

## **Encouraging Private Investment in Agricultural Research: Myth or Necessity for Developing Countries**

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**Joshua Ariga [1], Economist with the International Fertilizer Development Center, Alabama, USA**

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### **Introduction**

A number of studies show that declining soil fertility and natural resource degradation, population pressure, limited arable land, stagnant productivity and declining per capita food production in Sub-Saharan Africa do not augur well for sustainable agricultural development (Nkamleu *et al.*, 2003). The focus for many developing countries is on increasing both public and private investments for improving the performance of the agricultural sector; an issue that is being pursued at national, regional and international levels. For instance, the Comprehensive Africa Agriculture Development Programme (CAADP, <http://www.nepad-caadp.net/>) of the African Union (AU) keeps track of each member state's progress towards the goal of attaining agricultural investments of at least 10% of national budgets as per the Maputo Declaration of 2003 (African Union, 2003).

Promoting growth in agricultural productivity by increasing investments in agricultural research, extension, education and training is part of CAADP's agenda, and this is complemented by the wider African agenda for the development of regional science and technology (S&T) capacity. This includes fertilizers, crop protection products, farm machinery, genetically modified organisms (GMOs), farm management techniques that raise productivity (including integrated soil fertility management (ISFM)), precision agriculture, and local knowledge that enhance sustainability. Identifying the right technologies, developing output and input markets, prioritizing agriculture in national development strategies, and private-public partnerships are important aspects for a successful research and development (R&D) and technology adoption framework (Kerr and Kolavalli, 1999; Dorward *et al.*, 2004).

Though this article will not dwell on returns of investments in agricultural R&D, the role of R&D in the economic growth of developing countries cannot be overemphasized. A number of studies have demonstrated very high payoffs, despite the lag in benefits that often accompanies

such investments (Alston *et al.*, 2000; 2010; Evenson, 2001; Thirtle *et al.*, 2003; World Bank, 2007; Maredia and Raitzer, 2006; Alston, 2010). Agricultural R&D has the potential to reduce costs and/or raise output and therefore to shift the supply curve to the right. The InterAcademy Council and other public and private agencies have recognized the critical role of S&T in economic and social development and have recommended a doubling of public agricultural R&D funding by 2015 (IAC, 2004; NEPAD, 2006).

### **Major Players in Agricultural R&D**

The composition and structure of research institutions in most countries is fairly similar and has changed very little since 2000 (Beintema and Stads, 2011). Most agricultural research is carried out by state agencies (specifically national agricultural research institutes or organizations – NARs), university faculty, non-profit institutions in interlinked relationships with producer groups from whom they collect output levies, and private for-profit companies. Additionally, there is a group of private entities (companies, philanthropies, trusts and foundations) that do not carry out actual research but facilitate it by contributing funds towards causes or specific interests. The share of R&D for government agencies has declined over time, especially in staffing capacities while time spent on research in higher education sector has increased slightly (Beintema and Stads, 2011). Some NARs institutes collaborate via loose networks or formalized arrangements with others within the same region aimed at building a critical mass of R&D staff; e.g. the Forum for Agricultural Research in Africa (FARA, [www.fara-africa.org/](http://www.fara-africa.org/)) and the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA, [www.asareca.org/](http://www.asareca.org/)).

In addition, there is the Consultative Group on International Agricultural Research (CGIAR) and other international organizations with offices, staff and funding in developing countries and networks of collaboration cutting across national, regional and continental groupings. In 2003, approximately 10% of Africa's expenditure in agricultural research came from the CGIAR (Beintema and Stads, 2011). These research centres continue to be a source of new technologies that are tested and adopted in developing countries through NARs (Maredia and Raitzer, 2006). Most of the benefits of international R&D have trickled or spilled over to developing countries through such international centres (World Bank, 2007). However, such spillovers to NARs are getting squeezed as a result of tightening of intellectual property (IP) agreements and

diversification of research emphasis in developed countries to include areas related to environmental quality and efficiency in energy production (World Bank, 2007), and away from productivity-enhancing research, which creates more opportunities for spillovers.

