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Green Revolutions for Africa

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EXECUTIVE SUMMARY

Agriculture is the main source of income for over 60 per cent of the people of sub-Saharan Africa (SSA) and over three-quarters of its poor. As in Asia in the 1960s, agriculture is the only credible *initial* source of widely shared economic growth or employment generation in the region today. Yet in recent decades, throughout much of the continent, agricultural performance has been weak. Can sub-Saharan Africa learn from Asia's Green Revolution?

From 1967 to 2007, farm output per person fell by a quarter in sub-Saharan Africa, while it doubled in South Asia and tripled in East Asia, where farm growth was transformed by better varieties of staple food crops, water control and fertilizers. This growth came mainly from small, employment-intensive farms, which proved efficient as well as equitable. Rapid, science-based, smallholder-focused farm growth proved to be *the* precondition for Asia's twenty-first-century 'miracles' of fast, broad-based economic development. The evidence suggests that sub-Saharan Africa can follow a similar path, adapted to its varying agro-ecologies. Yet between 1980 and 2005 the overall share of public spending on African agriculture fell, and aid collapsed.

There are now renewed hopes that Africa's agricultural potential may at last be realized. Since 2000, farm output trends appear to have improved. Following pan-African initiatives, several countries have boosted the share of agriculture in public spending, prepared investment plans within the Comprehensive Africa Agriculture Development Programme (CAADP) and supported seed research and input delivery, including via the Alliance for a Green Revolution in Africa (AGRA). At the Gleneagles and L'Aquila G8 summits, pledges, at least, of aid to African agriculture rose sharply. Foreign investors have started to acquire African farmland. Do such changes portend an 'African renaissance' in agriculture?

There are three core challenges:

- *Needs*: hunger and malnutrition already affect a persistently large proportion of sub-Saharan Africa's people and a rising absolute number: between 1950 and 2010 SSA's population almost quintupled, and in the next 40 years it is projected to double again.

- *Yields*: these have been sluggish, particularly for staple food crops, and well below world averages.

- *Depletion*: the limited supply of good land has forced farmers onto marginal land, leading to soil mining, shorter fallows and rapid deforestation, while climate change makes farm water supplies less reliable and often scarcer.

In the past Africa's farmers used low external input (LEI) farming methods, including rotations and long fallows, to control pests and diseases and maintain fertility. These were well suited to situations of land abundance and labour scarcity. Subsequently, however, technical change has not kept pace with rapid population growth. There is recent evidence of success for more complex, science-based LEI farming but to replenish soils while raising crop yields (and farm employment) fast enough to meet growing needs, inorganic as well as organic fertilizers are normally needed. Yet, per hectare cropped, fertilizers added only 10 kg of main soil nutrients in 2008 in sub-Saharan Africa, as against 134 kg in South Asia. To obtain the substantially higher levels of fertilizer use that are required, such use must *pay* for farmers. That requires fertilizer-responsive seeds, water control and cheaper, denser transport networks. Also poor farmers will use little fertilizer if it is risky or unprofitable owing to low, unpredictable rainfall. By 2008 over 40 per cent of Asia's cropland was prepared for irrigation, as opposed to 2.6 per cent in sub-Saharan Africa. Large parts of the region are not economically irrigable, but others are, and addressing this is a CAADP spending priority.

Yield-enhancing innovations in sub-Saharan Africa must be adapted to its agro-ecological zones – humid, sub-humid, semi-arid – and to both rain-fed and irrigated agriculture. Green revolutions in these different farming systems require:

- Greatly increased resource commitments to agricultural research and its delivery;

- Development of rural infrastructure, for water, roads and sometimes storage;

- Institutional development, focused on enhancing market efficiency, but kick-starting markets where necessary (with trade credits, and sometimes 'smart' input subsidies[1]);

- Institutional change to secure, and in some cases redistribute, land rights; to regulate large-scale land acquisitions to safeguard smallholder rights and livelihoods; and to underpin collective-action frameworks, both for large farm and/or processing enterprises and small farms to jointly realize higher productivity, and for small farms to do so in collaboration with other small farms

Sub-Saharan Africa features promising examples of each of these requirements, and much can be learnt from both successes and failures, in the region and in Asia's Green Revolution. Especially in risky, rain-fed systems, public support for agronomic research, infrastructure and market- and land-related institutional development is needed to lay the foundations for sustained growth in farm output.

1 'The key with subsidies is to do them in ways that reach the poor and also build the market. We are calling those smart subsidies.' (Akin Adesina, then vice president of AGRA), cited in M. Fleshman, 'A Harvest of Hope for African Farmers', *Africa Renewal*, Vol. 22, No. 3 (October 2008). http://www.un.org/ecosocdev/geninfo/afrec/vol22no3/223-harvest-of-hope.html.

INTRODUCTION

Between 1967 and 2007, farm output per person in sub-Saharan Africa (SSA) fell by a quarter.[2] Meanwhile it doubled in South Asia and tripled in East Asia as part of a Green Revolution. There, better varieties of staple crops, water control and fertilizers transformed farm growth, mostly from small farms. This slashed poverty and proved efficient. Can this work in SSA, despite differences between and within the agricultural sectors of Asia and Africa?

Many experts argue that, in Africa as in Asia, the key to fast economic development is a big advance in farm technology and investment which is best if implemented by small-to-medium-sized, employment-intensive farms – not only to reduce poverty (though this is likely), but also because it is *efficient* in most conditions in Africa, as it was in Asia. Many African governments, and aid donors, have proclaimed their support for these propositions but between 1980 and 2005 public spending on African agriculture fell, and aid halved. The two-thirds of Africans who depended mainly on agriculture received barely 5 per cent of public resources. Compared with Asia, few resources went into rural transport, marketing facilities and farm research. Today less than 3 per cent of cropland in sub-Saharan Africa is irrigated, compared with 35 per cent in Asia.

However, there are signs of change. Under the African Union's Comprehensive Africa Agriculture Development Programme (CAADP), 22 states have pledged to raise the budget share for agriculture to 10 per cent.[3] The Alliance for a Green Revolution in Africa (AGRA) has begun to expand research support.[4] Aid to African agriculture has picked up. Overseas private companies and governments are also seeking to stimulate farm production, sometimes taking control of land to do so. The 2008 world food price spike reinforced this trend. Although the spike was partly reversed, events in 2010 suggest that it prefigured long-term trends. The case for raising food staples production in Africa is reinforced by global supply sensitivity to performance in

2 The data refer to three-year averages (1966–68 and 2006–68) in order to reduce the impact of chance weather fluctuations.

3 Launched in 2003 by the African Union, the CAADP aims to extend sustainable land management (including through extending irrigation), improve rural infrastructure and market access, support agricultural research and technology dissemination and increase food security. It is intended that this should be achieved primarily through mobilizing all African governments to commit 10% of their budgets to agriculture. For some governments committing to such a rise implies a major resource shift; in the case of Uganda, which in May 2010 became the eighteenth country to sign the CAADP compact, it would rise from 2.6% in 2008–09 (CAADP, *Annual Report, 2009*: 9).

4 Funded by the Gates and Rockefeller Foundations, and launched in 2006, AGRA aims to seed-fund projects in its focus areas, which include farm input distribution and support for agricultural research. AGRA has formed a range of partnerships, including with African Ministries of Agriculture and universities and, internationally, with bilateral and multilateral donors (including the International Fund for Agricultural Development (IFAD), the Food and Agriculture

the main grain-producing countries – highlighted by the impact on world markets of the 2010 Russian grain harvest failure – combined with rising long-term trends for both food demand and production costs. The former is due to world population growth and rising per capita incomes, especially in Asia and Latin America, and the latter to fuel/fertilizer cost pressures and global warming.

