

Repackaging Agricultural Research for Greater Impact on Agricultural Growth in Africa

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Abstract Despite the enormous research activities embarked upon by the various research entities in Africa over time, the expected research impacts remain obscure. This paper is a compilation of facts and figures from published peer reviewed articles, agricultural research and development reports from national and international institutions, and base-line data from the Africa Rice Centre aimed at elucidating the performance of agricultural research in Africa between 1960 and 2010. It discusses the constraints to the visible impact of agricultural research on the growth of Africa's economy, and suggests how to repackage agricultural research for more visible impact on Africa's economic growth. Results show that agricultural research has been beneficial for African agriculture widely and is believed to be the backbone of the economic growth of the continent. Agricultural research has also served as the bedrock of agricultural technological transformation to enhance agricultural growth. Research has helped to increase agricultural production and productivity and food security in several countries. Also, investment in agricultural research has yielded positive impact on poverty reduction and food security. However, food security and poverty are still visibly mining the African population. The major constraints in the utilization of agricultural research results are the lack of adequate public investment in agriculture, lack of well-trained researchers, inadequate research infrastructures and poor management of the agricultural research and development system. Findings show that in order to package agricultural research for visible impact on the economy, agricultural research systems would need to be adequately funded and handled by skilled human resources under good governance. An effective innovative agricultural policy would demand the initial acknowledgment that a break from the past is necessary to 'produce more and better' in Africa and that successful agricultural research systems should be designed in a framework of co-construction, co-execution and co-evaluation.

Keywords: *agricultural research, development, food security, governance, agricultural growth*

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1. Introduction

Agriculture remains one of the pillars of Africa's economic, social and rural development. About 70% of Africans and roughly 80% of the continent's poor live in rural areas and depend mainly on agriculture for their livelihood [1]. The sector accounts for about 20% of Africa's GDP [2,3], 60% of its labour force and 20% of the total merchandise exports [4,5]. It is the main source of income for 90% of the rural population in Africa [6].

Although most people in sub-Saharan Africa (SSA) engage in agriculture, its productivity has been stagnant from the 1960s until year 2001 when it rose slightly [7]. The reasons for this stagnation include inadequate returns from investments in agricultural research and development efforts, among others. Agricultural research has generated several kinds of technology with high potentials for impact, but the expected impact on farmers' productivity,

livelihood and quality of life has not been realized. This situation has its roots in the way research was being conducted, mainly because it did not adopt inputs from the non-research sector [8]. Institutional innovations are needed to improve productivity and make public agricultural institutions more responsive to markets, more accountable to the communities they serve, and better recognized as an important tool for achieving economic growth.

Chen and Démurger (2002), FAO (2001), and Seck *et al.* (2010) [9,10,11] reported that investment and technology are essential prerequisites for agricultural growth and development. Other studies have shown that huge productivity gains are possible and accrue where governments allocate the necessary resources to agricultural research and development [12]. In East and South Asia, for example, increases in government spending on agriculture have been clearly linked to rapid growth in agriculture and progress towards achieving the Millennium Development Goals [13]. In SSA, however,

public investment in agriculture is still far below what is needed, despite commitments by African governments to allocate 10% of their public spending to it [4].

Increased spending on agricultural research is vital, but it is equally important to ensure that the research carried out benefits the smallest farmers. In developing countries, research has too often by-passed the most needy farmers, offering solutions that are beyond their reach or simply inappropriate to their livelihoods. The challenge is to develop technology that is relevant to small farmers and to enable them to transform their farms into viable small businesses that make a vital contribution to local and national economies. This calls for client-oriented agricultural research.

In the past, agricultural research had worked as if farmers and end-users had nothing to say about the technologies and priority was given to cash crops research (cotton, coffee, cocoa, rubber, etc). Research on food crops was almost forgotten; but as soon as it was embarked upon, the same trend of linear top-down syndrome dominated so that research innovations were not effectively adopted. Several reasons may explain the aversion to technology adoption by the end-users. The main reason suspected in the 1950s and 1960s was that farmers were “ignorant” so that intensification of extension teaching was then targeted as the appropriate solution [14]. This view, however, divided farmers into innovators and idlers. The salient fact as disclosed by Asiabaka (1994) [15] is that it is not really true that farmers are ignorant; rather they have solid experience of agricultural activities and know what they need, meaning that the ideal solution would go beyond intensification of extension services. From the 1980s to the 1990s, it was discovered that the technologies developed did not tally with the farmers’ objectives. Therefore, it became imperative that farmers be involved at every stage of decision-making in the process of technology development and transfer and that a participatory approach should be designed to suit this process.

One of the challenges today is to effectively involve clients of the research system to generate more demand-driven research-for-development agenda. The institutional models for achieving this include, among others, the involvement of farmers and farmers’ organizations in the governance of agricultural research, and various types of contractual relationships with clients in executing research [11]. Another challenge is the strategy of decentralization being pursued in many countries. This is meant to bring publicly-funded service providers closer to their clients. The question, therefore, is whether decentralization and empowerment can actually lead to the required radical shifts in the flow of funding, to effect increasing funding flow to the end-users. If so, then who should contract the needed research services? For this to be feasible, we would need a good governance structure that is acceptable to all the stakeholders along the technology development and commodity consumption chain. This paper reviews the performance of agricultural research during the last two decades and discusses what is hindering the visible impacts of agricultural research on the growth of Africa’s economy and suggests a governance structure that can lead to the development of technologies that are acceptable to, and adoptable by male and female end-users for a better agricultural and economic growth..

