high poverty	moderate poverty	moderate poverty	very high poverty	low poverty	---	moderate poverty	low poverty	low poverty
Reduce hunger by half	very low hunger	very high hunger	moderate hunger	moderate hunger	high hunger	moderate hunger	moderate hunger	moderate hunger	very low hunger	high hunger
GOAL 2 | Achieve universal primary education										
Universal primary schooling	high enrolment	low enrolment	high enrolment	high enrolment	high enrolment	moderate enrolment	moderate enrolment	high enrolment	high enrolment	high enrolment
GOAL 3 | Promote gender equality and empower women										
Equal girls' enrolment in primary school	close to parity	almost close to parity	parity	parity	close to parity	almost close to parity	close to parity	parity	parity	parity
Women's share of paid employment	low share	medium share	high share	medium share	low share	low share	medium share	high share	high share	high share
Women's equal representation in national parliaments	very low representation	low representation	moderate representation	low representation	low representation	very low representation	very low representation	moderate representation	low representation	low representation
GOAL 4 | Reduce child mortality										
Reduce mortality of under-five-year-olds by two thirds	moderate mortality	very high mortality	moderate mortality	moderate mortality	high mortality	moderate mortality	high mortality	moderate mortality	low mortality	high mortality
Measles immunization	high coverage	low coverage	moderate coverage	moderate coverage	low coverage	moderate coverage	very low coverage	high coverage	high coverage	high coverage
GOAL 5 | Improve maternal health										
Reduce maternal mortality by three quarters*	moderate mortality	very high mortality	low mortality	high mortality	very high mortality	moderate mortality	high mortality	moderate mortality	low mortality	low mortality
GOAL 6 | Combat HIV/AIDS, malaria and other diseases										
Halt and reverse spread of HIV/AIDS	---	very high prevalence	low prevalence	moderate prevalence	moderate prevalence	---	moderate prevalence	moderate prevalence	high prevalence	low prevalence
Halt and reverse spread of malaria*	low risk	high risk	moderate risk	moderate risk	moderate risk	low risk	low risk	moderate risk	low risk	low risk
Halt and reverse spread of tuberculosis	low mortality	high morta lity	moderate mortality	moderate mortality	moderate mortality	low mortality	moderate mortality	low mortality	moderate mortality	moderate mortality
GOAL 7 | Ensure environmental sustainability										
Reverse loss of forests**	low forest cover	medium forest cover	medium forest cover	high forest cover	medium forest cover	low forest cover	high forest cover	high forest cover	high forest cover	low forest cover
Halve proportion without improved drinking water	high coverage	low coverage	moderate coverage	moderate coverage	moderate coverage	high coverage	low coverage	high coverage	high coverage	moderate coverage
Halve proportion without sanitation	moderate coverage	very low coverage	very low coverage	low coverage	very low coverage	moderate coverage	low coverage	moderate coverage	moderate coverage	moderate coverage
Improve the lives of slum-dwellers	moderate proportion of slum-dwellers	very high proportion of slum-dwellers	high proportion of slum-dwellers	moderate proportion of slum-dwellers	very high proportion of slum-dwellers	high proportion of slum-dwellers	---	high proportion of slum-dwellers	low proportion of slum-dwellers	moderate proportion of slum-dwellers
GOAL 8 | Develop a global partnership for development										
Youth unemployment	very high unemployment	moderate unemployment	low unemployment	moderate unemployment	low unemployment	high unemployment	low unemployment	moderate unemployment	moderate unemployment	moderate unemployment
Internet users	moderate access	low access	moderate access	moderate access	low access	moderate access	moderate access	high access	moderate access	moderate access

- Target already met or very close to being met.
- Target is expected to be met by 2015 if prevailing trends persist, or the problem that this target is designed to address is not a serious concern in the region.
- Target is not expected to be met by 2015, if prevailing trends persist
- No progress, or a deterioration or reversal.
- Insufficient data.

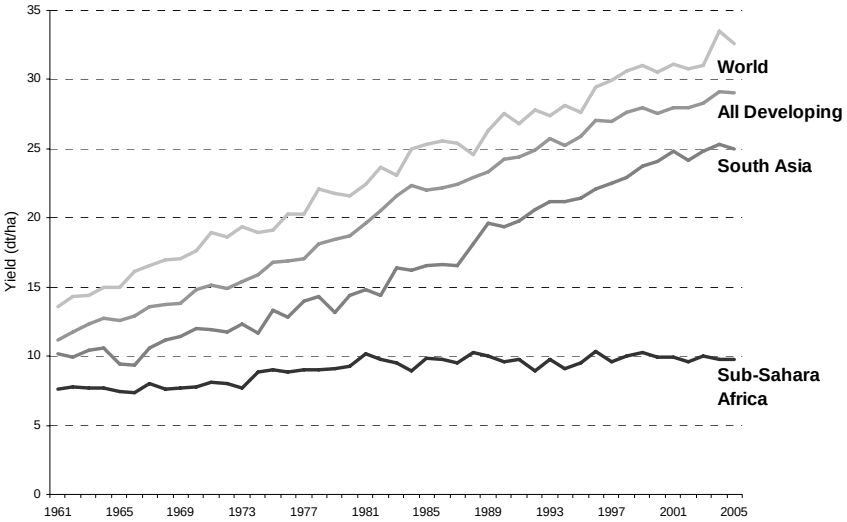
Source: Statistics Division, UN DESA

Figure 2: Percentage share of people living on less than $1 (or $2) a day (1990-2015)