Against this background, the Africa Programme at Chatham House held a series of meetings in 2008–10 to review the challenges and options facing African agricultural development. This programme paper and a related briefing paper draw on these discussions.

Organization (FAO) and the World Food Programme (WFP), thereby raising the value of the programmes to which it is committed.

THE PROBLEM

In the last sixty years the population of sub-Saharan Africa almost quintupled but, with a rapidly diminishing quantity of unclaimed cultivable land, cultivated area rose by much less: 52 per cent between 1961 and 2008, with much of the increase during the first decade.[5] Between 1962 and 2008, average cereal yields did not even double (rising from 0.8 to 1.5 tons per hectare), whereas in South Asia they rose from 1 to 2.6t/ha, and in East Asia from 1.5 to 5.4t/ha. Uniquely in the world, sub-Saharan Africa's cereals (and aggregate crop) output per person fell substantially. Food imports increased sixfold between 1967 and 2005, yet malnutrition rates stayed stubbornly high.

Over this period, rising population pressure has led to shorter fallows, expansion into marginal lands and deforestation (three times as fast as the global average). Soil quality has been depleted owing to over-cultivation and erosion by rain and wind. Henao and Baanante report that in 2002–03, 40 per cent of farmland was losing over 60 kg/ha of main plant nutrients each year and that 95 million hectares were severely depleted of soil nutrients.[6] Yet, per hectare cropped, fertilizers added only 10 kg of main soil nutrients in 2008, as against 134 kg in South Asia.[7] Farm productivity has remained sluggish: in the last thirty years average cereal yields rose from one ton to 1.5 tons per hectare, compared with a current world average of 3.4 tons, while output per person fell.

Urgent action is needed to stem soil nutrient loss, through measures to control erosion and through replenishment of soil structure and nutrients. While some environmentalists oppose all chemical inputs to farming, it is unreasonable to expect either African farmers or policy-makers to ignore the yield-increasing potential of increased fertilizer use, provided this will pay. However, without irrigation, fertilizer use in Africa's semi-arid regions is risky and unprofitable. Poor infrastructure and high transport costs, especially in areas of relatively low population density (Africa's average road density is equivalent to India's in 1950), also raise fertilizer costs for farmers, while lowering their revenue from marketed output. Moreover, fertilizer import prices

5 Data available at http://faostat.fao.org/site/377/DesktopDefault.aspx?PageID=377#ancor.
6 J. Henao and C. Baanante, *Agricultural Depletion and Soil Mining in Africa* (Muscle Shoals, AL: International Fertilizer Dev. Corp., 2006); cf. A. Haileselassie et al., 'Soil nutrient depletion and its spatial variability in Ethiopia', *Agriculture, Ecosystems and Environment*, 108, 2005: 1–16, and see M. Lipton, *Land Reform in Developing Countries* (London: Routledge, 2009), p. 339, fn. 46.
7 Nitrogen, phosphorus and potassium (nutrient equivalent) reached 257 kg/ha in East Asia. http://www.fao.org/docrep/009/a0257e/A0257E05.htm.

remain high because individual sub-Saharan countries, many of them land-locked, often purchase relatively small quantities.[8]

Some parts of Africa, for example Nigeria, Ethiopia and the Eastern Cape province of South Africa, have considerable irrigation potential, but in most countries the topography and river systems offer less scope for large-scale gravity-fed irrigation as a proportion of cultivated land than in much of Asia, while essential agronomic, engineering and administrative skills to manage such schemes are often in scarce supply. The underground water-table constitutes an alternative source, but access is sometimes very costly. In terms of irrigable area, there is greater scope for small-scale irrigation. However, the unexploited, but apparently economic, potential is still a small proportion of total cultivated area.[9]

Yet, despite constraints on irrigable area, the fact that in much of Africa, including some regions which can sustain rain-fed adoption of hybrid seeds and fertilizer, a high-yielding seed-fertilizer revolution has not yet occurred gives apparent cause for optimism. Relevant knowledge concerning improved inputs and farm practices can be adapted from areas where faster progress has been made. So as public commitment to agriculture recovers, the prospects for raising food output should be relatively high. Indeed, in some African countries, according to official data, farm output growth has accelerated in the past decade, sometimes to well over 4 per cent. However, the highest rates reflect a one-off recovery from conflict (and perhaps, as in Ethiopia, also dubious statistics). Moreover, much recent growth has come from high-value export crops with relatively few significant region- and crop-specific gains in staples productivity: on much of the continent, the latter continues to stagnate.[10] While export crop production may offer farmers greater command over food (through purchase) than would be achieved through planting the same land to food staples, small-scale farmers who rely solely on selling cash crops to buy staples add price risks to pervasive natural hazards. With low income, few assets and no insurance, few smallholders will commit most of their land to cash-cropping.

8 Cooperation between neighbouring countries to negotiate bulk fertilizer contracts could help to ease import prices.
9 For a recent analysis of the scope for irrigation development in sub-Saharan Africa, see L. You, et al., 'What Is the Irrigation Potential for Africa?' International Food Policy Research Institute (IFPRI) Discussion Paper 00993, June 2010.
10 Data for smallholder food production remain very weak, but data on food consumption, trade and nutrition are better; these suggest few significant gains in staples yields.

While Africa's labour force is growing at 2–3.5 per cent each year, many African households are unable to generate corresponding income growth from self- and waged employment. Are there alternatives to agriculture? Oil and minerals production has expanded and accelerated in several countries but has typically generated little employment. Often it has brought the familiar 'resource curse': corruption, inequality, and economic disincentives to non-mineral production.[11] Growth in manufacturing costs less per workplace than minerals (though more than farming). However, despite isolated pockets of success (Ghana, Mauritius) and good long-run prospects, in the medium term the costs are seldom competitive with Asia: skilled labour costs more and main markets are often further away. In early stages of economic development the main affordable source of extra employment, and hence of income and of poverty-reduction, is normally rising farm production, including of staples as in Asia's Green Revolution. Only later does this fuel rapid growth in non-farm and urban employment.

11 P. Collier, *The Bottom Billion: Why the Poorest Countries Are Failing and What Can Be Done About It* (Oxford: Oxford University Press, 2008).

STIMULATING AFRICAN GREEN REVOLUTIONS

The remainder of this paper considers what would make African green revolutions more likely. Technological options are discussed first, then institutional needs, particularly the requirements for better-functioning markets and appropriate land tenure. Finally the needs for improved R&D and physical infrastructure are highlighted.

Technical progress

Asia's Green Revolution focused mainly on irrigated wheat and rice. Sub-Saharan Africa's main food staples are more varied: unirrigated maize, cassava, yams, sweet potatoes, plantains, rice and millets. Though CAADP has designed, and finance is moving for, some major irrigation expansion, much of sub-Saharan Africa is unsuited to large-scale gravity-fed irrigation, while small-scale irrigation is also constrained by water access. African green revolutions must be adapted to the continent's diverse agro-ecological zones – semi-arid and sub-humid Sahel, moist savanna and humid rainforest – and must also be suited to rain-fed farming. This diversity raises issues of priority between high-potential areas (some of which have already benefited from yield gains owing to past research and development) and low-potential areas. The former require emphasis on access to fertilizers and fertilizer-responsive seeds; the latter require emphasis on improved land-water management combined with varietal and species selection based partly on the potential for resistance to water stress.[12]

In recent decades the debate on the appropriate path for technological change in African agriculture has also been governed by concerns for environmental sustainability and for equity in the form of innovation viability for poor, often remote, farmers as well as the better off.