### **Status of Public Agricultural R&D**

While there has been growth in R&D in a handful of African countries, others have faced either stagnant or plummeting expenditures (Beintema and Stads, 2011). For the 32 countries covered by the CGIAR Agricultural Science and Technology Indicators (ASTI) study ([www.asti.cgiar.org/](http://www.asti.cgiar.org/)), public agricultural R&D expenditures and staffing levels are varied and uneven, with only eight countries spending over \$50 million in 2008. For some countries, the levels of investment are too low to make any sizable difference in rural development and poverty reduction. Beintema and Stads (2006) found that overall R&D levels stagnated in the 1980s and 1990s. However, their 2011 study covering the 2001-2008 period shows a slight reversal, with Sub-Saharan African (SSA) levels at \$1.7 billion in 2008, 20% higher than 2001 (under inflation-adjusted purchasing power parity (PPP)). There is a great deal of variability and this growth is largely driven by a few countries that account for 70% of the region's public agricultural R&D (Ghana, Kenya, Nigeria, Sudan, Tanzania and Uganda). Most of this surge went towards rehabilitating neglected infrastructure and augmenting low salaries in public research institutions. For the Caribbean countries, 41, 39, 9 and 7% of R&D investments, respectively, came from government, donors, taxes and levies, and research contracts in 2001 (Roseboom *et al.*, 2001).

ASTI reports also show that growth in R&D in some countries has been influenced by significant government funding injections, while others are substantially dependent on external funding. Governments in Brazil, India and China (representing a combined population of 2.7 billion) have increased their contribution to agricultural R&D investments in the 2001-2008 period (Table 1 in Beintema and Stads, 2010); in 2000 these investments were \$1.25, 1.30 and 2.25 billion respectively (2005 PPP). For SSA as a whole (representing a population of 800 million), public expenditures were \$1.24 billion (2005 PPP) in 2000. By 2007, China's public expenditure had nearly doubled at \$4.3 billion, while SSA followed a slower growth path to approximately \$1.7 billion (Figure 1 in Beintema and Stads, 2011). Beintema and Stads (2008ab) and Stads and Beintema (2009) find that SSA's share of total agricultural R&D from donors, development

banks, and (sub) regional organizations is relatively higher than that for Latin America, the Caribbean and Asia Pacific. For instance in Mali, Mozambique, and Guinea the share of total funding from these sources is 50% or more (Figure 6 in Beintema and Stads, 2011), while for Namibia, Botswana and Zambia the larger share is contributed by the national governments themselves. For Brazil, India and China, the government's share in R&D continues to dominate R&D investments.

Looking at average relative intensities, SSA invested only 0.61% of agricultural gross domestic product (GDP) on R&D in 2008, far below the New Partnership for African Development's (NEPAD's) target of at least 1% of GDP. In 2000, developing countries as a whole spent 0.54% of their GDP on R&D, compared to developed nations' 2.36% (Pardey, 2010). The higher intensities for Latin America and the Caribbean are not necessarily an indication of intensive innovation (Roseboom *et al.*, 2001). In the same year, SSA employed only 68 full-time equivalent (FTE [2]) researchers per one million of economically active agricultural population (Beintema and Stads, 2011); in 2000, 40% of all FTE in agricultural research were employed in only 5 African countries, reflecting a fairly skewed distribution. Gender representation in developing country agricultural R&D is biased towards males (18% were females in 2000 in Africa).