2. Review Methodology

The paper is developed from a comprehensive review of peer-reviewed literature and an extensive review of the grey literature. A primary literature search was done online by visiting agricultural research and development sites such as The United Nations Food and Agriculture Organisation (FAO), The International Fund for Agriculture Development (IFAD), the International Food Policy research Institute (IFPRI), and also the Access to Global Online Research in Agriculture (AGORA) website using the various keywords for our research (Impact, Agriculture, Africa, Economic growth, etc). The grey literature search involved reference lists from other papers, the websites of the International Center for Agricultural Research, discussions with colleagues and searches in AfricaRice library. The authors individually reviewed the papers and reports, and prepared summaries that were discussed and agreed upon before the elaboration of the paper, The various draft were discussed and contributions from each author was integrated.

3. An Overview of Agricultural Research: What Was Achieved from 1990 to 2010?

For the preachers of the “gospel of agriculture”, such as Meijerink and Roza (2007) [16], the 1990’s was a decade of “agro-pessimism”. This means that the promise of agricultural development did not materialize, especially in SSA where it was believed that agricultural development would bring economic development as was the case of the Asian green revolution (Figure 1). However, an overview of the impact of research in agriculture for developing countries conducted by Waibel (2006) [17] revealed that past investments in agricultural research paid off considerably and yielded high rates of returns. This was also demonstrated by Alston *et al.* (2000) [18] who based their conclusions on several studies conducted in the United States of America (USA) and in developing countries.

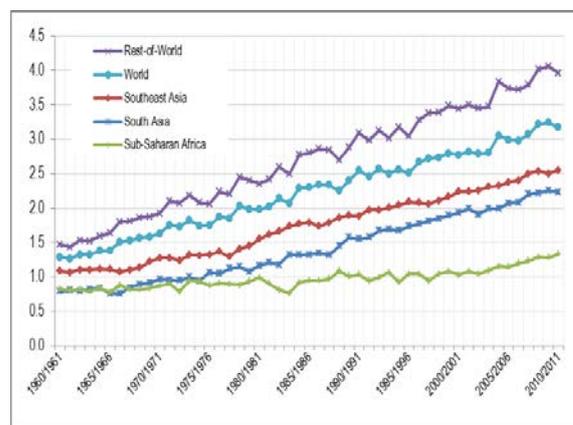


Figure 1. Average cereal grain yield (mt/ha) from 1960 to 2010 (Source: Will Masters (2011) [7] Retrieved from the web on)

Raitzer (2003) [19] conducted a meta cost-benefit analysis of all the investments in agricultural research at the International Agricultural Research Centres of the Consultative Group on International Agricultural Research (CGIAR) using two overarching principles: (i) high

degree of transparency, i.e. studies that had clearly derived key assumptions, provided a comprehensive description of data sources, and had a full explanation of data treatment; and (ii) “demonstration of causality”, i.e. studies that used a plausible counterfactual and demonstrated concise institutional attributes of the impact. The study revealed that an aggregate investment of \$ 7,120 million (1990 US dollars) produced benefit/cost ratios higher than 1, indicating efficient investments. The study also showed that research projects have generated more than 90% of the total CGIAR benefits. Over 80% out of this is attributed to plant genetic improvement, and the remainder to cassava mealy bug biological control. A negligible proportion is attributed to policy research [17]. Similarly, the average internal profitability rate for investments made on research and dissemination of Sahel varieties of rice in the Senegal River Valley is estimated at over 221%, which is considerably higher than the cost of access to capital valued at 18% for the period 1995-2004 [20].

3.1. Indicators of Agricultural Research Impacts in Africa

A holistic evaluation of the impact of agricultural research demands both qualitative and quantitative approaches. Consequently, the actual volume of the contribution of agricultural research cannot be measured because of insufficient research coverage and lack of appropriate qualitative evaluation techniques. Furthermore, because many African countries have small economies, inadequate capacities and resources to undertake their own basic research, but share similar agro-ecological and socio-economic conditions, the need for greater regionalization of Research and Development (R&D) arose [21]. This regionalisation was well accepted by the national R&D systems, and materialized in the establishment of the Forum for Agriculture Research in Africa (FARA), the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), the West and Central African Council for Agricultural Research and Development (CORAF/WECARD), and recently the Coordination of Agricultural Research and Development for Southern Africa (CCARDESA). Consequently, the agricultural challenges facing each major sub-region are in some respects similar with regard to the need to increase investment in agricultural R&D, to increase the yields of many basic food staples, to improve agriculture research capacity and infrastructure. The differences for regional approaches, occur in the range of key food staples, agricultural production systems, and constraints; the characteristics of individual economies; the current performance; and the degree of integration through trade [22,23] This paper will refer to the regional impact but also to the national impacts as well.

3.1.1. Impact of Crop and Livestock Commodity Research on Economic Growth

A review of the activities of the CGIAR over its first 40 years of existence revealed forty major achievements related to crop and livestock commodity [24]. These include:

Maize improvement in West and Central Africa (1971 to 2005); improved varieties were derived from the

CGIAR and their National Agricultural Research Systems (NARS) partners’ research, with increase in adoption of improved varieties from less than 5% in the 1970s to about 60% in 2005 and with annual economic benefits estimated at \$2.9 billion, an increasing trend over time, and an overall rate of return to research investment (CGIAR and national) of 43% [25].

Improved varieties of cowpea, which provide both food and livestock feed, are being widely adopted in the dry savannah of West Africa, with estimated benefits of \$299 million to \$1.1 billion which is still expected to accrue during 2000-2020.

Eastern and Southern Africa have also registered impressive gains, where improved varieties of common bean, developed with farmer participation, have been adopted on about 50% of the total bean area over 15 years. A study conducted in 2008 estimates that the new varieties are strengthening food security and raising incomes in 5.3 million rural households. The benefits of bean improvement research for Africa are estimated to have a current value of roughly \$200 million, compared to costs of about \$16 million [24].

New Rice for Africa, or NERICA, which combines the high yields of Asian rice with African rice’s resistance to local pests and diseases, has spread to about 250,000 hectares in upland areas, helping to reduce national rice import bills and generating higher incomes in rural communities.

