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Innovative Systems to Reverse Soil Degradation and Improve Water Management for Enhanced Food Security: Experiences from African Countries

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Innovative Systems to Reverse Soil Degradation and Improve Water Management for Enhanced Food Security: Experiences from African Countries

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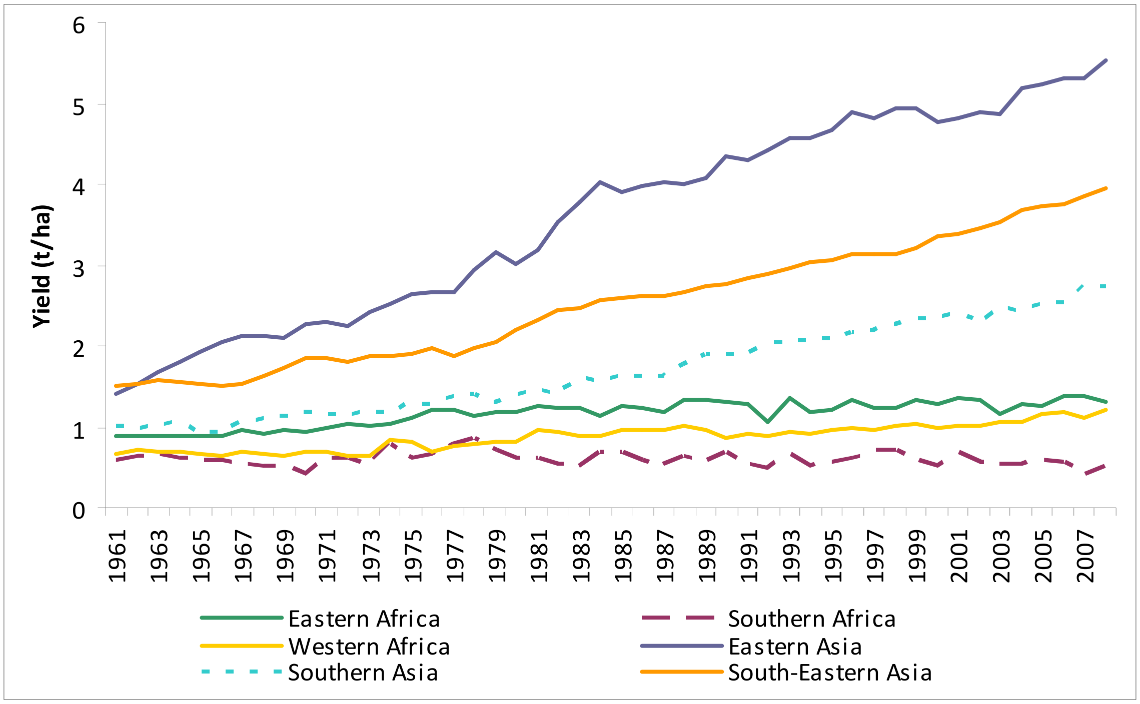
1.0 Introduction

Agricultural development lies at the heart of poverty reduction and increased food security of most developing nations. Sub-Saharan Africa (hereafter referred to as Africa) is, however, the only region in the world where per capita agricultural productivity has remained stagnant over the past 40 years (Sanchez *et al.*, 2005). Only 11% of the continent, spread over many countries, has high quality soils that can be effectively managed to sustain more than double its current production (Eswaran *et al*. 1997). Given the pervasive problem of soil degradation and infertility across much of Africa's agricultural area, the restoration of soil fertility is now recognized by many as the key entry point for increasing agricultural productivity in much of African smallholder farms (Sanchez *et al*., 2005; Sanchez and Swaminathan, 2005b; Martens, 2005).

Notwithstanding the above challenges, increased investment in agriculture is a must given that over 50-70% of the population in Africa are dependent for their livelihood on it and especially through smallholder production systems. It is against this background that the former UN Secretary General (Kofi Annan) in July 2004 announced what he called '*Africa's 21st Century Green Revolution*' to achieve the Millennium Development Goals by 2015 (MDG Centre, 2004). He called for special attention to farming systems in areas largely disconnected from functioning markets. This applies equally to remote areas in Africa, Asia, and Latin America. The call led to the establishment of the Alliance for a Green Revolution in Africa (AGRA) in 2007 to trigger a uniquely African green revolution – one that increases agricultural productivity while simultaneously improving the environment.

Yields of staple food crops (maize, rice, sorghum and millet) are typically 1.0 metric ton per hectare in Africa compared to 2-3 tons per hectare in Asia (Fig 1.0). Increasing the productivity of smallholder agriculture requires bringing to scale several practical interventions. A key one is the use of improved seeds. This, however, must go hand-in-hand with the use of fertilizers (both organic and inorganic) in order to realize their benefits. Where this combination has been adopted, yields have been improved enormously (Djurfedlt *et al*., 2004).This is, however, a major challenge especially in the smallholder sector. Because of low use of inputs, yield increase with improved crop varieties is estimated at only 28% in Africa compared to 88% in Asia (Evenson *et al*., 2003). This is the time to reverse this situation. After nearly two decades of neglect, agriculture is back on the policy agenda, for both African governments and their development partner (Martens, 2005; World Bank, 2008).