Recent developments

Despite declining resources, significant investments in plant breeding in Africa in recent decades include the Rockefeller Foundation-supported development of drought-tolerant maize in Southern Africa, NERICA rice in West Africa, which yields 2.5 tons per hectare without fertilizer (a breeding programme started in 1994) and the new IITA cassava varieties which can yield 50–60 tonnes per hectare. Other advances include notable progress in Kenya by the

12 On the potential impact of climate change on African Agriculture see World Bank, *World Development Report, 2010*.

1990s in the development of higher-yielding cowpea varieties. However, more yield-enhancing innovations are needed, while also of concern is the mixed performance and slow rate of uptake of some innovations, including NERICA rice varieties.[13] National food staple breeding programmes continue in many countries, but are under-resourced. AGRA has committed US$43 million towards funding development of 100 new crop varieties that mature earlier, produce larger yields and are suitable for ecologically varied environments, but increased commitment by recipient governments is also needed.

While there have been some successes in breeding higher-yielding food crops and in improving input delivery (discussed below), the majority of African farmers remain peripheral to these advances, primarily owing to problems of access and affordability and, especially in Africa's semi-arid high-risk farming areas, the suitability of some recommended innovations (e.g. fertilizer), with risks of crop burn in seasons of poor rainfall if not preceded by effective investment in soil moisture conservation.

Technological options: modern crop-breeding and organic/low-input agriculture

Africa's rising populations face fixed land endowments, which are increasingly claimed and used. Output growth therefore requires rising land productivity. Labour productivity must rise as well if farming is to remain attractive, but output, and hence land productivity, must rise faster than labour productivity if farm employment is to rise.

Strategies to raise food staple yields may emphasize high use of externally supplied inputs (HEI) – usually seeds developed through modern plant-breeding plus inorganic inputs – or low use of external inputs (LEI), sometimes with organic farming (OF).[14] Today, the high costs of modern inputs compel many African farmers to use OF and LEI farming methods by

13 Rice in Africa is grown in three distinct eco-systems: upland, rainfed lowland and irrigated lowland. The NERICA programme initially targeted the uplands, but now includes all three ecosystems: the first lowland varieties were released in 2005, and the first irrigated ones in 2007. There are now 81 varieties named NERICA, each based on cross-breeding African rice (*O. glaberrima*) with the Asian strain (O. sativa), which has been present in Africa since the fifteenth century, when it was brought by the Portuguese. The yield figure of 2.5 tons appears to refer to upland production, where average yields were lowest and where NERICAs have been most successful. See CGIAR Science Council, 'Report of the Fifth External Program and Management Review of the Africa Rice Centre' (Washington, DC: World Bank Consultative Group on International Agricultural Research, 2008. www.cgiar.org/pdf/agm07/agm07_warda_epmr.pdf.

14 Excluding propaganda definitions (favourable and unfavourable), OF requires minimization or major reduction 'of inorganic inputs of fertilizer, pesticide and herbicide' and LEI of all 'production inputs [that are] off-farm resources, such as purchased fertilizers and pesticides' with 'reliance on inputs from the farm itself, especially manure and compost, seeds and (usually) water'. M. Gold, 'Sustainable Agriculture: Definitions and Terms', US Department of Agriculture, August 2007, http://www.nal.usda.gov/afsic/pubs/terms/srb9902terms.shtml.

default. In fact, they have used LEI methods for centuries, combining these with innovations in both crops and crop varieties (for instance, neither maize nor cassava is indigenous to Africa). The main methods used were adapted to the land abundance and labour scarcity that typified much of rural Africa in the past. Now, however, much higher population densities – and land scarcity – require greatly accelerated innovation to raise yields: for instance, the abandonment of bush fallows in order to increase cultivated area necessitates alternative methods for maintaining soil fertility.

Efforts to improve LEI farming have focused both on raising the output of staple food crops for household consumption and on production, including pure cash crops, for market exchange (e.g. trials of hibiscus in semi-arid Eastern Kenya in the early 1990s alongside food crop variety and management trials). Where new or expanded cash cropping is promoted, viability is also contingent on market access.

Can LEI or OF provide the basis for a viable strategy to eliminate Africa's food shortages? Two recent overviews report yield gains of 60–100 per cent for OF/LEI in Africa (see Tables 1 and 2), but this prompts the question: if such gains are attainable, why are they not more widely captured?

Table 1: Yield gains from organic farming

Crop	*Average yield ratio*	*No. of observations*
Maize	1.68	8
Rice	2.60	2
Sorghum/millet	2.66	5
Vegetables	1.82	3
Bananas/plantain	2.95	2

Source: C. Badgley, J. Moghtader, E. Quintero, E. Zakem, M. J. Chappell, K. Aviles-Vazquez, A. Samulon and I. Perfecto, 'Organic Agriculture and the Global Food Supply', *Renewable Agriculture and Food Systems* 22(2), 2007: 86–108.

Table 2: Yield gains from sustainable agriculture

FAO Farming system	*Country*	*Crops*	*Average yield increase % (s.d.)*
Cereal-root mixed	Benin, Ghana, Nigeria	Maize, soybean	56.6 (10.9)
Maize mixed	Kenya, Malawi, Swaziland, Tanzania, Uganda, Zambia	Maize, beans, groundnut, potato, sunflower, sorghum/millet, cotton	104.6 (12.4)
Highland perennial	Uganda	Banana, plantain, potato	125.0 (29.8)
Highland temperate mixed	Ethiopia, Lesotho	Sorghum, teff, sweet potato	205.2 (90.9)
Agropastoral millet/ sorghum	Burkina Faso, Ghana, Mali, Niger, Senegal, Sudan, Zimbabwe	Millet, sorghum, cotton, groundnut, vegetables	149.3 (31.7)

Source: J. N. Pretty, A. D. Noble, D. Bossio, J. Dixon, R. E. Hine, F. W. T. Penning de Vries and J. I. L. Morrison, 'Resource conserving agriculture increases yields in developing countries', *Environmental Science & Technology*, 40(4), 2006: 1114–19.

Cost apart, possible explanations lie first in methodological weaknesses underlying the yield claims. These include:

- lack of clearly specified controls, small or non-random samples, and over-reliance on anecdotal data: few studies of LEI use controls or experimental layouts when calculating yields;
- ignoring the need for additional land and animals to produce organic matter and manure;
- ignoring the need for disease and pest control which may require crop rotation to 'clean' the land;
- overlooking the dependence of small farms on grass-roots NGOs for expert support when adopting currently promoted LEI and OF methods (a hidden cost usually excluded from cost-benefit assessments).

Small-scale farmers may not adopt yield-increasing forms of LEI and OF (such as investment in soil and water conservation, use of animal or green manure, or crop rotations to maintain soil fertility and reduce pest incidence), for several reasons:

- such methods may be time- and energy-intensive, including at peak farming periods;[15]
- although these methods may raise yields per cropped hectare, there is a 'hidden' rise in land requirements (see above);
- investment in creating structures for soil and water conservation and harvesting (which can raise yields and reduce risk), or in agro-forestry for green manure or browse, may be inhibited by lack of secure land rights;
- other forms of increased water access, such as small-scale off-take from rivers (either gravity-fed or pumped), or tapping groundwater, are heavily dependent on location, and are often sustainable *only* if not too many farmers use the water ;
- Currently promoted OF/LEI is knowledge-intensive and concentrated in limited areas where NGOs are working.

OF's most striking successes in raising farmer incomes often involve high-priced horticultural products for niche 'green' markets. While some LEI/OF innovations, including the building and maintenance, often with family labour, of soil and water conservation and water harvesting structures, have a key role in sustaining and raising land productivity on many African smallholdings, for staples, rapid yield gain entails an eclectic approach, drawing also on the scope for a seed-cum-fertilizer revolution, especially in more favoured rain-fed and irrigated areas, but recognizing the risks of some forms of HEI innovation.