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#### **Global Public Agricultural Research Intensities (Expenditure as a percentage of AgGDP)**

<b>Region/country</b>	<b>1981</b>	<b>1991</b>	<b>2000</b>	<b>2008</b>
<b>Developing countries</b>	0.52	0.50	0.54	-----
<b>Sub-Saharan Africa</b>	0.84	0.79	0.72	0.61
<b>China</b>	0.41	0.35	0.40	-----
<b>Latin America and Caribbean</b>	0.88	0.96	1.16	-----
<b>Developed countries</b>	1.41	2.38	2.36*	-----
<b>Total</b>	0.79	0.86	0.80	

Source: adopted from ASTI data used in Pardey *et al.* (2006). Note that these are provisional estimates representing agricultural research expenditures divided by corresponding agricultural gross domestic product (GDP). \*Pardey (2010) estimates this to be 5.28%.

Support from donors in staff training (often as part of a larger project) has declined considerably over the years as compared to pre-1980s, leaving an ageing research staff with insufficient replacement capacity in some developing countries. Beintema and Stads (2006) estimated that 77, 19 and 3% of Africa's FTE were absorbed by government agencies, higher education institutions and non-profits, respectively, in 2000. Some organizations, such as the Alliance for a Green Revolution in Africa (AGRA [3], [www.agra-alliance.org/](http://www.agra-alliance.org/)), are currently providing

funding for graduate training in plant breeding, agronomy and soil sciences to build capacity in Africa.

In terms of general areas of research allocation in Africa, 50% of FTE in 2000 was allocated to crop research, 20% to livestock, 9% to natural resources and 5-6% each to forestry, socioeconomics, fisheries and post-harvest research. The major research crops were fruits, vegetables and maize (11, 9 and 8% of all FTE crop researchers in 2000, respectively). Rice, cassava and sorghum each took 5-7%. A research focus on cash and high-value export enterprises means less research effort on staple cereal food crops and/or drier marginal land areas that depend on obscure or 'orphan' crops (that are, however, adapted to drought and diseases in these areas).

After a period of stagnation in the 1990s, the World Bank and other donor agencies are reported to be considering providing increased funding support for agricultural productivity programmes in East and West Africa. Fluctuations in funding for agriculture have created a difficult environment for attracting and retaining qualified researchers and financing much needed research, thereby raising concerns as to whether it is possible to sustainably intensify agricultural production to respond to increasing demand.

### **Private Agricultural R&D: Status and Focus**

A review of existing literature reveals that there is very little information on private R&D in SSA. The ASTI project, with assistance from the Bill & Melinda Gates Foundation has begun collecting information for a few African countries (Beintema and Stads, 2011; [www.gatesfoundation.org](http://www.gatesfoundation.org)). Private investments in R&D are often underestimated because it is difficult to collect accurate information, owing to confidentiality and limited available funding ( Global agricultural R&D in 2000 was estimated to be \$33.7 billion, 40% of which was conducted by private firms and the remaining 60% by public agencies (Pardey, 2010). Approximately 95% of the private R&D was carried out in developed countries. In developing countries, only 6.4% of the agricultural R&D was private. Asia and Pacific region had 9% private investment and SSA had only 1.7% (or \$26 million), mostly spent on crop improvement. In 2000 2% of all R&D spending in Africa was attributable to the private sector – most of which occurred in South Africa (Beintema and Stads, 2006).

Most of the private sector R&D in developing countries is involved in adaptive research geared towards testing and adopting input technologies from the developed world. In addition, the private sector is playing an increasing role in financing research (instead of conducting research), and many organizations are contracting government agencies and universities to do research on their behalf (the Bill & Melinda Gates Foundation, Ford Foundation ([www.fordfoundation.org](http://www.fordfoundation.org)) and Rockefeller Foundation ([www.rockefellerfoundation.org](http://www.rockefellerfoundation.org)), are examples). Beintema and Stads (2006) found that 30% of private companies in Africa were foreign, with links to local private and public agencies conducting research on seed and production for mostly export crops. There is a relatively low rate of private research expenditures on fertilizer technology compared to seed or agro-chemical R&D. This might change as fertilizer markets mature in developing economies and opportunities expand for private firms.