Figure 1.0: Cereal yield trends in regions within Africa and Asia



Source: FAOStat, 2008

This paper highlights five key issues critical in reversing soil and land degradation and improving food security in Africa through smallholder agriculture. These are improved seeds, fertilizers, extension, markets, and enabling policies. The next and second section highlights key innovations needed to improve soil fertility and water management. It also examines the role of new technology vis-à-vis better use of intrinsic knowledge and diffusion of best practices. The third section highlights the institutional support mechanisms required to scale up and sustain impacts of innovations. The fourth section highlights the key challenges and opportunities to support a larger transformation of food production in Africa for food security through improved soil and water management, taking into consideration constraints associated with climate and related tensions such as higher demands for water for non-agricultural use. The final section provides general policy recommendations that countries can draw from successful experiences, and suggests components of a national strategy for research and development in addressing food security through improved soil and water management.

The paper draws from evidence and lessons learnt from various agricultural research and development programs and projects in Africa. More specific references are made from those programs whose scope and outreach is large and cut across systematically, the major agro-ecologies and farming systems of Africa. Special attention is given to those supported by AGRA in 13 countries (Burkina Faso, Ethiopia, Kenya, Ghana, Mali, Malawi, Mozambique, Niger, Nigeria, Rwanda, Tanzania, Uganda and Zambia) where essential programmatic interventions (i.e., access to improved seeds, fertilizers, extension, market access, and enabling policies) are made.

2.0 Improving soil fertility and water management

2.1 ***Soil fertility management***:

There is, indeed, a consensus among the scientific community that low and declining soil fertility is the fundamental problem limiting smallholder agricultural productivity in sub-Sahara Africa (Sanchez *et al*., 2005). This means that little progress can be made without first addressing this key problem. Reversing this situation is particularly important in Sub-Saharan Africa where an estimated 300 million farmers live and work on marginal lands (UNCTAD, 2010). Limited use of fertilizers is a key factor contributing to the problem especially under conditions of continuous farming. Only a small proportion of farmers in Africa use fertilizers, on average, less than 9 kg of nutrients per ha (Morris *et al*., 2007). And this is certainly inadequate to raise crop yields significantly. The current state of Africa's fertilizer use per ha in Africa is about 10% of the world's average, indeed, untenable. National fertilizer recommendations for a good crop of maize, 3-4 tons per ha, is typically 10 times the current used rates (Jama *et al.*, 1997). The limited use of fertilizers in Africa, which accounts for less than 1% of the global fertilizer consumption, results in low agricultural productivity. This in turn is contributing to soil and land degradation through poor crop growth and concomitant poor aboveground biomass to cover the soils from the effects of erosive rain and wind, and declining soil organic matter because of limited crop residues available for recycling back to the soil.

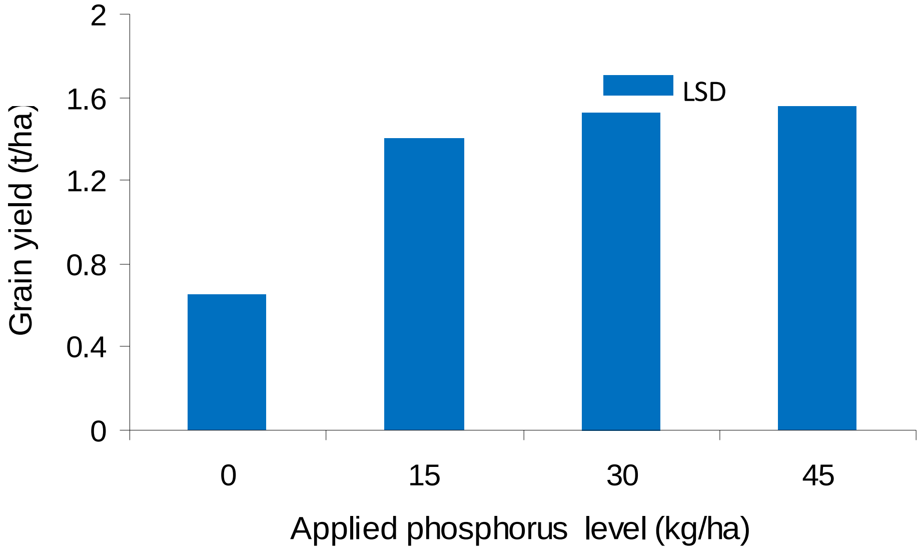
To deal with the varying conditions and circumstances of smallholder farmers, a wide range of soil fertility management innovations and approaches are needed. Fortunately, there is an array of proven technologies to replenish soil fertility (Sanchez, *et al.* 1997), ranging from primary use of organic inputs for the poorest to combinations of organic and inorganic fertilizers for the less-deprived groups (Sanginga *et al.*, 2009). With respect to organics, the use of farm yard manure from livestock is probably the most widespread soil fertility management option among both small and large scale farmers in Africa (Delve *et al*., 2001). Compost manure made from crop residues and household waste products is also common among smallholder farmers especially those who lack livestock. The use of leguminous crops in rotations or intercrops with other crops is also common among the, small and large scale farmers in Africa. Another possibility is the use of agroforestry technologies, such as improved fallows that involve the use of fast-growing leguminous trees into natural and generally grass-dominated crop lands set aside by farmers for a few years in some regions to improve soil fertility (Jama *et al.,* 1998). Such tree-based interventions can also contribute to improving the environment by increasing above and belowground biodiversity, sequestering carbon, and protecting watersheds. They can, indeed, act as entry points for minimum tillage and therefore conservation agriculture systems given their ability to control weeds through their shade once they develop good above-ground cover (Kiwia *et al*., 2009).