15 For example, getting organics to plants, maintaining water catchments.

Mainstream breeding and genetically modified crops

Africa's low growth rate for cereal yields per hectare between 1960 and 2000 is in marked contrast to the near fivefold yield increases in China over the same period.[16] By 2009, sub-Saharan Africa's average cereal yield was 1.8 times its level in 1961, but in China 4.5 times. Apart from irrigation, and (from 1977) land reform and better incentives, China's performance is based on better seed quality and farm practice.[17] Most African farmers still select and sow seeds from the previous year's harvest.[18] The expertise to generate improved seed stocks using conventional breeding methods (responsible for over 90 per cent of modern varieties in Asia and over 99 per cent in Africa), has been present for decades in a number of African countries and has achieved some significant successes (for example in Kenya and Zimbabwe). However, there is huge unrealized potential, including for other food staples, certainly for conventional plant-breeding and probably for genetically modified crops, although more knowledge of GM impacts is needed. In South Africa, recently introduced GM maize is herbicide-resistant, sometimes permitting moisture-conserving no-till agriculture.[19] As with bollworm-resistant GM cotton, gains have spread to smallholders. In West Africa, on the other hand, a transgenic cowpea resistant to pod-borer is available but illegal. The GM Round-up Ready (RR) white maize introduced in South Africa can generate yields which are substantially higher than traditional varieties. Although seed and chemical costs are almost double those for conventional varieties, reported gross margin gains are even greater (see Table 3).

However, some HEI technologies require precautions. KwaZulu-Natal farmers have experienced health problems from incorrectly applying chemicals to GM herbicide-ready maize, in some cases owing to inability to afford protective clothing. Weeds and pests develop resistance to herbicides and pesticides, requiring 'maintenance breeding'. Before supporting packages which encourage herbicide use, policy-makers should also ensure that reduced hire of weeding labour is likely to be compensated, for the poor, by employment gains (e.g. in harvesting) or cheaper food in local markets. With HEI and LEI,

16 Between 1961 and 2008 cereal yields doubled in sub-Saharan Africa (unweighted average across its four regions), influenced by an exceptionally good year in Southern Africa in 2008. Over the same period, yields in China rose by 457%. Source: FAOSTAT, accessed at http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor on 6/6/2010. Crop-specific comparison for wheat alone reveals a still stronger relative performance in China.

17 Mike Gale, Chatham House presentation, Science and Technology: GM Crops and Inorganic Fertilizers versus Organics and 'Natural' Farming, 8 July 2009.

18 Seed may also be obtained from relatives and neighbours, by purchase in local markets or, following harvest failure, through famine relief. Any consequent unsystematic cross-pollination may help to sustain, and occasionally even improve, yields but the latter only slowly and spasmodically.

19 In addition to positive impacts on soil structure and moisture retention, minimum tillage reduces the need to set aside land for grazing for bullocks.

an innovation which is focused on overcoming one constraint may encounter others unless both research and diffusion are sensitive to the full range of environmental conditions faced by farmers and to their priorities: early-maturing grain varieties when first introduced may attract severe bird attack unless at the outset a sufficient number of farmers in one locality take up the innovation to diffuse bird predation.

Table 3: Biotech (transgenic) white maize on smallholder farms in South Africa

	Yield (kg/ha)	*Seed cost (R)*	*Chemical cost (R)*	*Power cost (R)*	*Margin (R)*
Round-up Ready	1386	1168	629	454	3987
Bt*	794	879	250	486	1653
Conventional	750	663	352	810	738

* BT maize: a GM maize engineered for pest resistence and based on one of several Bt proteins derived from the bacterium *Bacillus thuringiensis.* BT maize was first introduced in S.Africa in 1998
Source: M. Gouse, J. Piesse, C. Thirtle and C. Poulton, 'Assessing the Performance of GM Maize Among Smallholders in KwaZulu Natal, South Africa', AgBioForum, 2009.

Some farm systems which use improved LEI methods and OF are sustainable and productive; and industrialized agricultures have sometimes dangerously over-used key external inputs, including both fertilizer and irrigation. However, much African agriculture uses few such inputs and in addition suffers not only very low productivity and growth but also unsustainable water and plant nutrient use. Especially in areas that are humid or sub-humid, high external input methods are essential for substantial yield gains. The task for policy is to secure informational, financial and physical access by low-income smallholders.

Meanwhile, farmers in semi-arid, rain-fed environments require improved water and soil management, as well as crop improvements geared to yield gain combined with drought tolerance or avoidance. This needs plant breeders who can identify and develop appropriate varieties, or even species. Equally important is improved farm management: control of water and soil run-off, better humus retention and replacement[20] – all measures which help soils to retain moisture and absorb inorganic fertilizer but mean greater labour input, which in turn pays better if plant breeders can generate drought-

resistant seeds offering higher yields. As in this instance, appropriate LEI, conservation and modern technology can be complementary.

Further evidence about the net benefits of both HEI and LEI approaches is needed, assessing both the short- and longer-term private and social impacts, while recognizing that LEI may be based on modern science and HEI may include elements of OF: for example, use of organic manures purchased from other farmers.

20 The low humus level in many areas, e.g. West African montmorillonite soils, makes organics a necessary precondition for (not a rival of) absorbable inorganics.

INSTITUTIONAL CHANGE: MARKETS

Institutions are 'the rules of the game' – formal and informal regulations and norms which govern human interaction.[21] The key institutions for diffusing farm innovation involve farm input (physical and services) and output markets and land rights. For African agriculture, at least three sets of institutions matter: those which underpin the operation of markets for relevant goods and services, the organization of collective action, and the governance and distribution of property rights (especially in land). All can have an influence through their presence or absence, form, interpretation and/or effectiveness of implementation.

Since the early 1980s, the case for institutions which support free markets, including in agriculture, has been widely articulated,[22] and has had considerable influence on policy, including in Africa's agricultural sector. However, there are also continuing roles for the state, particularly in low-income economies. This applies both to market regulation and to facilitating delivery of, or access to, goods and services where markets are missing, incomplete or imperfect: for example, the state can diffuse knowledge concerning new farm inputs or practices, especially in regions where access costs and/or ability to pay discourage private-sector provision of technical advisory (extension) services for farmers.

Experience shows that market privatization without provision for appropriate public-sector regulation can result in a lowering of farm performance and farmer welfare. In the 1990s, when the private sector was given an increased role in maize seed production in Kenya, complaints about poor quality quickly became common. Similar complaints have also arisen with respect to private production of NERICA rice seed, particularly in contexts where a single firm has been assigned a national monopoly.[23] In relatively remote areas low-income farmers often have no redress when a distant source supplies a substandard product, whether it be adulterated seed or day-old chicks which are all males.

Meanwhile, for most African farmers seed, fertilizer and pesticide innovations remain inaccessible, unaffordable, and/or risky. Input costs are raised by poor rural infrastructure and sparse trading networks, both in part due to low

21 See D. North, *Institutions, Institutional Change and Economic Performance* (Cambridge: Cambridge University Press, 2010).
22 See, for example, Dani Rodrik, Arvind Subramanian and Francesco Trebbi, 'Institutions Rule: The Primacy of Institutions over Integration and Geography in Economic Development', IMF Working Paper, WP/02/189 (Washington, DC: International Monetary Fund, 2002), http://www.imf.org/external/pubs/ft/wp/2002/wp02189.pdf.
23 GRAIN Briefings, 2009, NERICA, http://www.grain.org/briefings/?id=215.

population densities in lower-potential areas and to the dispersed residence patterns that have traditionally characterized parts of rural Africa. Ill-thought-out or vacillating state intervention in markets may damage farm performance but timely, appropriately focused state intervention may kick-start or sustain innovation and output expansion, especially if in remote areas it is combined with improvements in physical infrastructure (see below).