Recent research has also begun to document nutritional benefits from improved crop varieties. In Mozambique, the introduction of new orange-fleshed sweet potato significantly increased the intake of vitamin A among young children [26]. In Kenya, Farm Concern International undertook a woman targeted work on commercialization of traditional leafy vegetables, the intervention of which was later shown to be effective in increasing consumption of the micronutrient-rich vegetables [27]. Millet also was found very beneficial because of its high content of the minerals phosphorus, manganese and magnesium [28,29].

The first livestock-related impact listed regards the development of a vaccine against an ‘orphan’ livestock disease of poor people in Africa. The production and delivery of a vaccine for East Coast fever — a tick-transmitted disease that threatens some 25 million cattle in 11 countries of eastern, central and southern Africa — is being placed in the hands of private sector partners. It is expected to save more than a million cattle, with benefits worth up to US\$270 million a year in the countries where the disease is now endemic [24].

The second livestock-related impact listed concerns a change in policy that enables poor producers of milk to grow their businesses. Development impacts depend on not just new technologies but also better policies that offer rural people the means and incentives to invest in sustainable agricultural production and resource use. While it is hard to measure, the impacts of CGIAR policy research and advocacy appear to be substantial, as suggested by recent case studies indicating benefits of several millions of dollars. Research and advocacy aimed at decriminalizing the marketing of milk by small-scale vendors in Kenya created benefits for producers and consumers with an estimated value of \$44-283 million [24].

3.1.2. Impact of Natural Resource Management Research on Economic Growth

Research results on natural resource management have proved harder to implement and evaluate than work on crop improvement. Nonetheless, a set of seven case studies published in 2007 [30] indicates that such research is giving highly positive returns on investment, based partially on the benefits for agricultural productivity. If methodologies were available for gauging the environmental benefits as well, the returns would no doubt be much higher. By 2002, more than 66,000 farmers in Zambia had adopted an agro-forestry system called “fertilizer tree fallows”, which renews soil fertility using on-farm resources [31]. The system has been shown to boost maize production while reducing production risks and soil erosion, with benefits of up to \$20 million, compared with an investment of about \$3.5 million. In Malawi, an integrated agriculture-aquaculture system, introduced during the mid-1990s with active farmer participation at a cost of \$1.5 million, has created benefits worth nearly \$3.5 million by doubling the income of rural households and dramatically increasing fish consumption [32].

3.1.3. Impact of Agricultural Research on Nutrition

Berti *et al.*, (2003) [33] in their review of impact of agriculture interventions on nutritional status of households found that interventions that invested broadly in different types of capital were more likely to improve nutrition outcomes and that projects which invested in human capital (especially nutrition education and consideration of gender issues), and other types of capital, had a greater likelihood of effecting positive nutritional change, but such investment is neither sufficient nor always necessary to effect change. They [33] also revealed that most agriculture interventions increased food production, but did not necessarily improve nutrition or health. Furthermore, in the last few years, there has been increase of interest in how to shape agriculture for more impacts on nutrition, particularly among mothers and children [34,35]. Reviews conducted by several authors [33,36,41] concluded that the current state of empirical evidence for impacts on nutrition ascribed to defined agricultural interventions is weak and mixed. The statistical significance of impacts has been documented in a few cases, mainly in terms of micronutrient status (usually Vitamin A). However, net effects across all nutrients have not been documented and there is apparent lack of sound, empirical evidence on efficacy, effectiveness at scale, and cost-effectiveness of all kinds of agricultural intervention on nutrition remains a significant barrier to policy advocacy and investment. It is therefore time for methodologically rigorous studies that can produce findings which offer guidance on how best to leverage agriculture’s potential for nutrition [42]. It is encouraging to note that a gap analysis of impact of agricultural research on nutrition, has been already conducted [43] and identified 151 research activities ongoing or planned focussing on the agriculture-nutrition linkages in which more than 50 organizations are involved (the Bill and Melinda Gates Foundation, the United States Agency for International Development (USAID), the Canadian International Development Agency (CIDA), the International Development Research Centre in Canada

(IDRC), and the Department for International Development of the UK (DFID).

3.1.4. Impact of Agricultural Research on Poverty Reduction and Food Security

Poverty and hunger are closely linked and form a vicious circle. In many ways, hunger can be considered the severest form of poverty. People are willing to sacrifice many needs such as clothes, shelter, health care, and education before they surrender to hunger [44]. Several studies conducted to evaluate the impact of agricultural research in Africa widely demonstrated the positive impact of agricultural growth on poverty reduction and food security with a major component of this growth being driven by investment in agricultural research [45,46,47,48]. High rates of return are commonly achieved from agricultural research and development as seen in a comprehensive statistical analysis undertaken by IFPRI that indicates an average return of around 60% per year for research in developing countries [18]. In spite of this, however, investment in agricultural research has declined since the mid-1980s [48] and discussions still abound concerning how best to organize and manage international and national agricultural research.

Thirtle *et al.* (2003) [49] explored the relationship between agricultural productivity and poverty in 48 developing countries between 1985 and 1993. It was found that a 1% improvement in crop yields reduced the proportion of people living on less than US\$1 per day by 0.6. Fan *et al.* (2003) [50] also reported that rice varietal improvement research has contributed tremendously to increase rice production in several countries. In each country, the benefits from rice research are, on average, 10 times higher than the total agricultural research investment. Research has also helped to uplift large numbers of the rural poor above the poverty line. According to more recent impact assessment studies in SSA [51]–[54], national and international organizations are making a big impact in reinforcing food security and alleviating poverty through rice research. Rice varietal improvement contributed, on average, US\$375 million per year to the region’s economy. Overall, improved varieties have increased net revenues by \$93 per hectare, with the highest gains in irrigated and rain fed lowland ecologies. The annual returns to investment in rice research now exceed 20%. Studies also revealed that, without varietal improvement, the regional balance-of-payment deficit for rice imports would have been 40% higher [55]; moreover, an additional 658,000 hectares of land would have been required to maintain current levels of consumption. NERICA, developed by AfricaRice and its partners, is a well-known breakthrough. It is considered as one of the major recent advances in rice variety improvement. There are many reports of NERICA’s positive impact on farmers’ livelihood across SSA, from Guinea in West Africa to Uganda in East Africa. Impact studies also reveal that rice research contributes effectively to the realization of almost all the Millennium Development Goals, including halving levels of poverty and hunger, promoting education, improving health, reducing child mortality, empowering women and ensuring environmental sustainability [56].