The choice of what type of fertilizer, organic or inorganic, to use however depends on what is the lowest cost option for providing nutrients at the farm-gate. In general consensus exists among the scientific and development community that the highest and most sustainable productivity gains per unit nutrient added are from mixtures of inorganic inputs (fertilizers) and organic inputs (Swift, *et al.* 2007; Nyamangara *et al*., 2003). It is not an either/or situation but the use of both sources of nutrients. This moves away from the '*fertilizer package*' approach which has frequently failed in the region. It does the same for the 'organics only' advocacy which is also problematic. It is, therefore, important to emphasize the integration of organic sources of nutrients with mineral fertilizers, especially the macronutrients (nitrogen, phosphorus and potassium). While organics could supply the amounts of nutrients required, the quantities required to do so are often huge and uneconomical. It is for this reason that AGRA is facilitating the scaling up of this integrated approach of improving soil fertility. This is being done through its program on soil health that was initiated in 2008 and that is targeting 4.1 million smallholder farmers in 13 Africa countries for over 5 years. The organic options promoted include grain legumes, farmyard and compost manure, agroforestry technologies and good agronomic practices including conservation agriculture where it is feasible (AGRA, 2009).

Among the organic sources of nutrients, the most promising are probably those that involve the production of dual purpose grain legumes (Sanginga *et al*., 2009) that produce both foods of high nutritional value and feed for livestock. Additionally, they can improve soil fertility through the fixation of atmospheric nitrogen biologically. Examples are soybeans, common beans, groundnuts, cowpeas, pigeon pea, and chickpea. The legumes are either intercropped or rotated with the staple food crops (e.g., maize, sorghum and cassava) in many areas of Africa. They normally have an attractive benefit-to-cost ratio for famers to engage in their production. Because of their high protein content relative to cereals, the grain legumes do also improve household nutrition considerably. Their residues are widely used to supplement livestock feed, and thus improve incomes and nutrition while access to quality manure that goes back to the farm to improve soil fertility.

The yields of the grain legumes are, however, generally low especially in soils that are low in available phosphorus. This can, however, be addressed through application of small amounts of phosphorus fertilizers. This can more than double grain yields (Fig. 2) and produce extra biomass for recycling back to the soil to improve its organic matter content (Kaizzi *et al.*, 2011). The study by Kaizzi *et al*., (2011), showed that by increasing rates of phosphorus (P) application, the financial returns are normally attractive up to 30 kg P/ha (benefit/cost ratio =≥ 2) but for rates above 30 kg P/ha the marginal returns per unit of additional P are not financially attractive (benefit/cost ratio =< 2). Besides improving yields, phosphorus is needed to enhance biological nitrogen fixation by legumes like soybeans. Phosphorus application is important given that the soils in many regions of sub-Sahara Africa are deficient in available soil phosphorus (Sanchez *et al*., 1997). Phosphorus can be supplied through conventional phosphorus fertilizers or from finely ground phosphate rock, and there are several "reactive" rock deposits in Africa that could be further exploited (Van Straaten, 2002).

Figure 2.0: Soybean response to P application in Uganda between 2009 and 2011



The use of integrated inorganic and organic fertilizer approach to soil fertility management approach has, however, many challenges. The key ones are improving access to seeds of grain legumes, fertilizers, affordable credit, markets, and strong farmers associations. With respect to grain legumes there are 5 inter-related challenges that needs to be addressed: a) poor access to improved seeds – less than 10% of the smallholder farmers in Africa have access to improved legume seeds, b) low yields – smallholder yields average under 0.5 tons per ha for most grain legumes, and high post-harvest losses typically in excess of 30%, c) limited area planted to grain legumes – typically 5% or less of the cultivated area which can be increased considerable if access to improved seeds, extension and markets are enhanced, d) limited and variable biological nitrogen fixation potential – can be increased to levels as high as 150 kg per ha if small amounts of phosphorus fertilizers and the appropriate rhizobium inoculum are applied (Giller**,** 1997), and e) a large proportion of the nitrogen fixed biologically is taken off through the grain harvest – this can be mitigated through application of supplementary fertilizers and recycling of crop residues.