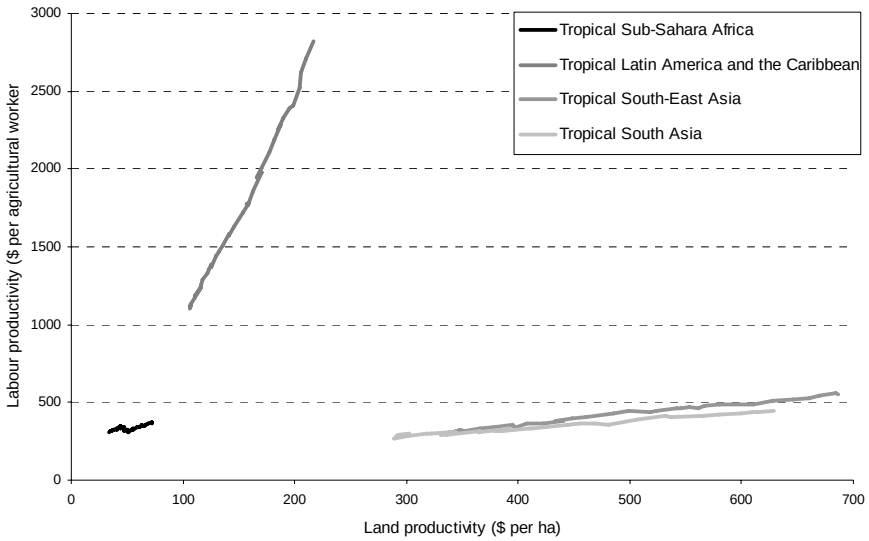
Source: World Bank staff estimates (2006)

Figure 3: Cereal yield trends (1961-2005)



Source: FAOSTAT data (2006)

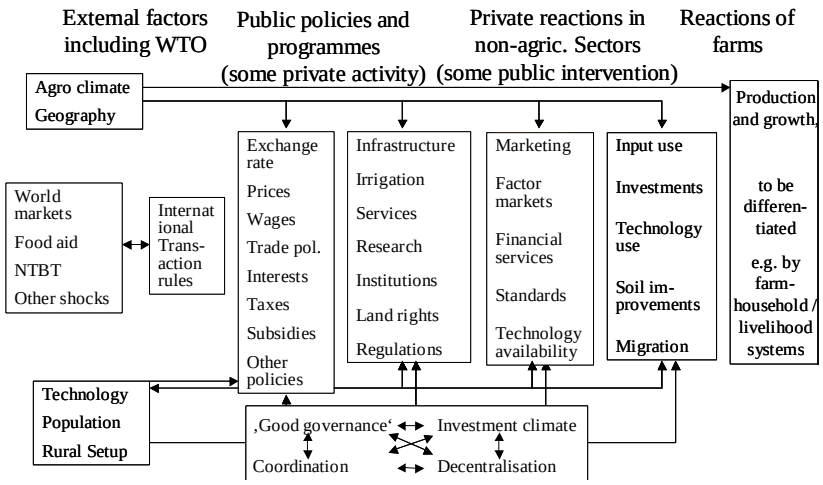
Figure 4: Factor productivity in agriculture 1961-2005 (in 1989 –1991 international Dollar)



Source: Stan Wood (IFPRI)