Some recent action has been taken to deliver improved seed and fertilizer to more farmers, including initiatives supported by AGRA, which, by April 2009, had made grants in 13 countries totalling some $84 million, much oriented towards development and distribution of improved seeds.[24] AGRA's Programme for Africa's Seed Systems has four main sub-programmes: Agro-dealer Development, Education for African Crop Improvement, Fund for the Improvement and Adoption of African Crops, and Seed Production for Africa. It has so far focused on nine countries, aiming to address an identified deficit in improved seed varieties and weakness in the distribution of inputs. In Mali, Malawi, Kenya, Tanzania, Rwanda and Nigeria, AGRA promotes credit provision through local traders for seed and fertilizer purchase in packages of 1–5 kg, substantially reducing the distances that farmers must travel to buy these inputs. The traders receive training in input use so that they can advise farmers. The credit is funded with bank loans and credits from agri-business, and AGRA guarantees the loans.

Significant national initiatives to disseminate improved inputs include Malawi's launch in 2005–06, with external agency support, including from DfID, of a US$5 million subsidy programme for maize seed and fertilizer.[25] Farmers receive vouchers which they exchange for seed and fertilizer. Between 2005 and 2007 the programme funding expanded to US$60 million, and Malawi went from food deficit to a 1.3 million-ton surplus (in 2006–07), exporting 391,000 tons of maize worth US$100 million. However, country needs vary: in Kenya in the 1990s, increased efficiency in the fertilizer market was achieved through market liberalization rather than state-supported market development (see below).

Governments can sometimes work with seed companies to ensure access to improved seed. This is highlighted by the contrast between disappointingly slow diffusion of NERICA rice in West and East Africa[26] (first released in 2000) and the much faster uptake of a rust-resistant pearl millet hybrid

24 Action Aid (2009), *Assessing the Alliance for the Green Revolution for Africa*, pp. 4–5, 10 and 29–32. http://www.actionaid.org/docs/aai%20report_assessing%20agra.pdf.
25 This followed prolonged dry spells and a serious drop in food production in 2004–05.
26 By 2007, NERICA was estimated to be grown on 6.7 per cent of Africa's rice area.

(HHB67) released in southern India in 2007, with seed companies involved in aggressive marketing from the outset.[27] However, India benefits both from a more densely developed rural infrastructure than most of Africa and from more uniform production environments, advantages which jointly enlarge market size. In Kenya, where the main maize surplus areas have relatively good infrastructure, big seed companies have been involved in the introduction, also in 2007, of a *striga*-resistant maize hybrid,[28] but such involvement is less likely where growing conditions and/or market access are less favourable: there, initial efforts to kick-start markets in farm inputs and services (knowledge, credit, insurance) must come largely from the public sector, with inputs also from NGOs and civil society.[29]

That appropriate policy for enhancing input market performance varies according to local conditions is well illustrated by the experiences in Malawi and Kenya noted above. In countries such as Malawi, where a farm input market is missing or underdeveloped, state subsidization of farm inputs in order to encourage innovation and reduce risk can be organized so as to support the development of the private sector – in this case by creating an expanded role for private traders in input and credit supply. In Kenya, where use of improved seed and fertilizer is more diffuse and state intervention in input and output markets has been inefficient, a combination of market liberalization and increased state investment in the provision of public goods (rural infrastructure, development of yield-enhancing crop varieties) has, over the past two decades, had a positive impact on farm performance. The liberalization of the Kenyan fertilizer market in the early 1990s (with price controls and import quotas abolished), combined with the elimination of barriers to private maize marketing and, especially from 2003, increased investment in rural transport infrastructure, was associated with positive trends in fertilizer use, maize productivity and maize consumption between 1990 and 2007. The market-liberalizing reforms led to increased competition

27 Regional harmonization of seed regulation would enable seed companies to market seeds that are 'allowed' in more than one or two countries.

28 Striga, a parasitic plant, affects 3.6 million hectares in Kenya and can lead to yield losses of over 30%. It is difficult to control, especially on poor soils. A partnership between the African Agricultural Technology Foundation (AATF), BASF, the International Wheat and Maize Improvement Centre (CIMMYT), national research stations, local seed companies, NGOs and farmers has contributed to the development of five cultivars of imazidalinone-resistant maize, coated with the herbicide imazapyr, with over 15,000 demonstrations already implemented.

29 The speed of new input diffusion is of course also a function of suitability: in the case of NERICA rice questions have been raised about the attractiveness of the NERICA varieties to African smallholders. For example: early maturity, which is a feature of NERICA, although seen as an advantage in upland systems can lead to massive bird damage if only a few farmers grow NERICA; and short straw implies bending over by women harvesting rice by the sickle and is more painful and difficult than for long straw rice. Short straw is also a disadvantage if straw is used as animal feed, or if it is used for other purposes, such as roofing (CGIAR, 2007, p. 94). While more aggressive marketing might help to overcome the first constraint, it would not address the others.

among suppliers, reducing the margin between fertilizer import and wholesale prices, increased density of the input distribution network, and finally a reduction in both retail prices and costs to farmers of accessing fertilizer. The proportion of farmers using fertilizer in the main maize season rose by 25 per cent between 1996 and 2007. In Kenya's high-potential maize zone, fertilizer dose rates averaged 187 kg per hectare, comparable to or higher than dose rates on rain-fed grains in South and East Asia.[30] However, such reforms, and their impacts, remain relatively fragile: in Kenya in 2008–09 political violence, which destroyed infrastructure in Western Kenya, combined with drought and the surge in world fertilizer prices, threatened this success story. A combination of political stability and further investment in public goods (such as port facilities and processes, and maintenance of the rail network) is needed to sustain input distribution margins and contain price increases.

The key services needed by farmers are credit, insurance and technical advice/new knowledge dissemination. In much of sub-Saharan Africa climatic risk and high monitoring costs make the provision of formal insurance to small-scale farmers prohibitively expensive. However, in higher-potential areas with reliable rainfall there is scope for pursuing pilot programmes focused on key crops and local rainfall records. Meanwhile, despite localized successes with micro-finance (in terms of credit uptake and repayment) and with seasonal trade credit, most small-scale farmers also remain without access to formal credit; even a specialized rural development bank such as Uganda's CERUDEB has found it difficult to advance into agricultural lending, as has a land bank in South Africa. The widespread inability of the poor to take risk or to access affordable credit suggests a need to reappraise the potential for state-managed support for market-based distribution of new, yield-enhancing farm inputs, plus seasonal credit and basic technical advice. However, proposals for new arrangements for provision of seasonal credit through private crop traders have greater prospects of success in relatively densely populated farming regions with higher potential, such as the Kenyan highlands or Uganda's fertile crescent around the northern shore of Lake Victoria, and are least likely to be viable in low-income, high-risk areas. There, both the stabilization and increase of crop yields may require prior implementation of improved land and water management practices. In the small farm sector this is likely to involve the public sector in knowledge dissemination and farmer mobilization. It is also important not to under-rate the extent to which other approaches, both informal and formal, can be used

30 Joshua Ariga and Thomas S. Jayne, 'Private Sector Responses to Public Investments and Policy Reforms: The Case of Fertilizer and Maize Market Development in Kenya', IFPRI

to compensate for lack of access to formal credit and insurance markets. Tailoring input innovations to emphasize features such as divisibility – suitability for distribution and adoption in small quantities, which raises affordability – and resilience to climatic risk can significantly reduce capital and risk constraints. In Kenya, since the liberalization of the fertilizer market, there has been an increasing tendency to repackage 50 kg packets into smaller sizes – 25 kg, 10kg, 2 kg and even 1 kg packets. Malawi's maize seed and fertilizer subsidy programme also focuses on small-scale packaging. Meanwhile, informal rotating savings and loan institutions can undertake some farm finance, as in Ghana and Kenya, although they are not well adapted to financing seasonal inputs (when all members need credit at the same time).