Evaluation of the impact of rice research on food security has shown that rice research is the single largest

documented source of agricultural research benefits in the developing world [57]. Annual economic benefits from research enhanced rice productivity, as documented by CGIAR centres and their partners, by more than \$19.5 billion. This is nearly 150 times the combined annual investment in rice research as provided by IRRI through the national systems. Ironically, rice research is the source of roughly half of all documented benefits from the CGIAR system, although it has usually received less than 10% of CGIAR expenditures [58]. Other analyses have also shown that research-enhanced productivity on rice is the largest expected source of future impact for the poor among focal crops for agricultural research. For example, the World Bank Development Research group of analysts have found that the productivity growth rate for rice has more than doubled the global poverty reduction potential of any other agricultural product. In the same way, a study by the agricultural economists of the International Institute of Tropical Agriculture (IITA) show that maize research in West and Central Africa pays off and that the generation and diffusion of modern maize varieties in SSA lifted more than one million people out of poverty within three decades (1971-2005) [59]. The study further revealed that maize improvement research had a benefit-cost ratio of 21 in the region. This means that every dollar invested in maize research generated additional food worth \$21. Estimates for country-level benefit-cost ratio ranged from 11 (Mali) to 84 (Nigeria), with an average rate of return of 43% in West and Central Africa. Since maize and rice are major staples in large regions of Africa, it is clear that investment in agricultural research is yielding perceptible impacts on food security and poverty reduction.

4. What Needs To Be Changed?

In spite of the litany of benefits derived from agricultural research outlined above, the number of hungry people grew from 175 million to 239 million in Africa during the period of 1990-1992 to 2010-2012 [60], while the number of people living below the international poverty line has increased from 289.7 million in 1990 to 386.0 million in 2008 [61]. Two thirds to three quarters of the rural poor live on agriculture where they, like the urban poor, critically depend on sustained productivity growth for affordable food [62]. The explanations frequently cited include geography and environmental decline [63] poor policies and institutional failures [64]-[65]; lack of technology; unfavourable external conditions; lack of effective demand for farm output; continuing government failures that frighten investors; and market failures that also discourage investment [63]. It is true that Africa is endowed with natural resources. However, they are not always of high quality and there are many substantial natural limitations to agriculture; climate change, bad soil quality, higher disease and pest pressure are constraining African agriculture which heavily depends on rainfall in many sub-regions. But, it is believed that that things are getting worse, because of the natural resources degradation resulting from population growth, including deforestation for fuel wood, overgrazing and other unsustainable land management practices leading to widespread soil fertility decline [66,67]. This

takes place while most African farmers already use too little fertiliser to maintain the fertility of their soils [67,68]. In 2006, a report from the International Centre for Soil Fertility suggested that African soil nutrients were, on average, depleting five times quicker than they were renewed [69].

The need to better understand, prioritize and meet the pressing global challenges facing resource-poor agricultural communities is overwhelming [70].

The Global Conference on Agricultural Research for Development (GCARD) identified a number of current practices which suggest the need to repackaged agricultural research to induce clearer visibility of its impacts. These practices invariably comprise conceptualization, processing and delivering in agricultural research.

4.1. The Conceptualization of Research for Development

The adoption of the United Nations' Millennium Development Goals (MDGs) was followed by the adoption by the African heads of state and government of the Comprehensive African Agricultural Development Program (CAADP) [71] inspired by the New Partnership for Africa's Development (NEPAD). The basis for CAADP was the realization that "Agricultural development is fundamental to cutting hunger, reducing poverty, generating economic growth, reducing the burden of food imports and opening the way to expansion of exports" [4]. Agricultural research, technology dissemination and adoption are the fourth "pillar" of CAADP and have the potential for producing long-term benefits. They work closely with partners like the United Kingdom Department for International Development (DFID)'s 'Research into Use' (RIU) program which aims to boost the support available to help farmers to adopt new options. RIU focuses on ensuring that research results are put into use in the field, and on out-scaling and up-scaling workable options that can improve farmers' lives. RIU strongly supports both the Forum for Agricultural Research in Africa (FARA) and CAADP by funding events, providing training, and helping CAADP to develop the key partnerships used to produce the CAADP brand and broad communication system. CAADP has affected the scaling up of support to science and technology programs at the regional and national levels. This support includes funding for the sub-regional research organizations such as CORAF/WECARD, ASARECA, as well as national programs in Ghana, Mali, Senegal and Kenya. At the national level, the "second generation" poverty reduction strategy paper is being used to aid the implementation of CAADP [12].

Unfortunately, the interlinked nature of the four "pillars" of CAADP is weakened. In addition, there is no emphasis on research by the NARS on reducing under-nourishment. Thus there are cases of malnutrition in the face of abundant food supply because of the lack of integrating researches on crop production, nutrition and health. Also, research on the processing of farm produce in SSA is missing in the agenda of all the programs [12]. Besides the absence of programs for attracting increased participation of the private sector in African agricultural research, there is insufficient investment in university education for science and technology [12]. Consequently,

another major problem facing national agricultural R&D systems is the aging of qualified researchers. Traditionally, Africa has had a pro-public sector research approach, often regarding the private sector as capitalistic and exploitative. Efforts made towards involving the private sector mostly evolved into the formation of parastatals (quasi-private organisations). Agricultural research is still far from being a priority for political decision-makers. During the 1990s, state investments in agricultural R&D diminished annually by 0.2% [72]. The structural adjustment programmes during this period restricted the public sector in the various countries. Consequently, state investments have decreased or remained stagnant in many African countries despite the positive effects of agricultural research.