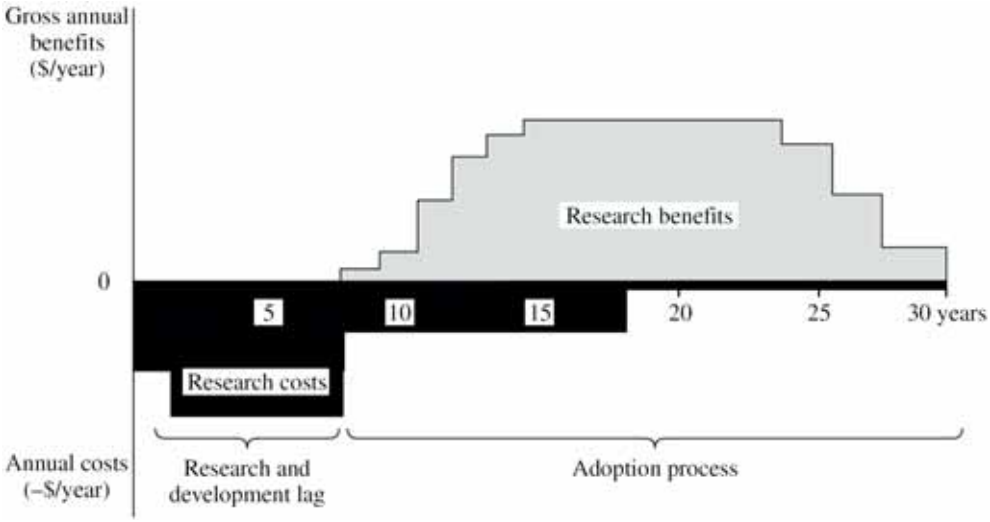
Table 1: Rural road network in humid and sub-humid countries of Africa		
Country	Existing density (approx. 1990) (Km / 1,000 sq. km)	Required density to match India in 1950 (Km / 1,000 sq. km)
Benin	36	291
Cameroon	38	168
Congo	1	47
Ivory Coast	94	258
Ghana	17	429
Madagascar	67	137
Mozambique	17	135
Nigeria	97	718
Sierra Leone	80	391
Tanzania	66	181
Zaire	36	110
Source: Peter Hazell (2004)		

Figure 5: Agricultural policy domains



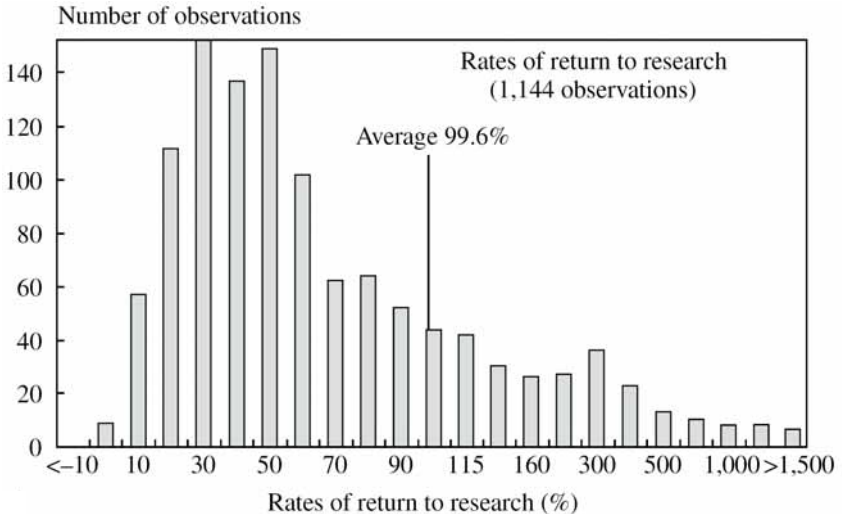
Source: Dr. Michael Brüntrup (DIE)

Figure 6: Flows of resources, benefits, and costs



Source: Alston, Norton, and Pardey (1995)

Figure 7: Distribution of rates of return to agricultural R&D



Source: J. M. Alston et al (2000)

Table 2: Economic rates of return to education by level, latest year available				
Countries	Year	Primary	Secondary	Higher
Total SSA		24.3	18.2	11.2
Botswana	1983	42.0	41.0	15.0
Ethiopia	1972	20.3	18.7	9.7
Ghana	1967	18.0	13.0	16.5
Lesotho	1980	10.7	18.6	10.2
Liberia	1983	41.0	17.0	8.0
Malawi	1982	14.7	15.2	11.5
Nigeria	1966	23.0	12.8	17.0
Sierra Leone	1971	20.0	22.0	9.5
Somalia	1983	20.6	10.4	19.9
South Africa	1980	22.1	17.7	11.8
Uganda	1965	66.0	28.6	12.0
Yemen	1985	2.0	26.0	24.0
Zimbabwe	1987	11.2	47.6	-4.3
Source: Psacharopoulos (1994)				

Table 3: Economic rates of return on World Bank-supported projects, 1974-1992		
Sector	1974-1982	1983-1992
Total infrastructure projects	18%	16%
Irrigation and drainage	17%	13%
Telecommunications	20%	19%
Transport	18%	21%
Airports	17%	13%
Highways	20%	29%
Ports	19%	20%
Railways	16%	12%
Power	12%	11%
Urban development		23%
Source: World Bank (1994)		