One problem reported in several African countries over the past decade is the failure of local markets to clear bumper harvests resulting from yield-enhancing innovation and favourable climate conditions – e.g. cassava in Nigeria and maize in Ethiopia. The reasons may include high transport costs to move produce to urban markets, state-enforced price distortions and/or perishable products. Promising public-sector initiatives to overcome inadequate effective demand for food surpluses include the World Food Programme's 'Purchase for Progress' (focused primarily on Africa), which links food consumption assistance to agricultural development through food procurement, and the CAADP's 'home-grown school feeding' concept, with local sourcing of food for school meals. Despite their often disappointing record in Africa from the 1960s and 1970s, farmers' cooperatives also have a role to play in bulking up produce and lowering the transport and storage costs of market access. However, among the lessons learned from that period are that cooperatives are more likely to succeed where most of the membership is literate, and that at quite low membership levels the advantages of scale in primary (local-level) societies may be more than offset by a reduction in group cohesiveness.[31]

Discussion Paper 921 (Washington, DC: International Food Policy Research Institute, 2009).
31 For an example of a major Ghanaian cooperative success story, and the problems and opportunities it faces, see M. Tagoe, 'Farmer-owned Businesses: the Example of Kuapa Kakoo in Ghana', in L. Cotula and R. Leonard (eds), *Alternatives to Land Acquisitions: Agricultural Investment and Collaborative Business Models* (London, Bern, Rome, Maputo: IIED, SDC, IFAD, CTV, 2010).

INSTITUTIONAL CHANGE: LAND RIGHTS

In order for government policy to promote effective and equitable technological development in farming, it is necessary to address key issues relating not only to access to farm inputs and services but also to land. In the latter case, important questions are: What is a 'good' farm size and distribution of farm land? What are recent trends in land acquisition? How do alternative institutional arrangements for land access affect the prospects for, and impact of, technological innovation?

Efficiency, equity and farm size

In developing economies, small and large farms face strikingly different costs for labour and capital. Small farms using mainly family labour have lower labour recruitment and supervision costs. Larger farms face lower costs in borrowing for, buying and operating larger-scale equipment such as tractors and deep, motor-powered, tubewells. In low-income, labour-abundant economies, where capital is scarce, there is an efficiency case for supporting small-scale, labour-intensive farms. Small farmers also tend to manage other resources more intensively: their management time has a low opportunity-cost, smaller areas are easier to oversee, and farmers often know their hired workers, while family labour is better motivated and needs less supervision. Low labour costs in slack seasons also often increase the labour-intensive development and maintenance of farm fixed capital such as fencing, terracing or storage. Consequently there is a widely observed *inverse relationship* in developing economies between farm area and both labour-per-hectare and output-per-hectare.

The efficiency and equity advantages of small family farms in developing economies suggest a win-win case for land reform, especially where land is very unequally distributed. However, the introduction of yield-enhancing technologies entails costs and start-up risks, both in purchasing and managing new inputs and in finding new market outlets. Are small farms badly placed to incur these costs and risks? There is clear evidence, including from India's Green Revolution, that small farmers adopt yield-enhancing inputs and practices – if profitable and accessible – at least as intensively and successfully as large farmers. However, medium-scale farms usually pioneer innovation, partly because of biases in agricultural research and farm support towards their more favourable resource endowments, and also because they are more able to carry risk and to access commercial credit (whereas the owners of the very largest farms may be less motivated to pioneer innovation). Yet a uniformly small-farm sector supported by an appropriate

physical and service infrastructure – as in Japan, South Korea and Taiwan in the 1950s and 1960s, and in China, parts of South Asia and Indonesia in the 1980s – can achieve rapid diffusion of innovation and high land productivity. Significant African successes in small-scale innovation diffusion include cocoa in Ghana; cotton and coffee in Uganda; coffee and tea in Kenya; high-value horticulture in Eastern Africa; irrigated farming in Iringa in Tanzania, Mwea in Kenya and the Niger River Basin in Mali.

Recent evidence (such as from China, Indonesia and Kenya) also shows that small farms, organized in groups, can successfully match large farms' economies of scale in terms of storage, transport and/or processing and can competitively supply both domestic supermarkets and export outlets, either directly or via processing intermediaries.[32] However, this does not always work: difficulties in achieving effective group organization mean that sometimes large farms are better able to guarantee delivery of a regular minimum throughput. This advantage may enable them to pioneer innovations which enhance the value of land yields, especially with new products for export. Can one combine the labour-cost advantages of small family farms with those of large units for post-harvest activities? This has been successfully done in several ways, including contract farming, or 'outgrower' schemes (in which core large farms and surrounding small farms deliver to the same processor). However, there is no hard evidence that small farms need such links in the case of food staple production.

Recent and on-going large-scale land acquisitions

The pace of large-scale farm land acquisitions in Africa, usually by foreign investors, has recently accelerated, but many of these large holdings do not catalyse small-farm development. In Ethiopia, Ghana, Madagascar and Mali land allocations in plots of over 1,000 hectares totalling some 2 million hectares have been approved since 2004, mainly to large-scale foreign buyers. Although this is a small proportion of the total, it is land with high potential that has been targeted, most of it previously under use or claim. So far there has been little development of the transferred land. As also in Tanzania and Mozambique, action to safeguard or even consult local interests has been scanty, while acquisitions have been facilitated by institutional and organizational change in host countries, including bilateral

32 See *World Development*, November 2009, 37/11 (Special Issue: Agrifood Industry Transformation and Small Farmers in Developing Countries) and Cotula and Leonard (eds), *Alternatives to Land Acquisitions*. Ghana's Kuapa Kakoo federation of cocoa cooperatives has

investment treaties, revision of investment codes and 'one-stop-shops' to help investors negotiate local regulations. Owing to the widespread use of traditional systems of land tenure, with limited formal records of individual land rights, local livelihoods are often undermined by such land acquisition. Little good potential unclaimed land remains and investors are acquiring land which is informally claimed by small-scale farmers under customary tenure rules.[33] Laws designed to protect local resource rights have been undermined when they are perceived to hinder increased foreign investment: in Mozambique the 1997 Land Act set out the basis for delimiting community land but both interpretative practice and a 2007 amendment have undermined such protection. Meanwhile, transparency is often lacking in contract negotiations, with little external scrutiny. Since land registration is often inaccessible to local users, any compensation has been confined to land improvements, with none for loss of basic land rights. Most African economies also lack robust mechanisms to enforce compliance with any investment commitments made by buyers.

Given the prospects for rising global demand for food and biofuels, demand for land by large-scale investors is likely to continue. However, such investments can be more effectively structured to share value with smallholders: the institutional options include contract farming, joint ventures, community leases and management contracts. All exist in Africa and other developing regions. Criteria which can be used to assess commitment to value-sharing in projects proposed by purchasers include:

- distribution of ownership of key assets (e.g. land, processing facilities);
- voice (who takes/influences business decisions);
- risk (how supply, production, market and other risks are shared); and
- reward (how costs and benefits are shared).

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also invested in downstream processing and marketing: it owns a 40 per cent share in the Divine chocolate brand.

33 L. Cotula, S. Vermeulen, R. Leonard and J. Keeley, 'Land Grab or Development Opportunity? Agricultural Investment and International Land Deals in Africa' (London, Rome: IIED/FAO/IFAD, 2009). See also L. Cotula and W. Vermeulen, '"Land Grabs" in Africa: Can the Deal Work for Development?', IIED Briefing, September 2009.