Regarding seed supplies of grain legumes, it important to recognize that seed companies are generally not interested in their production because farmers can replant them over several seasons. Given this, two strategies appear to be most appropriate and sustainable for addressing the seed requirement of improved legumes seeds. The first is the informal sector that uses farmers associations and community-based organization. They can, indeed, produce quality seeds if they can gain access to the initial or foundation seeds, training and close supervision (Sentimela *et al*., 2004). The second approach is the use of those seed companies that are interested, create demand and markets for the seeds, and assist them to gain access to affordable credit from financial institutions. This is, indeed, the approach used by AGRA especially with young and local seed companies. Demand and awareness creation for their seeds is created through large scale participatory demonstrations with farmers that AGRA and others are funding. The seed companies also get support in improving their technical and managerial skills of running viable businesses. These efforts have helped create a large number of privately owned seed companies that are producing seeds needed by farmers in their regions and making them available through a network of agrodealers or rural input stockists. These have been expanded and strengthened with the support of AGRA and others, in particular COMESA (Common Markets for Eastern and Southern Africa) whose secretariat is based at Lusaka, Zambia.

Besides seeds, public-private partnerships can be used for other inputs that are needed to enhance the impacts of integrated soil fertility management practices in smallholder agriculture in Africa. An example is the supply of rhizobium inoculum that is needed to improve to root nodulation and thus biological fixation of atmospheric nitrogen by legumes and into the soil. The availability of the inoculants is limited in many countries although the technology exists in research stations and universities. This challenge has now been addressed in Kenya, thanks to a partnership between a local fertilizer company and a local university. The partnership was brokered in 2008 by some technical support from the Africa Knowledge Transfer Partnership, an initiative of the British Council that linked the local university and the fertilizer with expertise in the United Kingdom on commercial production techniques of rhizobia inoculum for grain legumes. This has helped build capacity at the company to mass produce the inoculum and the university to provide the quality assurance and the required technical backstopping. The various projects in the Kenya and many others in sub-Sahara Africa have provided markets for the produced inoculum and therefore incentives for the company to continue producing them. This case is a good example of how the private sector can be supported and engaged to put into use agricultural technologies developed with funding from the public and do so in ways that are beneficial to smallholder farmers.

2.2 ***Water management***

Lack of investment in irrigation infrastructure means most of the population in Africa depends on rain-fed agriculture for their food production. The risks associated with this are, however, high – with inter- and intra-seasonal rainfall variability that often leads to crop failures. Reducing this risk not only provides the immediate benefit of food security, but also provides incentives for farmers to invest in farming as a business. One way to improve this situation is through water harvesting from runoff water in the fields during the raining season or by preventing the loss of water through evaporation from soil surface. It is estimated that only between 15 and 30 % of the incoming precipitation as rainfall is used for production in Africa (Rockstrom, 2000). The rest is lost to evaporation from soil surface (30 to 50%), surface runoff (10 – 25%) and drainage 10 to 30% (Rockstrom, 2000). Water harvesting, used in its widest definition of collecting water for productive use, can indeed be an entry point for addressing the water constraints of farmers in Africa (Prinz *et al.*; 2001).

Some promising options for agricultural water management include runoff harvesting through simple in-field micro-catchments and terracing of slopping fields; simple irrigation systems such as sprinkler and trickle irrigation systems and the use of treadle pumps that are manually operated. Soil water retention can also be improved by increasing the level of soil organic matter through agroforestry (root biomass and leaf fall), residue retention and manure application. There is need to expand the use of these technologies that have been proven successful in various pilot projects. Wider use of these technologies will need incentives (e.g., subsidies, tax breaks) and affordable credit. With these interventions, they have the potential for increasing the area under cultivation, to increase food production during the dry season, and to make a significant contribution to poverty reduction.

In the African context, small-scale and technically simple water management systems have proven to be more successful than large projects due to their lower cost and greater ease of operation and maintenance (Martens, 2005). Low-cost systems attempt to retain the benefits of conventional systems whilst removing the barriers to adoption. Most of the innovations in this area have been in trickle irrigation led by India, Nepal and China (Rockstrom, 2000). These countries have emphasized the development of systems that do not rely on automatic control or other labour-saving devices, thus helping to generate demand for local skilled labour. In Africa, the treadle pump (PRINZ et al.; 2001) is becoming popular among farmers in many countries for dry season vegetable production. Examples are Kenya, Malawi, South Africa, Swaziland, Tanzania and Zambia. This is particularly so in urban and peri-urban areas where market access is better.

To scale up land area under irrigation, efforts similar to those of Asia are needed where governments subsidized irrigation programs (Shah *et al*., 2003) but done in ways that foster a greater public-private partnership (PPP) that is essential for sustainability. This is required to address three key problems that challenge large irrigation and drainage in Africa that is largely publically-funded: low water use efficiency, a high reliance on government financing, and poor standards of management and maintenance (World Bank, 2007). Globally, experience with PPP in irrigation and drainage (I&D) is scant (World Bank, 2007; 2008). This is more so in Africa where it is known, there are apparent misconceptions. For instance, central government may not be interested because they generally want to control over investment decisions, and they don't often see the private sector as a welcome partner. For the farmers, besides their willingness to pay for water and services provided, they also fear losing land to the private party if they are unable to pay. This is particularly so in the absence of secure land rights. Notwithstanding these problems, public-private partnerships can have dramatic improvements in the efficiency of investments and operations. They have, however, so far not resulted in sharp swings in the relative proportion of public and private spending. A recent study showed pumping costs are less than 150 USD in Asia compared to 500 USD per ha in Africa (Ngigi, 2009). Such partnerships need to be developed given the high costs of irrigation in Africa.