The relatively low private investments in developing countries can be attributed to a number of constraints: predominance in subsistence crop production which do not augur well for investors who desire lucrative returns from value-addition; the low proportion of purchased inputs in total production do not provide the incentives that drive private enterprise; underdeveloped and small-sized input and output markets; poor infrastructure; stifling regulations that encourage rent-seeking; and an unfavourable policy environment for private sector agro-business growth. All of these constraints contribute to a low rate of introduction of new technologies. For the private sector to engage in R&D mechanisms are needed which allow them to recoup their costs and make profits. These include a number of enabling factors: favourable policy environment, enactment of IP rights regime, a pool of qualified researchers, national legislation that makes it possible to import and test new technology (without unnecessary bureaucracy and heavy tax burdens while also respecting environmental, safety and other concerns) and other attractive incentives.

Echeverría and Beintema (2009) indicate that private sector investment in R&D is increasing in some countries, creating more activity for agricultural research agencies. Private research in biotechnology has increased globally, partly as a result of the strengthening of IP rights. There are increased contractual arrangements to carry out research on behalf of agro-businesses (i.e., Monsanto, Syngenta and others). Again, most of this research is applied rather than basic research (Box 1). However, these developments have realigned the public goods nature of public

research by incorporating excludability into new products, which enables appropriation of benefits by developers.

### **Box 1: Biotechnology**

Biotechnology, especially the creation of genetically modified (GM) products, is gaining ground as one way of increasing crop and animal productivity and improving nutritional value of crops. Biotechnology provides a more way to patent inventions and so is dominated by private multinational corporations (Monsanto, Syngenta, etc.). This is one area where the private sector is partnering with the public sector in developing countries on adaptive and basic research, providing synergy from these global-local linkages. Apart from South Africa – which has legislated and commercialized biotech products – and a few other countries in the process of finalizing legislation (Kenya, Nigeria, etc.), most of Africa is yet to embrace biotechnology fully (Bindraban and Rabbinge, 2004). More support is needed in building human capacity and providing information on food safety and on the links between food security, nutritional status and biotechnology, a case that has not been well articulated.

Looking at agricultural R&D simply through the dichotomy of private and public investments can mask the fact that several private-public partnerships result in commercially viable products. Other R&D outputs that may be difficult to measure and are sometimes overlooked are the spin-off benefits from public R&D activities, which may occur by design or happenstance (Box 2).

### **Box 2: International Public Research Organizations**

The International Fertilizer Development Center (IFDC) Urea Deep Placement (UDP) innovation addresses the problem of nitrogen-use efficiency for rice production ([www.ifdc.org/Projects](http://www.ifdc.org/Projects)). UDP involves the insertion of large urea briquettes into the rice root zone of flooded rice after transplanting, instead of the conventional broadcasting and incorporation of fertilizers. The technology reduces fertilizer use on average by 25-30% and increases yields by 20-40% compared to broadcasting. Though developed by using public funds, the UDP technology has spurred private investment in the development of briquette machines. In addition, there is ongoing research into cost-saving fertilizer application methods that will substitute for intensive labour. Also, IFDC work in developing agro-dealer networks in SSA provides opportunities for private firms to innovate in product development, adaptation and

marketing within value chains. CABI (<http://www.cabi.org>) and IFDC are also involved in encouraging adoption of ISFM and building capacity for development and adaptation of innovations.

The Real IPM Company (K) Ltd (<http://www.realipm.com>) is a private firm developing biocontrol products for inclusion in IPM programmes in various Africa countries. Though operating as a private commercial enterprise, this firm gets specific project support from donors, including the UK Department for International Development (DFID) and the US Agency for International Development (USAID) among others, and projects to conduct R&D in production techniques and effective use of products in the field. This company collaborates with the International Centre for Insect Physiology and Ecology (ICIPE, <http://www.icipe.org/>) by commercializing some of the latter's research findings.