Possible actions to make outsider investment in land development more likely to benefit local small farmers include requiring potential investors to develop business models which share value added with local producers; more thorough scrutiny of investment proposals by host governments; negotiation and enforcement of deals which maximize local benefits; scrutiny of contract negotiations by civil society, combined with pressure for better deals; and action by local farmers and NGOs to protect local land rights and get better deals from governments and private investors. An international code of conduct for investment in land (similar to the Minerals Transparency Initiative) has also been proposed.[34]

Land reform

Improving the design of large-scale land investment does not address the existing extreme inequality of land distribution in some parts of Africa, often the legacy of colonization and European settlement patterns. Such inequality, alongside high levels of under- and unemployment, harms the poor, agricultural output and probably GDP growth.[35] Large farms use land less labour-intensively than small ones, leading to opportunity costs from lower farm output and employment, and a reduction in supply and demand linkages to the non-farm sector. Where land is concentrated in small family farms, many of these linkages tend to be to small-scale, labour-intensive enterprises, thereby encouraging both output and employment expansion, as well as reducing poverty.

Land reform is 'legislation intended and likely to directly redistribute ownership of, claims on, or rights to farmland – and thus to benefit the poor by raising their absolute and relative status, power, and income, compared to likely situations without the legislation'.[36] Such reform can contribute to ensuring that a green revolution will not only raise land productivity but cut poverty through:

- direct generation of extra income for the poor, from farm labour and from land;
- generation of demand for non-farm outputs of the poor, including from non-poor smallholders whose output and incomes rise;

34 This section is closely based on Cotula's presentation to the Chatham House meeting 'Land Reform or Land Grab?', 16 February 2010.
35 Lipton, *Land Reform in Developing Countries*, pp. 102–10.
36 Ibid.

- easing pressure on food prices.

It is harder for a green revolution to achieve these outcomes in the same degree if land is concentrated in large farms since these tend to be capital-intensive, require fewer local labour-intensive outputs and are less focused on staple foods.

However, not all that purports to be land reform matches the above definition. What is most likely to do so is the redistribution of ownership rights from large farms (private, state or collective) to small-scale farmers and, in some cases, the landless. This may be done in various ways but in democracies, to be acceptable, redistribution depends on some form of compensation. Such redistribution reinforces production and efficiency incentives – even avoidance tends to get land to smaller farms . Collectivization, on the other hand, damages the poor because of its adverse incentive effects, the remoteness of management from the field level, incentives for the state to abuse the collective organization in order to extract surplus, and (usually) excessive farm size. Some types of tenancy reform and *de*collectivization may strengthen the poor's land rights, but others harm the poor: restrictions on land leasing may reduce their access to land; decollectivization into large 'private' holdings tends to leave most land in mechanized, sometimes quasi-collective units. These reforms are also less relevant in Africa than the redistribution of ownership rights, since tenancy is less widespread here than in Asia or Latin America and decollectivization is rarely a policy issue. However, in Africa as elsewhere, collectivist biases can derail land reform.[37]

Also important in Africa is the formalization of the land claims of those farmers – the great majority – who hold land under various forms of customary tenure. Recent initiatives have demonstrated the scope for dramatically lowering land adjudication costs but further progress is urgently needed in devising appropriate rules and administrative arrangements to keep land registers up to date. This requires accessible, local-level registers, administered by persons who know, and are known by, local residents.

However, simple formalization of the status quo may fail to address inequities within customary law itself. For instance, under the latter women's rights are often subsidiary to those of men. Although frequently the main food producers, women – whether married, single, widowed or divorced – often

37 Ibid., pp. 195–7.

depend on husbands, fathers or other male kin for access to the land which they cultivate, and have no right of veto over the alienation of such land to third parties (whether through sale, lease, loan or mortgage). The formal recognition of such a right could itself increase women's security as farmers. Formal recognition of their right to own land and to transact in the land market, where such does not exist, could also enhance their dynamic role as farm entrepreneurs and innovators.

Since 1970, the proportion of farmland in smaller farms has risen (and typical farm size has fallen) in almost all developing countries with comparable data.[38] Although the fall in average size stems partly from subdivision at inheritance, the facts that such subdivision is maintained and that the proportion of land in small farms has risen suggest that smaller farms are still achieving greater land-use intensity and greater cost efficiency per unit of output than larger units.[39] Some farmers also buy or lease small amounts of land from larger owners. However, the normal pattern is that the advantages of small farms – based largely on lower labour costs, higher labour motivation and more effective labour supervision, as noted above – are eroded as development occurs, employment and wage rates rise, and financial and physical capital become increasingly attractive as a substitute for labour. Put simply, the cost advantage of small family farms in labour transactions is gradually replaced by that of large farms in capital transactions. Governments which have promoted small-scale farming need to adjust the institutions that influence farm size as larger farms become more appropriate, but this is far in the future for most of Africa.

38 Ibid., pp. 91–102.
39 Such farms are also valued for the security they offer in providing at least part of a household's basic subsistence.

R&D AND PHYSICAL INFRASTRUCTURE

Institutional change will facilitate and incentivize technical change on African farms only if there is an adequate, affordable supply of appropriate innovations (on-farm and post-harvest) and adequate physical infrastructure in rural areas. Sustained innovation requires an effective, reliably resourced R&D programme, agreed between international and national research agencies and taking account of research and development by the relevant multinationals. The planning and evaluation of publicly financed research, which ranges from fundamental research in crop breeding methodology through to species and varietal trials and the testing of farm management practices at regional research sub-stations, should exploit the scope for farmer consultation, especially by those working at sub-station level; local trials need to be designed partly in response to farmers' priorities and the results fed both upwards to national centres and to farmers themselves. There is also scope for giving greater, and more systematic, emphasis to the organization of farmers' groups to participate in the final testing of innovations prior to general release.

An African agricultural renaissance also entails development of roads, rail networks and warehousing capacity serving the farm sector. Figures 1–3 illustrate how Africa lags behind India in the development of these resources. Africa cannot fulfil its potential to raise food production and become a net exporter without improvements in transport and storage capacity and increased and diversified crop-processing capacity. Thin transport networks raise the cost of accessing both farm inputs and market outlets; inadequate local storage and processing capacity combined with high transport costs lower the returns to farmers from the production of food surpluses and further reduce the incentives to innovate.

In 2001–02, high rates of adoption of improved seed and fertilizer among Ethiopia's maize farmers, plus good weather, resulted in a bumper harvest which was followed by an 80 per cent drop in the maize price: 300,000 mt of grain rotted in farmers' fields.[40] In Nigeria, greatly improved cassava yields following the adoption of improved varieties were also followed by local market gluts and a decline in uptake. For bulky and/or perishable crops, support for R&D that is focused on the design and development of small- and medium-scale crop-processing facilities can reduce unsold surpluses while adding value to farmers' output by lowering transport costs and/or increasing storability of the finished product. Kenya's Rural Feeder Roads Programme

40 Steven Were Omamo, Chatham House presentation, October 2009.

illustrates how significant improvements can be achieved in rural transport infrastructure by using local labour and hand-held tools for construction and maintenance, thereby limiting budgetary pressures; but the main rural transport arteries often need increased central government resource commitments, especially in more remote areas.