A consultative process has been established through the FARA-Sub-Regional Organisation for strengthening agricultural research-CGIAR-NARS (FARA-SRO-CGIAR-NARS) Training Groups. This is meant to ensure that training responds to African needs. The overall goal is to enhance the NARS' capacity in agricultural research, for incorporating appropriate elements of sustainable use of genetic resources [4] organic agriculture or climate smart agriculture for resilience and sustainability [73], integrated pest management, policy research, biotechnology, information technology, technology dissemination and farm-level impact assessment.

4.2. The Processes

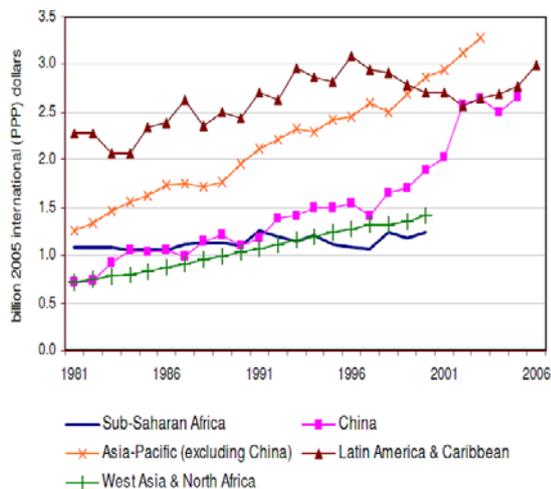


Figure 2. Public agricultural research and development investment trends in developing countries, 1981–2006 (Source: Beintema and Stadt (2010) [72])

As stated earlier, the capacity of African Agricultural scientists is low. Staatz and Dembele (2008) [74] noted that half of a sample of 48 SSA countries had fewer than 100 full-time equivalent (FTE) scientists where 40% were working in five countries namely, Ethiopia, Kenya, Nigeria, South Africa, and Sudan. Africa contributes only 0.3% to the capital of worldwide scientific results and has only 70 researchers to 1 million inhabitants compared to 4,380 in Japan [75]. Moreover, Africa has a poor capacity for innovation [76] with a menial ability of the national scientists to form meaningful productive partnership with scientists from either the CGIAR or Advanced Research Institutions. There is no strategy by national governments, their development partners and the CGIAR system to

direct investment into building and returning a new generation of agricultural scientists. Apart from Botswana, Mauritius and South Africa, most African National Agricultural Research Institutions (NARIs) are short of funds [77]. They depend mainly on donors to support up to 75% of their budgets for research funding and sustenance. Consequently, due to competing demands, investments in agricultural science and technology have stagnated over time in many developing countries (Figure 2).

Moreover, most public information domains are still not widely accessible to African agricultural research institutions. Beintema and Rahija (2011) [78], in their communication at the ASTI/IFPRI-FARA conference in Ghana, reported the existence of large variations in research capacity and growth over time by countries and observed high staff turnover and brain drain whereby researchers leave their institutions due to low salaries and inadequate conditions of service [79].

The United Nations Food Conference of 1974 projected that, for effective national development through agriculture, the NARS in Africa must increase their research expenditure to 0.5% of Agricultural GDP (AgGDP). The United Nations Food and Agriculture Organization (FAO) and the World Bank, respectively, recommended 1 and 2% [80]. Nonetheless, in 2002, the average was 0.54% [81] - Only four countries spent over 2.0% of their AgGDP on research; 22 countries spent less than 1.0%, while 11 countries recorded less than 0.35%. Data from IFPRI [82] revealed stagnation in agricultural spending in the 1990s where region-wide funding grew by only 20% between 2001 and 2008. The data show that Nigeria had the highest level of spending which shows tremendous increase ranging from US\$110 million in 2001 to US\$404 million in 2008. Seven other countries including South Africa invested more than US\$50 million each in 2008. The complaint was that many African countries have suffered unstable inflows of donor funding and development bank loans leading to a dwindled spending in some countries since the turn of the millennium. Therefore, there exists growth retardation in some 13 nations such as Guinea, Burkina Faso, Gabon, Mali, Mauritania, Senegal, and Togo in West and Central Africa and Eritrea, Ethiopia, Malawi, Mauritius, Namibia, and Zambia, and in East and Southern Africa. This has severely weakened some research institutes [83].

Private sector spending represented only 2% of all agricultural funding in 2000, and most of this was in South Africa [84]. Conversely, the completion of large donor-funded projects, and the subsequent withdrawal of funds, has precipitated severe financial crises in some countries.

African heads of state, during their meeting in Mozambique in 2003, pledged to allocate 10% of their national budgets to agriculture by 2008. Burkina Faso, Ethiopia, Ghana, Guinea, Malawi, Mali, Niger and Senegal have exceeded this target and most others have made significant progress towards it [85]. CAADP's agricultural growth target is 6% and, of the 42 countries investigated, 10 (Angola, Ethiopia, Mali, Mozambique, Namibia, Niger, Rwanda, Senegal, Tanzania, and Uganda) have exceeded this target while four others (Democratic Republic of Congo, Ghana, Malawi, and Sierra Leone) achieved 5-6% (Figure 3).