Farmers associations can be an important means of sharing the high costs of irrigation facilities. For instance, renting water pumps collectively as a group is common in several countries in Africa (Ngigi, 2009; Thomas *et al.*, 2005; Agyare *et al*., 2008) and helps to reduce costs and therefore burdens on an individual farmer. Key to this is strengthening farmers association so that they can become cohesive and entities that respect and abide by contractual agreement with others in business. To improve affordability of the pumps, the importation of irrigation equipments, especially small water lifting technologies for rural household use, may require policy support in the form of import duty waivers.

Otherwise, when there is in-country capability, production of the same technologies could be encouraged by incentive mechanisms.

3.0 Institutional support mechanisms to scale up and sustain impacts

3.1 Improving fertilizer supply

Fertilizer prices in Africa are typically 2-3 times higher than what they are in international markets. The scenario has, however, changed since the world food crisis in 2008 because of high grain prices which has made fertilizer use financially attractive. Governments in partnership with the private sectors are implementing both supply and demand-side factors that are commonly mentioned in conceptual overviews of what is required to promote increased inorganic fertilizer use in Africa in a sustainable manner (Morris *et al.*, 2007). Cost reductions can be achieved all along the supply chain: from procurement to shipping of fertilizer, to unloading and bagging to transportation and retailing at the farmer level. In general, port handling and inland transport each account for about 30% of the high farm-gate prices of fertilizers that are typically 3-4 times the cost-insurance-freight price of fertilizer at major import ports in Africa.

AGRA is currently facilitating public-private sector dialogue to address the high costs of fertilizers in all 5 countries that are also important entry points of fertilizers in Africa. Some of the interventions needed require changes in national policies currently in place. For instance, there are constraints of tariff and non-tariff nature that add to the cost of fertilizers in the countries. In Uganda, for instance, there is a 6% withholding tax on fertilizers. This is often passed to farmers because fertilizer suppliers cannot claim it with ease from the revenue authorities. Removal of such taxes on fertilizers that are essential commodities for achieving food security requires a policy change. In most cases, policy changes are not costly, but require someone with evidence in support of it to champion it.

Given the high cost of fertilizers that has stabilized little since the 2008 global food crisis, governments need to intervene to make this essential commodity more affordable to its farmers. They could, for instance, facilitate access to affordable financing as an incentive for local fertilizer importers who do not have access to offshore financing and letter of credit with suppliers. The government of Rwanda is pioneering this approach (Government of Rwanda. 2007). In 2006, this government financed and procured the fertilizer needs of the country by use of a regional fertilizer company. Once in the country, the government also subsidized the distribution and retailing of fertilizers to different regions of the country by private companies. This was done through a competitive bidding auction. The government paid 50% of the cost and the farmers the remaining 50%. These interventions saw fertilizer use in Rwanda increase by nearly 10 fold between 2006 and 2009 from meager 4,000 metric tons annually. The program was accompanied by a complementary effort to intensify crop production in ways that increase the yields of target staple food crops (maize, wheat and potatoes) and enhance the returns to investments made in fertilizers and improved seeds. With these interventions and with the development of an expansive network of agro dealers that could stock the input in rural areas, thanks to the support of AGRA and its partner organizations, the government is now in the process of sustainably financing the subsidy program rather than exiting from it completely.

Another good example of public-private partnership initiative to improve fertilizer comes from Tanzania, and is on the utilization of the Minjingu phosphate deposits in northern Tanzania. In this case, a private company bought from the government during the process of economic liberalization a dysfunctional factory. The company rapidly went into production taking advantage of the existing infrastructure. It was greatly assisted by the fertilizer subsidy program that the government has launched which gave priority to the use of the local Minjingu fertilizer over imported ones as cost-saving measures and by the awareness created through projects funded by AGRA and other development partners.

Following these public and private partnership interventions, Minjingu fertilizers made up nearly a third of the 200,000 metric tons of fertilizers that Tanzania used in 2010 within 3 years. This would probably have not happened without the support of the government, including subsidies provided by the government for smallholders to access fertilizers. This is an example of how public and private sector can work together to improve fertilizer supply. AGRA-focal countries are implementing significant fertilizer subsidy programs, ranging from 20% in Kenya to 70% in Malawi (Wanzala *et al*., 2011) through a voucher system. In this system, the vouchers are dispensed through the agrodealer network who redeems it through local banks that have been engaged to manage the subsidy funds by the governments. Beneficiary farmers are selected through the local extension staff and village level community leaders. The programs have had mixed results but in general positive in terms of increasing fertilizer supply and use. And good examples are the programs of Rwanda and Malawi (Wanzala *et al*., 2011; Sanchez *et al*., 2009).