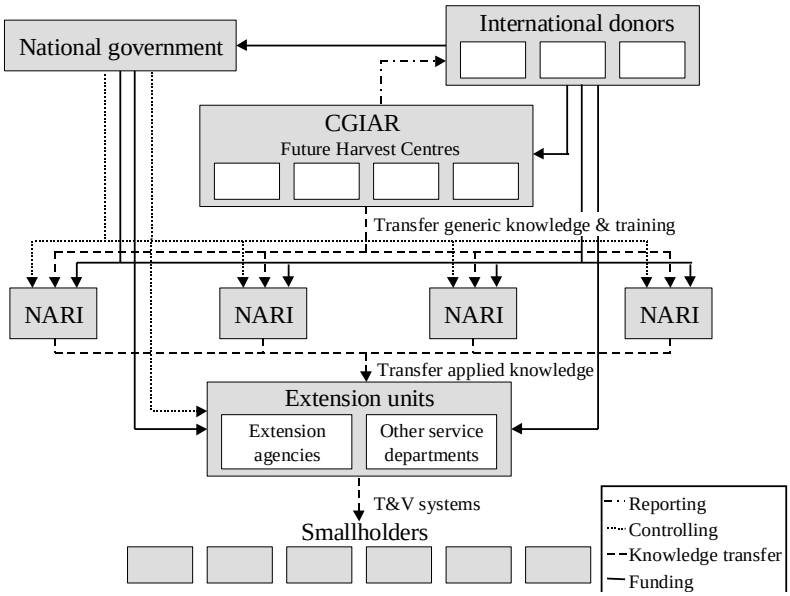
Figure 8: Marginal returns to government investment in rural Uganda[27]

Investment	Central	East	North	West	Uganda
Benefit–cost ratio					
Agricultural R&D	12.49	10.77	11.77	14.74	12.38
Education	2.05	3.51	2.10	3.80	2.72
Feeder Roads	6.03	8.74	4.88	9.19	7.16
Murram Roads	n.s.	n.s.	n.s.	n.s.	n.s.
Tarmac Roads	n.s.	n.s.	n.s.	n.s.	n.s.
Health	1.37	0.92	0.37	0.96	0.90
Number of poor people reduced per million shillings					
Agricultural R&D	21.75	66.31	175.52	48.91	58.39
Education	3.57	21.60	31.38	12.62	12.81
Feeder Roads	10.51	53.85	72.82	30.49	33.77
Murram Roads	4.08	11.88	14.80	9.77	9.70
Tarmac Roads	2.59	13.12	62.92	9.39	9.73
Health	2.60	6.15	5.95	3.46	4.60

Source: Fan, Zhang and Rao (2004)

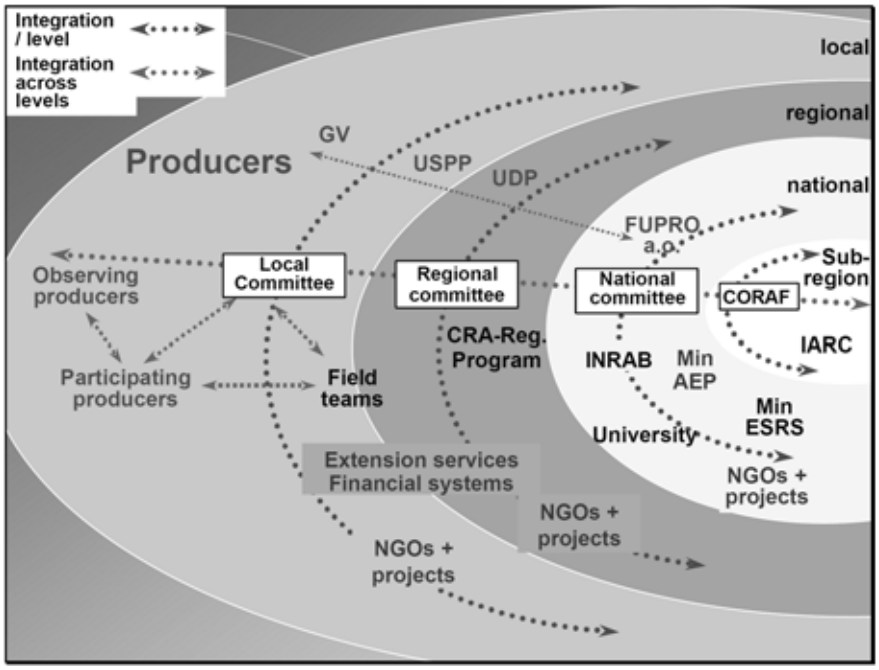
[27] The abbreviation n.s. indicates that the respective coefficients are not statistically significant.