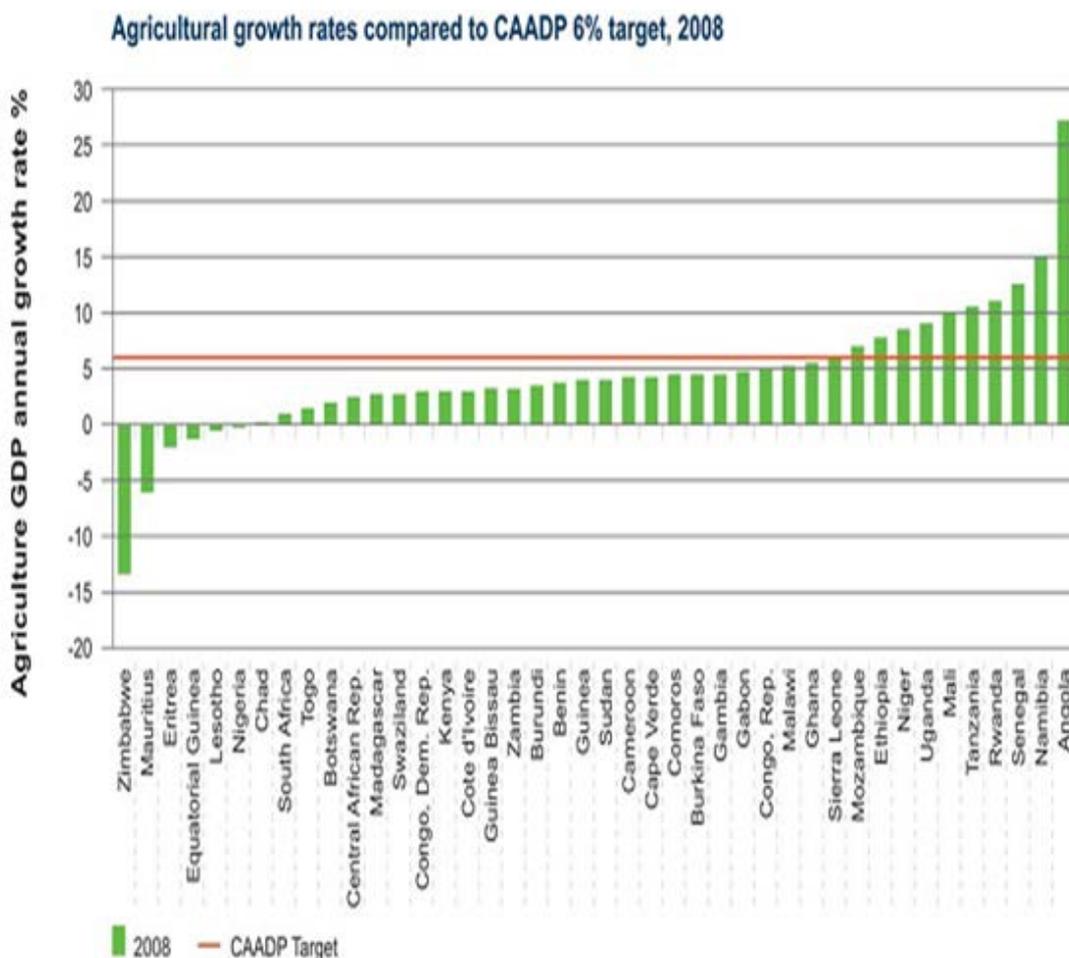


Figure 3. Agricultural growth rates compared to CAADP's 6% target (Source: World Bank 2009 [84])

4.3. The Delivery

The extension services are insufficient and there is no interaction and coordination of research. The private sector contributes about 2% to research support [12] thus proffering very limited leverage for the coordination of agricultural research. This situation discourages client responsiveness, organizational collaboration and partnerships, thereby causing a lack of impact orientation and system linkage, both within and among institutions [86]. The CGIAR's (2005) [87] report on SSA Task Forces shows the absence of credible mechanisms for effective interaction and a high level of competition among Centers causing a duplication of efforts and failure to ensure that programs are aligned with the priorities of the sub-regions. The Framework for African Agricultural Productivity [88] was thus developed to provide guidelines and criteria for encouraging implementers and investors to work in harmony and at an appreciable sustainable scale to achieve the African vision.

5. Re-packaging Agricultural Research for Development

For an efficient agricultural sector, there should be appropriate innovations to combine adequate funding, partnership at all levels, a good information sharing system, adequate research and market infrastructure, and concerted governance.

5.1. Funding

Finance is a key element that serves as a tool for tidying up and transporting research innovations from source to end-users. Agricultural research impacts can be more visible and expanded only through adequate investment by supporting appropriate research capacity and infrastructure. Hence, Mokwunye (2010) [12] suggests that researchers should diversify their sources of funding and national governments should address under-investment. Headey *et al* (2009) [89] used expert surveys by interviewing senior policymakers in ministries of agriculture, ministries of finance, planning authorities, and donor agencies, in two selected sub-Saharan African countries – Uganda and Ghana and found out that the under-investment in agriculture sector could be attributed to “a range of institutions and processes, including weak and inconsistent political leadership, ineffectual and organizationally dysfunctional ministries of agriculture, and budgetary processes that disadvantage both short term spending and long term planning in agriculture”. Calestous Juma, an international development researcher at Harvard University says that “No country has ever been able to sustain agricultural growth without consistent research and development” [90]. He calls on governments, funding donors and researchers in the region to collaborate more closely to maximize the potential of agricultural research and that African states should substantially increase budget for agricultural research. In 2010, the

GCARD recommended that developing countries must work towards endogenous funding by allotting at least 1.5% of GDP to agricultural research for better socio-economic transformation of African countries.