Considerable effort is also going into developing the fertilizer delivery systems focusing on business and technical farmer advisory training. An important intervention here is expanding the agrodealer (stockist) networks at the grass roots level. Success is remarkable where this happened such as agro-dealers pilot project program in western Kenya that was pioneered by the Rockefeller Foundation (Kelly *et al.* 2003) and that is expanded further with the support of AGRA. Some of the key lessons are: a) development of rural stockists (agrodealers) can be an effective mechanism for accelerating smallholder access to quality agricultural inputs in Africa, b) there is a strong positive correlation between the availability of credit and the volume of trade in fertilizers and other agricultural inputs in agriculture, and c) distribution and sale of appropriate small packs of agricultural inputs increases their affordability, safety and quality.

3.2 Increasing access to improved germplasm

With improved planting material, the large yield gap between actual and potential yields that is common in Africa's smallholder sector could be reduced, and thus contributing to increasing productivity. Currently, the yield gap stands at over 50% for maize, a staple food crop of many countries in the continent. About one third of this gap can be explained by lack of improved; the other two thirds can be explained unhealthy soils which can be managed through integrated soil fertility management practices, and good agronomy (timely planting, weeding, pest and disease control, appropriate plant population, water conservation, among others). The same is true for other important crops in the region, e.g., cassava, sorghum and rice (Djurfedlt *et al*. 2004). This yield gap is, indeed, evidence of the untapped potential for increasing production and productivity of agriculture in Africa.

The use of improved planting material must go hand-in-hand with the use of fertilizers (both organic and inorganic) in order to realize their benefits. Where this combination has been adopted, yields have been improved enormously (Djurfedlt *et al*. 2004).This is however a major challenge, especially in the smallholder sector. Because of low use of inputs, yield increase with improved crop varieties is estimated at only 28% in Africa compared to 88% in Asia (Evenson *et al.* 2003). To address these intertwined interventions simultaneously, AGRA is providing support to development of local seed companies and agrodealers as one strategy to improve access to both seeds and fertilizers. Both the seed companies and agrodealers are facilitated to access affordable credits from several banks AGRA has brokered a grantee scheme with. Additionally, for purposes of sustainability, they get training and sustained mentoring on sound business management techniques.

3.3 Improving market access

There is, indeed, considerable potential for Africa to increase agricultural growth and alleviate hunger and poverty through market-led processes. Significant investments are, therefore, made by AGRA and its partners to improve access to markets. Contrary to the pessimism expressed in some quarters, adequate market opportunities exist that are yet to be fully exploited and that could support more rapid and sustained agricultural growth in Africa. For instance, staple foods represent a promising domestic market opportunity, particularly because Africa is not only a net importer of many staple foods but also because projections show that continent-wide demand for human consumption and livestock feed will double by 2015, adding another $50 billion per year to effective demand (Thurlow *et al.* 2007). Many African farmers are well positioned to compete in these staple markets. Moreover, growing urban markets in Africa are increasing the demand for more diverse and higher value-added foods, thereby offering new opportunities for many African farmers.

Many African countries also possess a comparative advantage in those commodities imported by other African countries. By reducing their trade barriers in both the agricultural and non-agricultural sectors, African countries can increase intra-regional agricultural trade by more than 50 percent (DIAO *et al.* 2003). Intra-African trade can also increase food security by facilitating the transfer of production from high potential agro-ecological zones to areas with structural food deficits. Since cross-border exports may not be subject to the same level of stringent quality standards required for international markets, intra-African trade might be more accessible to smallholders (Peacock, *et al.* 2004). Greater cross-border trade in food staples could also help stabilize food supplies and prices at sub-regional levels in drought years.

Given the small landholdings (typically under 2 ha) and limited general aggregation among smallholder farmers in Africa, a critical issue is improving farmers' competitiveness, and capacity to improve their market position. One way to enhance such productivity is by taking advantage of economies of scale. Collective marketing through rural producers' organizations can be one effective way to overcome constraints faced by small scale farmers, including lack of capital, imperfect information, geographic dispersion, poor infrastructure and communications (Bienabe *et al.*, 2005). Acting collectively through farmers' associations, farmers can mitigate transaction costs, and therefore accrue benefits from collective marketing. In this regard, AGRA is facilitating linkages of farmers association to a major grain buying project of the World Food Program called *'Purchase for Progress'*. Key interventions include building farmers capacity to meet supplies of the quality required by the program. This includes training farmers on how to reduce post-harvest loss, a major problem in Africa. A key challenge here is lack of good storage facilities within the farms and in rural centres. To address this, AGRA is working with both the public and private sector to invest and/or rehabilitate existing structures. Farmers' organizations can pay them through rental and co-funding arrangements.

Contract farming is another mechanism for improving market access that AGRA is promoting. This has the potential to take over the roles previously served by the state in the provision of information, inputs and credit. There are many success stories in Africa that can provide insights for developing this mechanism further. In general, contract farming arrangements have however been limited to cash crops and particularly those destined for export and not for food crops that are also locally traded. The vast majority of contract farming arrangements also tend to exclude smallholder farmers (Singh, S. 2000). If designed well, contract farming arrangement could help manage problems related to access to production inputs (improved seeds and fertilizers), extension, and output markets. These are interventions that are implemented through AGRA's core programs. To a large extent, significant growth in mobile telephony in Africa in recent years is aiding access to information and services by smallholder farmers.