Figure 9: The Top-Down Model



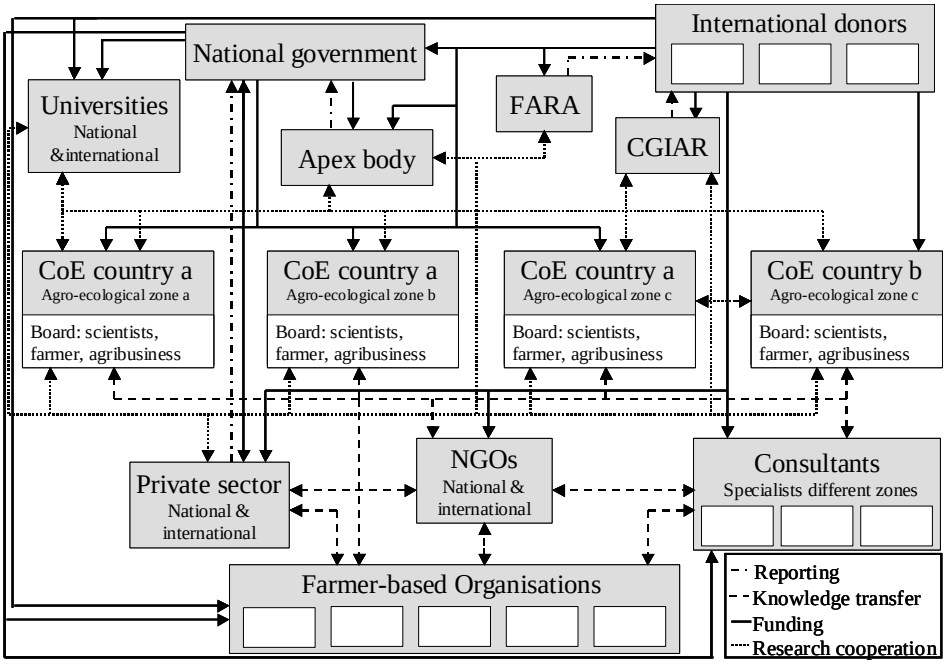
Source: Nicole Rippin

Figure 10: Concept for the institutionalization of demand-driven agricultural research in Benin



Source: Arodokoun, D. et al (2002)

Figure 11: Conceptual model for building an effective research system



Source: Nicole Rippin

5 Bibliography

AgREN (The Agricultural Research and Extension Network) (1999): New methods and old institutions: the 'systems context' of farmer participatory research in national agricultural research systems. The case of Uganda; online: http://www.odi.org.uk/agren/papers/agrenpaper_93.pdf#search=%22agren%20New%20methods%20and%20old%20institutions%3A%20the%20%E2%80%98systems%20context%E2%80%99%20of%20farmer%20participatory%20research%20in%20national%20agricultural%20research%20systems.%20The%20case%20of%20Uganda%22

Alston, J. M. et al (2000): A meta-analysis of rates of return to agricultural R&D: ex pede Herculem?, Research Report 113, Washington, DC: IFPRI (International Food Policy Research Institute); online: http://www.ifpri.org/pubs/abstract/abstr113.htm

Anderson, J. R. (1994): Agricultural productivity in Africa: discussion, in: *American Journal of Agricultural Economics* 76 (3), 625-626; online: http://chla.library.cornell.edu/cgi/t/text/pageviewer-idx?c=chla;cc=chla;sid=5db8658c7b1bc19d80b5f67fa61a755f;rgn=full%20text;idno=5032826_76_003;view=image;seq=0278

Arodokoun, D. et al (2002): Institutionalising demand-driven agricultural research: experiences with the management cycle of agricultural research in Benin; online: http://www.tropentag.de/2002/abstracts/full/199.pdf

Baker, J. L. (2000): Evaluating the impact of development projects on poverty: a handbook for practitioners, Washington, DC: World Bank; online: http://siteresources.worldbank.org/INTISPMA/Resources/handbook.pdf

Beintema, N. M. / G.-J. Stads (2004): Sub-Saharan African agricultural research: recent investment trends, in: Outlook on Agriculture 33 (4), 239-246; online: http://www.asti.cgiar.org/pdf/Outlook.pdf#search=%22Sub-Saharan%20African%20agricultural%20research%3A%20recent%20investment%20trends%2C%20in%3A%20Outlook%20on%20Agriculture%20%22

Beintema, N. M. / G.-J. Stads (2004): Investing in Sub-Saharan African agricultural research: recent trends, Washington, DC: IFPRI (International Food Policy Research Institute); online: http://www.ifpri.org/2020africaconference

Beintema, N. M. / J. Roseboom (2003): Building impact-oriented R&D institutions, Amsterdam: InterAcademy Council; online: www.interacademycouncil.net/Object.File/Master/9/057/0.doc

Belli, P. et al (1997): Handbook on economic analysis of investment operations, Washington, DC: OED[28] (Operations Policy Department); online: http://wbln0018.worldbank.org/environment/EEI.nsf/d94e136e025a639d85256ad80052cbd5/97ae8f7d43d439a485256706005d5a78/$FILE/econanal.pdf

Block, S. A. (1994): A new view of agricultural productivity in Sub-Saharan Africa, in: *American Journal of Agricultural Economics* 76 (3), 619-624; online: http://chla.library.cornell.edu/cgi/t/text/pageviewer-idx?c=chla;cc=chla;sid=5db8658c7b1bc19d80b5f67fa61a755f;rgn=full%20text;idno=5032826_76_003;view=image;seq=0278

Breman, H. / K. Debrah (2003): Improving African food security, in: *A Journal of International Affairs* 23 (1), 153-170; online: http://www.syngentafoundation.org/pdf/2003_mali_breman_improving_african_food_security.pdf