5.2. Leadership Model

There is a crisis of management, with top-heavy bureaucracy, centralization of decision making, and lack of incentives for the innovation process for effective research [91]. The leadership model used by Pillar IV of CADDP could be ideal for greater success. The model involves the expectant beneficiary actors while being imbedded in effective governance with components of a good governance system. Improved governance and accountability systems can make an important contribution to the performance of agricultural research organizations [92] and restore coordination and cooperation in the agricultural research system. "Governance" in this context specifically refers to the process of decision-making and implementation. Reform should include the induction of the effective participation of actors in the value chain and redefinition of the relationships between researchers and other relevant professionals. It should be characterised by partnership at all levels, a hybrid of partnership, based on consultation within planning, implementing, evaluating and optimizing research results. This form of partnership will encompass:

- The rule of law which, according to Hamilton (2008) [93], entails the expectation that the rights of people, their relationship with others and the role of government and its impact on people's lives will be determined by established and knowable rules.

- Transparency: - For Parigi *et al.* (2004), [94] "transparency means that decisions taken and their enforcement are done in a manner that follows rules and regulations". Information is freely available and directly accessible to those who will be affected by such decisions and their enforcement. The international agricultural research system has developed into a network comprising scores of actors within a very large number of organisations from field to national level and in many different countries. The fact that this network is highly decentralised increases the need for transparent and flexible working tools.

- Responsiveness- a model to meet the objectives of the agricultural sector through the development of innovative institutional models that encourage the participation of alternative research funders and suppliers [91].

- Participation - Men and women should be the cornerstone for good governance and the top-down, gender-indifferent approach should be avoided to pave the way for the spread of knowledge to boost the adoption of innovations. This is because technology targeted for poor farmers requires even greater effort for adaptation to local conditions, given the complexity and diversity of the production systems [95]. Qualitative transformation cannot be effected by agricultural research alone due to the diverse production conditions in Africa. Interaction among actors is highly desirable.

- Equitability and inclusiveness - Agricultural research stimulates interaction and interactive learning among the various stakeholder groups involved in agricultural value chains and should ensure the combined contribution of all

stakeholders, including farmers. Agricultural research dully responds whenever knowledge and information are needed in order to augment rather than replace the existing knowledge [8].

Consensus-orientation - A proactive participation of stakeholders is required in the governance board where a predefined participatory approach is used. Stakeholders, being the major target users of innovation, are required to define research priorities and ensure their implementation.

Accountability - Ideal agricultural research governance involves changes in the way researchers are evaluated, their behaviour and attitudes towards the production environment. Furthermore, all institutions should have a good communication strategy to relay messages among researchers and to other stakeholders (farmers, extension workers, decision makers, etc.).

5.3. Practical Packaging of Research for Development: Case of the Africa Rice Center

This section presents the example of AfricaRice and its tradition of partnership with NARS scientists, international research centers and other agents of change, such as NGOs, extension services, universities, and the top management of research institutions.

5.3.1. AfricaRice and Its Unique Modus Operandi

The Africa Rice Center (AfricaRice), formerly the West African Rice Development Association (WARDA), was created in 1971 by 11 West African countries. Today, it comprises 24 member countries in West, Central, East and North African regions¹. It is currently the leading pan-African rice research organization with the mission to contribute to poverty alleviation and food security in Africa through research, development and partnership activities. It seeks to increase rice sector productivity and profitability to ensure sustainability of the farming environment. The approach is partnership at all levels. AfricaRice conducts research and development activities in collaboration primarily with the NARS, academic institutions, advanced research institutions, farmers' organizations, NGOs, and donors. This is targeted for the benefit of African farmers, mostly small-scale producers, as well as the millions of African families for whom rice is the staple.

5.3.2. Partnership with Scientists and Other Agents of Change

Since its early days, AfricaRice adopted the "Task Force" approach, which ensured the constant flow of knowledge and broad consultations with stakeholders. This approach has been indispensable for achieving technology development, dissemination and adoption. The Task Forces metamorphosed into the ROCARIZ² which structured itself around a multi-country, issue-driven 'Task Force' that decentralized the international research agenda to the NARS [96]. The aim of ROCARIZ was to link together rice stakeholders in West and Central Africa to generate improved and relevant rice technologies, and facilitate their rapid transfer to end-users by enhancing the

¹ The 24 countries are Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Côte d'Ivoire, Democratic Republic of Congo, Egypt, Gabon, the Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Madagascar, Mali, Mauritania, Niger, Nigeria, Republic of Congo, Senegal, Sierra Leone, Togo and Uganda.

² ROCARIZ (a French acronym) stands for West and Central Africa Rice Research and Development Network.

capacity of the National Agricultural Research and Extension Systems (NARES). This enhanced capacity boosted participatory rice research planning, technology generation, evaluation, and transfer. The network increased knowledge sharing and improved the capacity of NARES staff which is a credit to the *modus operandi* of the Task Force. The learning-by-doing approach was used by the network to engage the national partners and AfricaRice scientists as equal partners in all aspects of the research-for-development cycle. The cycle covers idea generation, priority setting, fund raising, work planning, building collaborative teams, project execution, monitoring and evaluation, and reporting. CORAF/WECARD's decision to merge its cereal networks in 2005 compelled AfricaRice to explore other means of continuing its rice R&D partnership with the NARES. At present, there are 6 Task Forces through which collaboration is being reinforced to achieve the priorities set for research-for-development. These are: Rice Breeding Task Force, Rice Agronomy Task Force, Rice Processing and Value Addition Task Force, Rice Mechanization Task Force, Rice Policy Task Force, and Gender in Rice Research and Development Task Force. The Task Forces are facilitated by AfricaRice and have decentralized governance decided by the members.