3.4 Improving access to affordable credit

Affordable credit is required to develop input and output comprehensive chain of any commodity, from its production to marketing. This is essential given the high costs of inputs, especially fertilizers. The current agricultural credit landscape is characterized by a variety of small-scale, donor-funded NGO efforts. What is needed is bringing on board the banks that have greater financing capacity but are generally apprehensive of funding smallholder agriculture because of either real or perceived risks. Towards addressing this challenge, AGRA has established a major program on innovative financing that aims at unlocking financing for the agricultural value chain, including fertilizer supply, from local financial institutions (AGRA, 2009).

The innovative financing program is designed through credit grantee arrangements with funding from AGRA and its partners. For instance, AGRA in partnership with Equity Bank (a local bank in Kenya), IFAD and the Kenyan Ministry of Agriculture, created a loan facility of US $50 million that was backed with a US $5 million cash guarantee fund. As a result, affordable credit was made available to 2.5 million farmers and 15,000 agricultural value chain operators such as rural input shops, fertilizer and seed wholesalers and importers, grain traders and food processors. Similar credit guarantee arrangements have now been made with the National Microfinance Bank in Tanzania and with the Standard Bank. The latter is focusing on 4 countries: Tanzania, Mozambique, Ghana and Uganda. Many countries and their development partners are, indeed, now adapting the financing mechanism to their conditions. Successes and lessons learnt should be urgently documented to serve as basis for programming improvements.

3.5 Investing in agricultural research and extension services

Agricultural research can contribute significantly to improvement in agricultural production and poverty reduction in sub-Sahara Africa. A study by Alene and Coullibally's (2009) revealed that agricultural research reduces the number of poor people by 2.3 million or 0.8% annually and by doubling research investments in SSA poverty would be reduced by 9% annually. Given its importance, AGRA has made significant investment to strengthen national research, education and extension. On education, for instance, grants have been made by AGRA to 10 universities in Africa to support the training of 170 soils and agronomy students at MSc and PhD level. Over 10,000 frontline extension officers from the Ministries of Agriculture are also being trained with emphasis on approaches to scaling up integrated soil fertility and water management technologies. This is essential given that these technologies are both knowledge and capital intensive.

There is strong evidence to suggest higher levels of adoption where extension is intensive and sustained for a long time (Olayide *et al*., 2008). Unfortunately, the challenge in most countries is the limited number of extension workers and limited budgets to make them mobile and visit the farmers regularly to enhance the uptake of ISFM practices. To facilitate this, participatory adaptive research is embedded in all the large scale integrated soil fertility and management projects AGRA is rolling out in its focal countries. This engages farmers through several approaches, with farmer field schools being the most commonly used. Some of the research topics include developing crop and site-specific fertilizer recommendations, and conservation agriculture potential of the legumes-cereals rotations systems promoted. This could enhance the resilience of the system to climate change related problems. Impact studies are also included in the research activities, including the potential of the soil fertility options to improve uptake by women and youth. This is certainly with pigeon peas, one of the legumes promoted, that in addition to improving soil fertility also provides food (grains), livestock feed and fuelwood (Jama *et al*., 2008), This particular crop is very attractive to women farmers since firewood collection is one of their major tasks and it is becoming increasingly scarce in many areas in Africa.

3.6 Improving weather forecasts

Given that most agriculture in Africa is rain-fed, there is need to improve the present status of poor weather forecasting services in Africa (Adejuwon, 2006). More accurate prediction of short, medium and long term weather conditions at both national and regional level are necessary. There are many uncertainties farmers face with respect to the unpredictability of weather in Africa particularly the onset and cessation of the rainy season (Cooper *et al*., 2007). This affects their decisions on when and what to plant. There is mounting scientific evidence indicating that if current climate trends continue, drier areas will become drier and droughts more frequent (Rosenzweig *et al.* 1994), and wetter areas more flooded. Improving weather predictions requires strengthening the surveillance capacity of regional and national weather programs and fostering greater collaboration between states in the region and beyond. Given that water and food security are inter-twined, there is also great need to improve hydrological data monitoring, collection and dissemination systems at national and regional level.

A complementary point to take into consideration is the possibility of having massively available weather related insurance programs for smallholder farmers – to help them deal with droughts, floods and breakout of pests and diseases. On the latter, AGRA is exploring various options through the credit guarantee arrangements with the financial institutions. A key challenge to the design of appropriate weather-indexed crop insurance programs is the lack of ground-based weather stations that can provide the long term data required, especially rainfall that they are mostly based on (Adejuwon, 2006).