Brüntrup, M. (1997): Agricultural price policy and its impact on production, income, employment and the adoption of innovations: a farming systems based analysis of cotton policy in northern Benin, in: F. Heidhues (ed.), Development economics and policy: Bd. 9, Frankfurt/Main: Peter Lang GmbH, Europäischer Verlag der Wissenschaften

Canning, D., E. Bennathan (2000): The social rate of return on infrastructure investments, Washington, DC: World Bank; online: http://www.qub-efrg.com/uploads/wps2390.pdf

[28] Today IEG (Independent Evaluation Group)

CGIAR (1997): World's dryland farmers need new agricultural technology – "Green Revolution" never reached them, Washington, DC: CGIAR (Consultative Group on International Agricultural Research); online: http://www.worldbank.org/html/cgiar/press/dryland.html

Chema, S. / E. Gilbert / J. Roseboom (2003): A review of key issues and recent experiences in reforming agricultural research in Africa, Research Report 24, The Hague: ISNAR (International Service for National Agricultural Research); online: http://www.isnar.cgiar.org/publications/pdf/rr-24.pdf#search=%22A%20review%20of%20key%20issues%20and%20recent%20experiences%20in%20reforming%20agricultural%20research%20in%20Africa%22

Clark, N. (2001): Innovation systems, institutional change and the new knowledge market: implications for Third World agricultural Development, Maastricht: UNU (United Nations University), INTECH (Institute for New Technologies)

Diao, X. et al (2006): The role of agriculture in development: implications for Sub-Saharan Africa, Washington, DC: IFPRI (International Food Policy Research Institute); online: http://www.ifpri.org/divs/dsgd/dp/papers/dsgdp29.pdf

Diao, X. / Hazell, P. (2005): The role of agriculture and small farms in economic development, Washington, DC: IFPRI (International Food Policy Research Institute); online: http://www.ifpri.org/events/seminars/2005/smallfarms/sfproc/SO1_hazell.pdf#search=%22research%20and%20development%20role%20government%20ssa%22

- (2004): Exploring market opportunities for African Smallholders, Washington, DC: IFPRI (International Food Policy Research Institute); online: http://www.ifpri.org/pubs/ib/ib22.pdf

Dunavant Zambia Ltd (s.a.): Co-financing application of Dunavant Zambia Ltd in terms of DEG's development program towards Zambia for a training and empowerment project to train and mentor more than 120,000 small-scale farmers in best agricultural cultivation techniques thereby assisting the farmers to substantially increase their yields and income, Lusaka: Dunavant Zambia Ltd, mimeo

Evenson, R. E. (2003): Making science and technology work for the poor: lecture 2: the "price of admission" to the growth club for African countries, Maastricht: UNU (United Nations University), INRA (Institute for Natural Resources in Africa), Addis Ababa: UNECA (United Nations Economic Commission for Africa); online: http://www.ksg.harvard.edu/sed/docs/k4dev/evenson_unlecture2_0310.pdf#search=%22Making%20science%20and%20technology%20work%20for%20the%20poor%3A%20lecture%202%3A%20the%20%E2%80%9Cprice%20of%20admission%E2%80%9D%20to%20the%20growth%20club%20for%20African%20countries%22

- (2000): Economic impacts of agricultural research and extension, in: *Handbook of Agricultural Economics*, B. L. Gardner, C. R. Rausser (eds.), Elsevier Science; online: http://www.elsevier.com/wps/find/bookdescription.cws_home/600083/description#description

- (1994): Agricultural productivity in Africa: discussion, in: *American Journal of Agricultural Economics* 76 (3), 627-628; online: http://chla.library.cornell.edu/cgi/t/text/pageviewer-idx?c=chla;cc=chla;sid=5db8658c7b1bc19d80b5f67fa61a755f;rgn=full%20text;idno=5032826_76_003;view=image;seq=0278

FAO (Food and Agriculture Organization of the United Nations) (2005): Special event on Green Revolution in Africa; online: ftp://ftp.fao.org/docrep/fao/meeting/009/j5421e.pdf

- (2004): Contribution of agricultural research and extension to food security and poverty reduction in the African region; online: http://www.fao.org/DOCREP/MEETING/007/J1417E.HTM#2

- (2001): Agricultural investment and productivity in developing countries; online: http://www.fao.org/DOCREP/003/X9447E/X9447E00.HTM

FARA (Forum for Agricultural Research in Africa) (2006); Agricultural research delivery in Africa: an assessment of the requirements for efficient, effective and productive national agricultural research systems in Africa: executive summary and strategic recommendations, Accra; online: http://www.fara-africa.org/files/NARS%20Assessment%20exec%20sum.pdf#search=%22Agricultural%20research%20delivery%20in%20Africa%3A%20an%20assessment%20of%20the%20requirements%20for%20efficient%2C%20effective%20and%20productive%20national%20agricultural%20research%20systems%20in%20Africa%22

Fan, S. (2004): Infrastructure and pro-poor growth, Helsinki: OECD DACT POVNET Agriculture and Pro-Poor Growth Workshop; online: http://www.oecd.org/dataoecd/24/56/36562655.pdf#search=%22Infrastructure%20and%20pro-poor%20growth%22