### **Conclusions and Recommendations**

Juxtaposing the current low levels of agricultural R&D and the high potential payoffs, a grossly underfunded pillar of agricultural development is revealed. Significant lags in the onset of benefits associated with some agricultural R&D endeavours (coupled with weak IP legislation) raise uncertainties for potential investors; there is a fairly long period from the inception of R&D to adoption of technology. Such lags call for sustained funding in order to achieve the high returns that are associated with agricultural R&D, but which take some time to develop. This scenario offers tough choices to private investors when coupled with an uncertain policy environment and limited demand in some developing countries.

The above discussion assumes separability between private and public R&D, but partnerships between the two that are sometimes difficult to untangle. International public research organizations often conduct joint research projects with national research and private entities. In addition, some products from public R&D may create opportunities for private research companies to generate complementary technologies or services that enhance the performance of the main product and yield profits. These private R&D investments are even more difficult to quantify or measure.

One conclusion to be drawn from the literature review is that private R&D in developing countries faces numerous obstacles both in initial momentum and sustained growth. It is possible that current high prices for both inputs and products, coupled with increasing population

pressure, may trigger increased R&D investments to tackle the problems of rising costs of production and consumption. There is a case for increasing private R&D investments, given the right policy and legal framework, the existing economic and demographic conditions coupled with changing consumer tastes and preferences, and that opportunities exist throughout the value chain for some firms with the necessary vision and skills to generate new products that will raise efficiency and productivity. However, such creativity will not survive in a vacuum and will require a holistic approach that creates the conditions for the necessary elements to thrive. Some of these desirable conditions are elaborated below.

Economies with relatively small agricultural sectors may not offer sufficient incentives for private R&D investments and therefore global and regional partnerships can provide opportunities for economies of scale. Regional economic blocs and partnerships by firms in developing and developed countries can provide a threshold for private R&D; these links should take advantage of South-South cooperation where technologies meant for particular agro-conditions in one country can be tested and adopted in similar environments in other countries. Such partnerships can extend to include public-private linkages that avail technologies and tools from the CGIAR to local firms or research agencies for testing and dissemination.

But the key to raising private R&D lies in creating a conducive climate where rules are transparent and implementable. This is important, especially for developing countries, e.g. in SSA where public funding is limited and private investment needs to be encouraged. Under such circumstances, governments would need to focus on designing, enacting and implementing proper policies, and provide the necessary instruments (e.g. regulations including IP) supported by the enforcing agencies, in a way that ensures that the private sector (national, regional and international corporations) will feel confident. Political, social and economic stability, human resource development and other resources necessary for R&D and business operations will help to reduce the cost of R&D and lower the risk to investors.

## **Appendix**

### **Figure 1. Annual Growth Rates in Agricultural R&D Spending, 1976-2000**

Source: This figure is extracted from Beintema and Elliott (2009); it is sourced from Beintema and Stads (2008ab) based on ASTI datasets ([www.asti.cgiar.org](http://www.asti.cgiar.org)) and other secondary sources. These estimates exclude Eastern Europe and former Soviet Union countries. Estimation

procedures and methodology are described in Pardey *et al.* (2006) and various ASTI regional reports available at [www.asti.cgiar.org](http://www.asti.cgiar.org).

## **Figure 2. Public Agricultural R&D Investment Trends in Developing Countries, 1981-2006**

Source: This figure is extracted from Beintema and Elliott (2009). It is sourced from ASTI datasets and secondary sources underlying Beintema and Stads (2008ab) and Stads and Beintema (2009).

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### **Notes**

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[2] FTE are based on the actual time researchers embark on R&D activities. For instance, faculty at universities undertake non-R&D activities as part of their work and so FTE sums only the specific times spent on R&D.

[3] Institutions such as AGRA are funded by private foundations such as the Bill & Melinda Gates Foundation, Ford Foundation and Rockefeller Foundation; these institutions have increased their funding to research recently.