4.0 Key challenges and opportunities for large scale impacts

Improving soil fertility and water management in ways that improve smallholder agricultural productivity at scale requires improving access to the five core interventions discussed before, viz,– improved seeds, fertilizers, extension, markets, enabling policies. This requires high level of planning and coordination of public and private investments at national and sub-national levels. Getting this to happen is, however, not easy. Success is, however, beginning to emerge where this has happened. And examples are in the breadbasket regions of the focal countries where an integrated approach has been adopted– e.g., southern highlands of Tanzania and northern Ghana. Other examples are areas where the Millennium Villages Project is operating (Sanchez *et al.*, 2009). In these regions, productivity of smallholder farms have been raised by 2-3 times over the previous levels of 1.0 ton per ha or less for staple cereals – maize, rice and sorghum. This is contributing to improving the overall welfare of the farmers and in-depth impact assessments are on-going. The next step is to scale up and sustain the gains made. This is possible as the Malawi government has demonstrated through the use of 'smart subsidies' that foster public-private partnership in delivery of input and output markets as well as provision of extension and advisory services (Denning *et al*., 2009).

The level of funding required to get these essentials is estimated to be in the range of 15-20 $ per capita per year. At this level of investment, it is feasible that significant impacts could be made within 5-10 years as is demonstrated by the Malawi and Rwanda programs. A key challenge in most countries, even when funding is available, is weak institutional delivery capacity. Most national research and institutions have limited skilled staff; some retired ones are being recycled in many institutions. Fortunately, most countries are on this course now with significant investments taking in extension staff training. For instance, Mozambique has launched a strategy to increase its frontline to

4000 from under 600 over the next 3-4 years towards achieving its green revolution (Government of Mozambique, 2007).

5.0 Implication for national policies and planning

While the funding levels required for transforming smallholder agriculture sounds ambitious, it is essential if one takes into consideration the consequences of not investing adequately – growing populations and growing food insecurity, huge food import bills (now over 20 billion dollars annually), and environmental degradation from expansive agriculture into marginal lands that is more challenged by climate change factors. There is reason for optimism. Agriculture is back on the funding frontier of the development community – thanks in part to the 2008 global food crisis (World Bank, 2008). Many governments are also now making significant investments in agriculture and several are about or have surpassed their commitment of 10% of the national gross income going to agriculture as per the 2005 Comprehensive African Agricultural Development Program commitment (Kolavalli *et a*l., 2010). The CAADP 10% is a guideline, and what level of investment is necessary would be determined by the countries themselves taking their socio and geo-political conditions. With the growing investments in agriculture, countries are indeed reporting significant growth rates (World Bank, 2007) although there are no recent independent studies to confirm them yet. This interest and political commitment should be sustained until at least over the next 10 years. This is more likely to achieve significant results, perhaps the 6% per annum CAADP targets (Kolavalli *et a*l., 2010), given the neglect on investments on agriculture for the past 20 years.

National level policy and budgetary support to improving production must go hand in hand with regional ones, and especially on interventions that improve access to markets. Without markets, the rest of the inventions, especially that of expensive fertilizers will come to a naught. There are many approaches that could be used including measures to stabilize prices in the short-term through direct public intervention, including the use of guaranteed floor prices. This is essential to get farmers to use production technologies improved seeds and fertilizers within the context of integrated soil fertility management) and raise agricultural productivity. Without such a concerted strategy, as Cochrane (1958) put it, *"technological advance sows the seeds of its own destruction"*.

Finally, collaborative regional research initiatives should be strengthened and focused on issues that have larger impacts such as climate change issues. This requires greater support for institutions with greater regional coverage and that have the capacity to do more analytical work. Towards this end, AGRA is closely collaborating with the CGIAR centres and specialized UN agencies such as UNEP on this issue of predicting better the consequences of and interventions to enhance adaptation to climate change – a major requirement to achieving Africa's green revolution. There is also need to support pan African and regional level economic and policy institutions that are increasingly playing a vital role of agenda setting and advocacy. Examples are NEPAD/CAADP that is pan African, and sub-regional economic commissions – e.g., COMESA and the East Africa Community, the Economic Commission for the West Africa States. These institutions are currently receiving funding from both bilateral and multilateral donors.

6.0 Conclusion

It is evident that achieving food security in Africa will be difficult without reversing the current trends of declining smallholder agricultural productivity **(Fig. 1).** A key entry point is improving access to improved seeds, fertilizers that can be part of a wide range of proven integrated soil fertility management practices, extension, markets, and enabling policies including the provision of affordable credit. These interventions will not only increase agricultural productivity but will also contribute to reversing soil and land degradation. They could lead to greater investment in agricultural water management in ways that increases productivity and also helps buffer farmers from climate variability. Fortunately, the knowledge to do that is available and investments by AGRA and other development partners in several countries are beginning to demonstrate this integrated approach at a scale. Going to scale, however, requires strong public and private partnership. It also requires strengthening both human and institutional capacity in many countries. And this is, indeed, now happening and in a very encouraging manner. African governments and their development partners are committed to support this effort that needs to be sustained at least over the next 10 years. This is bound to reverse the prevailing soil and land degradation in Africa, increase agricultural productivity and food security, and contribute to the overall goal of achieving a unique green revolution in the continent.

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