Fan, S. / X., Zhang / N. Rao (2004): Public expenditure, growth, and poverty reduction in rural Uganda, DSGD discussion paper no. 4, Washington, DC: IFPRI (International Food Policy Research Institute); online: http://www.ifpri.org/divs/dsgd/dp/papers/dsgdp04.pdf

Gabre-Madhin, E. Z. / S. Haggblade (2003): Successes in African agriculture: results of an expert survey, MSSD discussion paper no. 53, Washington, DC: IFPRI (International Food Policy Research Institute); online: http://www.ifpri.org/divs/mssd/dp/papers/mssdp53.pdf#search=%22)%3A%20Successes%20in%20African%20agriculture%3A%20results%20of%20an%20expert%20survey%22

Gardner, B. (2004): Global public goods from the CGIAR: impact assessment; online: www.arec.umd.edu/b**gardner**/papers/Impact%20of%20the%20CGIAR.doc

GFAR (Global Forum on Agricultural Research) (2003): Conference report: linking research and rural innovation to sustainable development, Rome; online: http://www.egfar.org/gfar2003/documents.shtml

Gill, G. J. / D. Carney (1999): Competitive agricultural technology funds in developing countries, London: ODI (Overseas Development Institute); online: http://www.odi.org.uk/NRP/41.html

GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit) (s.a.): Statusbericht an das BMZ, Eschborn, mimeo

GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit) (2005): Programme de conservation et de gestion des ressources naturelles, Bénin: appui à la gestion de la recherche agricole nationale du Bénin: state of art: the path towards impact ?, Eschborn, mimeo

Haggblade, S., ed. 2004. Successes in African Agriculture: Building for the Future. Findings of an International Conference, Pretoria, South Africa, December 1–3, 2003. Feldafing, Germany: InWEnt; online: http://www.ipms-ethiopia.org/docs/workshops-Meetings/Project_Launching%5CSuccesses%20in%20African%20Agriculturet%20(Haggblade).pdf#search=%22Successes%20in%20African%20Agriculture%3A%20Building%20for%20the%20Future%22

Hazell, P. (2006): The role of agriculture in pro-poor growth in Sub-Saharan Africa, London: Imperial College; online: www.egdi.gov.se/word/workshop_summary_8_9_march_2006.doc

- (2004): Challenges and opportunities for agriculture in Sub-Saharan Africa, Washington, DC: IFPRI (International Food Policy Research Institute); online: www.arec.umd.edu/AREC445/HazellConference.ppt
- (s.a.): Technological change, Washington, DC: IFPRI (International Food Policy Research Institute); online: http://www.ifpri.org/2020/focus/focus08/focus08_08.asp

IAC (InterAcademy Council) (2004): Realising the promise and potential of African agriculture, Amsterdam; online: http://www.eldis.org/static/DOC16263.htm

Jones, M. (2005): Key challenges for technology development and agricultural research in Africa, in: *IDS Bulletin* 36 (2), 46-51; online: http://www.future-agricultures.org/pdf%20files/Jones.pdf#search=%22monty%20jones%20ids%20bulletin%20vol%2036%22

Kachelriess, S. / A. Matthess (2005): Valoriser des résultats de recherche pour le développement: conception des référentiels technico-économiques pour la promotion des innovations agricoles au niveau des groupes cibles faiblement lettrés au Bénin, Cotonou: MAEP (Ministère de l'Agriculture, de l'Elevage et de la Pêche), Cotonou: INRAB (Institut National des Recherches Agricoles du Bénin), Eschborn: Deutsche Gesellschaft für Technische Zusammenarbeit, mimeo

KfW (Kreditanstalt für Wiederaufbau) (2006): Doing business in 2006, Frankfurt/Main; online: http://www.doingbusiness.org/

Kremer, M. / A. P. Zwane (2004): Encouraging private sector research for tropical agriculture, in: *World Development* 33 (1), 87-105; online: http://www.brookings.edu/views/articles/kremer/200601.pdf

MAEP (Ministère de l'Agriculture, de l'Elevage et de la Pêche), *INRAB* (Institut National des Recherches Agricoles du Bénin), (2004): Evaluation du cycle de gestion de la recherche agricole du Bénin: rapport de l'atelier tenu à Bohicon du 8 au 10 septembre 2004, Cotonou, mimeo

Matson, P. A. et al (1997): Agricultural intensification and ecosystem properties, in: *Science* 277, 504-509; online: http://iis-db.stanford.edu/pubs/10588/matsonpartonpowerswift1997.pdf

Matthess, A. (s.a.): Organisationsberatung für Verbände und Vereinigungen der Agrar- und Ernährungswirtschaft, Eschborn: Deutsche Gesellschaft für Technische Zusammenarbeit, mimeo