5.3.3. Partnership Model with Other CG Centers and Institutions

AfricaRice is one of the architects of the Global Rice Science Partnership (GRiSP), which was the first CG Research Program (CRP) to be approved by the Fund Council and the CGIAR Consortium Board in November 2010. It is led globally by the International Rice Research Institute (IRRI), based in the Philippines. AfricaRice is responsible for implementing GRiSP in Africa. Implementation will also occur through the CRP led by the International Water Management Institute (IWMI) on 'Durable solutions for water scarcity and land degradation' and the CRP on 'Climate change, agriculture and food security' led by the International Center for Tropical Agriculture (CIAT). It is expected that links will be established with the CRP on 'Policies, institutions, and markets to strengthen assets and agricultural incomes for the poor' led by the International Food Policy Research Institute (IFPRI) and the CRP on 'Integrated systems for the humid tropics' led by the International Institute of Tropical Agriculture (IITA). Other co-architects of GRiSP are the Centre de coopération internationale en recherche agronomique pour le développement (CIRAD), Institut de recherche pour le développement (IRD) and Japan International Research Center for Agricultural Sciences (JIRCAS). Collaboration will also be established with emerging strong national research systems, notably those from Brazil, China, Egypt, and India. Advanced research institutes and universities in developed countries are also playing a key role, mostly in conducting basic research that is beyond the capacities and comparative advantages of CGIAR centers and other partners. In addition, collaboration is being established with international organizations and centers such as the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), the Centre for Agricultural Bioscience International (CABI)

and the International Center for Development-oriented Research in Agriculture (ICRA).

Ten conditions (Box 1) have been recognized as being essential for the success of this complex partnership [97]. They may be summarized in a single sentence - "Partnership is not something that is superimposed on research activities; real partnership is an integral part of research activities that are conducted by the common will of collaborating scientists, to find common solutions to rice farmers' constraints in the world."

Box 1. Ten conditions for the success of Global Rice Science Partnership (GRiSP)

1. Exclusion of hegemonic thinking. This will disprove the initial belief at AfricaRice that the world can evolve with and through diversity alone and that it is the synthesis of these differences that will make for a way forward.
2. Regional differences should be taken into account. Africa and Asia for instance are entirely two entirely different regions. Similarly, each of them differs from Latin America. At any instance, the area of intervention should determine the methods to be adopted. Basic preoccupations under consideration should serve as a guide even in the face of exploiting complementarities.
3. Institutional identities should be respected. This factor is particularly essential for AfricaRice. For example, all flags should be made to fly in GRiSP. This is a call for a co-existence among all the member countries.
4. There should be equity in resource allocation based on the real needs as expressed by the various continents. The specific countries involved should participate in deciding the resource allocation.
5. Bureaucratic bottlenecks should be removed. This inadvertently increases transaction cost. Research funds should be strictly used for research and not for bureaucracy: the simpler things are, the better it is for all of us.
6. Decisions of governing bodies should be respected. Failure or neglect of this could lead to hegemonic thinking which counteracts our partnership model thereby leading to diluted accountability and lack of transparency.
7. There should be a concerted effort towards strengthening all stakeholders, especially African stakeholders, to strengthen the operational capacity of all entities involved. Adequately equipping farmers, processors, and others for ownership and adoption of technological innovations is the vital target.
8. Meaningful impact requires a conducive environment and adequate incentives, which is the sole responsibility of policy makers. Communication channels should be established with policy makers. In Africa, the Council of Ministers provides a platform for direct dialogue with 24 ministers at each sitting. The objective is to present a comprehensive analysis of the current situation of rice production, propose solutions and formulate a number of concrete and pragmatic recommendations to optimize production. This is a credit to the AfricaRice policy makers
9. NARES have an important role to play. NARES should no longer be viewed solely as consumers of ideas but as both consumer and producers. They should have the means to effectively express their creative genius like their peers within this partnership.
10. The trend of over-assessment and over-reporting should be broken as it makes scientists spend more time in preparing their assessments than in doing research. To avoid all this, rules must be defined and trust established. Effective mechanisms should be established to maintain order.

AfricaRice is establishing the "rice sector development hubs" to involve a large number of farmers and other rice value chain actors such as rice processors, rice millers, and rice marketers. These hubs will be the testing grounds where thematic scientists from AfricaRice and other agents of change from the Task Forces and partners will join efforts to generate appropriate technologies using integrated research-for-development protocols and following a reverse-research approach. This type of research process will exploit a combination of approaches

whereby the producer-consumer preference with those of other value chain actors would be required. Through this multifaceted partnership, AfricaRice and all the stakeholders ensure:

- adequate funding to support research activities, infrastructure and human resources;
- a good and practical information sharing system to enhance effective communication between researchers and stakeholders;
- good governance that follows the rule of law, is accountable, transparent, responsive, equitable, inclusive, effective, efficient and participative.

6. Conclusion

Agricultural research and technology adoption have impacted food supplies and poverty alleviation. Yet, roughly one billion people go hungry every day and 1.4 billion live in extreme poverty, indicating that more effort is needed to address the main challenges and opportunities facing agricultural research, technology generation, knowledge dissemination and delivery systems. Agricultural research systems need to be adequately funded and handled by skilled human resources under good governance. Defining innovative agricultural policies in Africa requires a break from the past in order to 'produce more and better'. Clearly, a framework of co-construction, co-execution and co-evaluation is necessary for successful farming. Each actor in the agricultural value chains has a contribution to make and it is the sum of the various individual contributions that leads to new knowledge and processes. It is therefore important for the various actors to maintain dialogue in order to establish effective innovation systems. Africa has suffered long enough from dirigisme (a form of dictatorship whereby initiatives and decisions are undertaken by the ruling bodies and imposed on the production units), low productivity and non-systematic approaches. These have led to the neglect of strategic areas such as research and extension, marginalization of professional organizations in policy formulation and assessment, and the prevailing non-conducive environment for private sector involvement. Consequently, a change in mindset is essential and should encompass all actors, public and private. An improved distribution of responsibilities is required and should be the result of dialogue, dictated by merit, involving all the actors at all stages of the value chains. Africa can and should reject a fatalistic attitude. After all, it has sufficient water and land, large human capital and a number of unused technologies. The continent must reframe its rural development by daring to think differently and invest in its future by embracing a framework of information and cooperative analysis.

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