- (2005): Strengthening farmer organizations: inquiry to the experiences made by GTZ supported projects and programs, Eschborn: Deutsche Gesellschaft für Technische Zusammenarbeit, mimeo

Matthess, A. / B. Agbo (2005): Financement durable de la recherche agricole du Bénin: principes, situation actuelle et réflexions sur des améliorations: présentation table ronde à l'occasion des journées scientifiques du centenaire de la recherche agricole du Bénin, Eschborn: Deutsche Gesellschaft für Technische Zusammenarbeit, mimeo

Matthess, A. / D. O. Koudande (2004): Générer et gérer des connaissances pour le développement: Etat d'avancement du bilan d'acquis de la recherche agricole nationale, Cotonou: MAEP (Ministère de l'Agriculture, de l'Elevage et de la Pêche), Cotonou: INRAB (Institut National des Recherches Agricoles du Bénin), Cotonou: SNRA (Système national de recherche agricole), Cotonou: FSA/UAC (Faculté des Sciences Agronomiques / Université Abomey-Calavi), Eschborn: Deutsche Gesellschaft für Technische Zusammenarbeit, mimeo

Matthess, A. et al (2003): Intégration du projet AGRAN dans le programme environnement/protection et gestion durable des ressources naturelles en milieu rural (ProCGRN) et collaboration avec APRRA: rapport des ateliers tenus à l'IITA les 14 et 15 octobre 2003 et le 30 octobre 2003, Cotonou : INRAB (Institut National des Recherches Agricoles du Bénin), Cotonou: SNRA (Système national de recherche agricole), Cotonou: FSA/UAC (Faculté des Sciences Agronomiques / Université Abomey-Calavi), Eschborn: Deutsche Gesellschaft für Technische Zusammenarbeit, mimeo

Meinzen-Dick, R. et al (2004): Science and poverty: an interdisciplinary assessment of the impact of agricultural research, Food Policy Report, Washington, DC: IFPRI (International Food Policy Research Institute); online: http://www.ifpri.org/pubs/fpr/pr16.pdf#search=%22Science%20and%20poverty%3A%20an%20interdisciplinary%20assessment%20of%20the%20impact%20of%20agricultural%20research%22

Omamo, S. W. (2003): Policy research on African agriculture: trends, gaps and challenges, Research Report 21, The Hague: ISNAR (International Service for National Agricultural Research); online: http://www.eldis.org/static/DOC12002.htm

Pomareda, C. / F. Hartwich (2005): Agricultural innovation in Latin America: understanding the private sector's role, Washington, DC: IFPRI (International Food Policy Research Institute); online: http://www.ifpri.org/pubs/ib/ib42.pdf

Psacharopoulos, G. (1994): Returns to investment in education: a global update, Washington, DC: World Bank; online: http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/1993/01/01/000009265_3961003230826/Rendered/PDF/multi_page.pdf

Raitzer, D. A. (2003): Benefit-cost meta-analysis of investment in the international agricultural research centres of the CGIAR, Washington, DC: CGIAR (Consultative Group on International Agricultural Research) Science Council; online: http://www.sciencecouncil.cgiar.org/activities/spia/pubs/0303-1.pdf

Roseboom, J. (2004): Agricultural research and extension funding levels required to meet the Anti-Hunger Programme objectives, Rijswijk; online: www.fao.org/sd/dim_kn4/docs/kn4_040401a1_en.doc

Spencer, D. S. C. (1994): Infrastructure and technology constraints to agricultural development in the humid and subhumid tropics of Africa, Washington, DC: IFPRI (International Food Policy Research Institute); online: http://www.ifpri.org/divs/eptd/dp/papers/eptdp03.pdf

UIS Bulletin on Science and Technology Statistics (2004): A decade of investment in research and development (R&D): 1999-2000, issue No. 1; online: http://www.uis.unesco.org/template/pdf/S&T/BulletinNo1EN.pdf#search=%22A%20decade%20of%20investment%20in%20research%20and%20development%20%22

UNDP (United Nations Development Program) / *UNICEF* (United Nations International Children's Emergency Fund) (2002): The millennium development goals in Africa: promises & progress: report prepared by UNDP and UNICEF at the request of the G-8 Personal Representatives for Africa, New York; online: http://portal.unesco.org/en/file_download.php/b2869afa7464504544fcb0e2b57ee5e3mdgfinalAfrica.pdf

Watson, R. / M. Crawford / S. Farley (2003): Strategic approaches to science and technology in development, Policy Research Working Paper 3026, Washington, DC: World Bank; online: http://ideas.repec.org/p/wbk/wbrwps/3026.html

World Bank (2006): Implementation completion report on a loan/credit/grant in the amount of US$38.1 Million to the Senegal for a agricultural services and producer organizations project in support for the first phase of the agricultural services and producer organizations program, Washington, DC, mimeo

- (1994): World development report 1994: infrastructure for development, New York, Oxford University Press; online: http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/1994/06/01/000009265_3970716142907/Rendered/PDF/multi0page.pdf