Figure 1: Road networks in most African countries are too thin

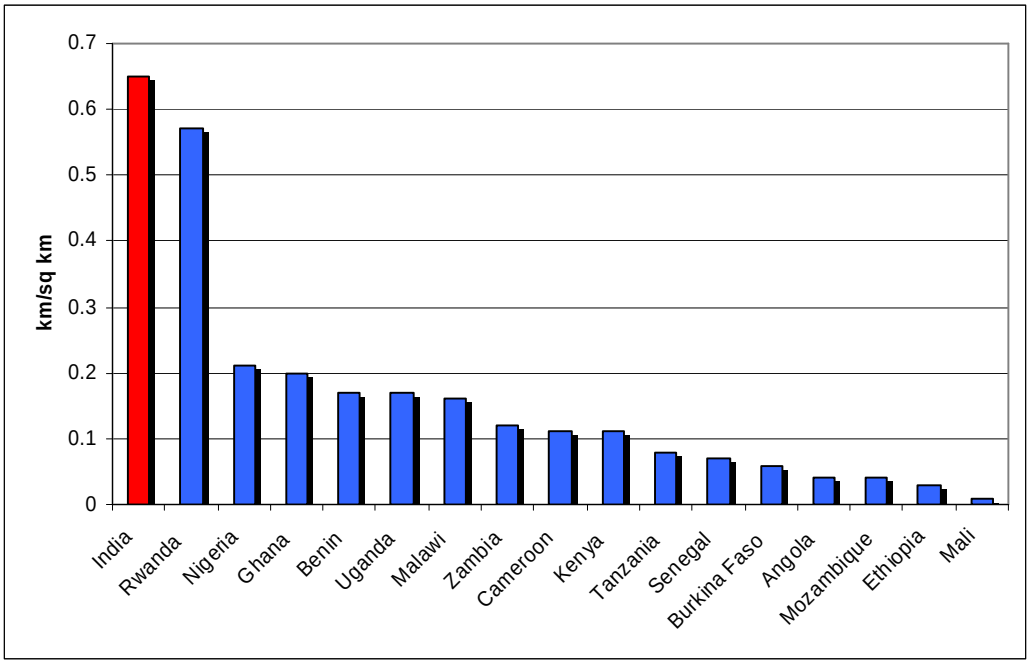
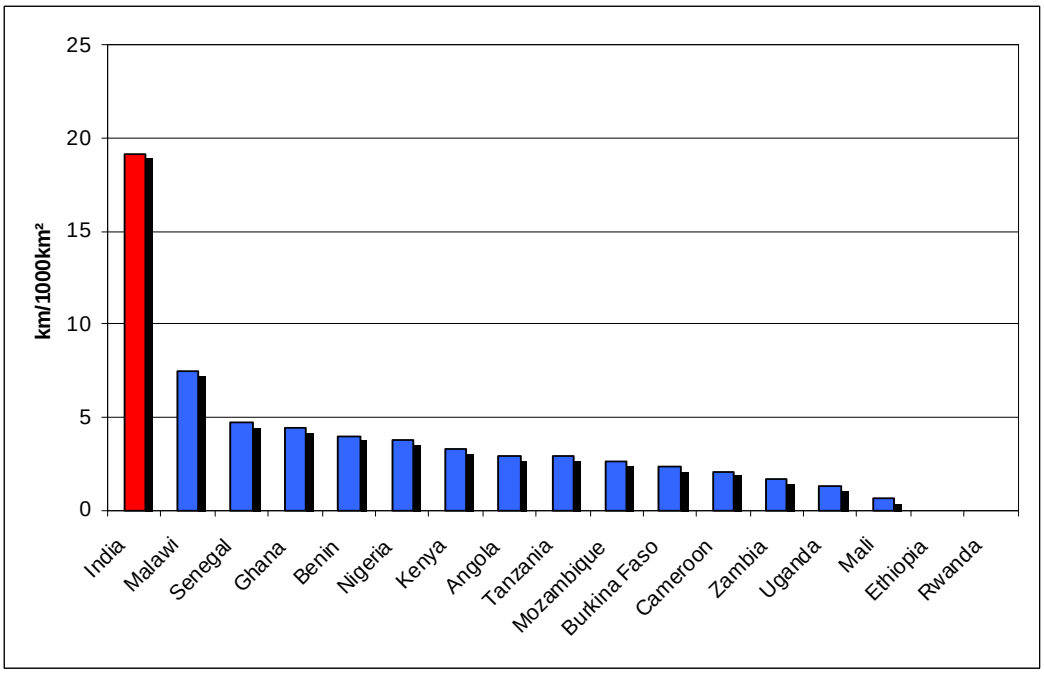
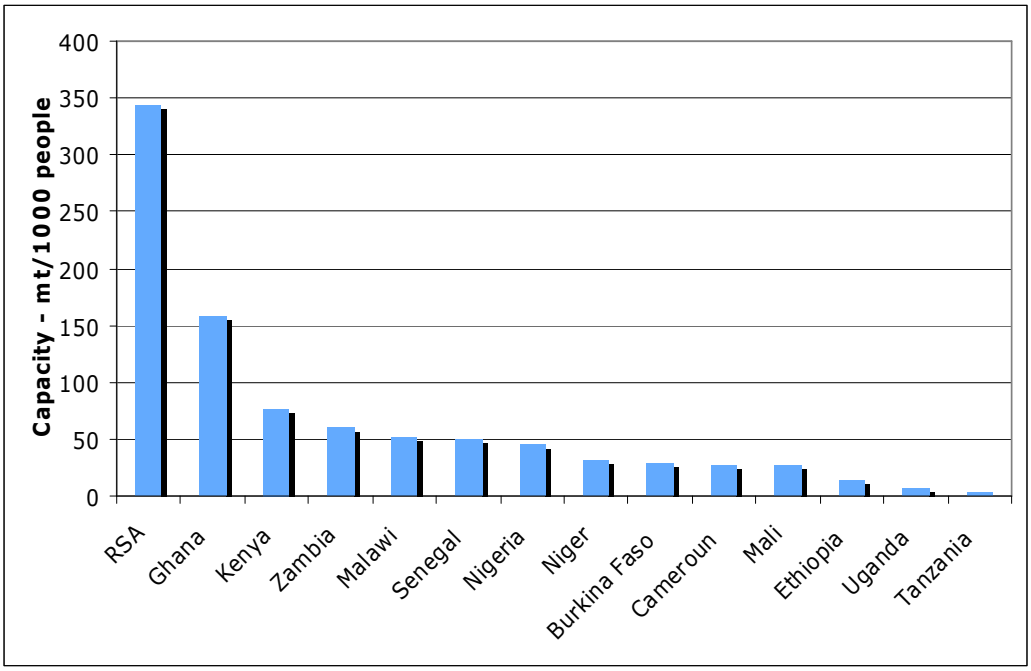


Figure 2: Railway networks in most African countries are too thin



Source for Figures 1 and 2: Alix-Garcia (2007), cited by Omamo in presentation to Chatham House meeting 'Agriculture in Africa: Improving Markets and Institutions'.

Figure 3: Formal warehousing capacity in most African countries is too low



Source: ACDI-VOCA (2008), cited by Omamo in presentation to Chatham House meeting 'Agriculture in Africa: Improving Markets and Institutions'.

CONCLUSION

The last fifty years have seen agriculture in Africa develop much more slowly than in Asia or Latin America. Output per head has fallen; food imports have risen. Yet there have been instances of crop-breeding success, and of significant yield response to fertilizer, successful irrigation management and institutional reform. There is an urgent need for increased resource commitments to modern plant breeding to help raise crop yields, complemented by better physical and institutional infrastructure and increased emphasis on water and soil management, to enhance yields sustainably while lowering farmers' exposure to climatically generated risk.

To eliminate the food supply shortfall requires a pragmatic approach to identifying and diffusing viable innovations in order to enhance yields for sub-Saharan Africa's diverse agro-ecologies. Key components of such an approach include:

- enhanced land management: investments to reduce erosion, restore land fertility, control and harvest water, and irrigate and drain as appropriate;
- increased research (most probably with public funds) on appropriate technologies, including crop varieties that perform well in low-rainfall environments and HEI modern varieties, mainly suited to well-watered environments (and with greater prospects for both privately funded development and public-private research partnerships with seed companies);
- rigorous estimation of returns in farmers' fields to LEI and OF methods;
- use of smart subsidies, small-scale credit, and technical advice to kick-start adoption of improved inputs and methods;
- infrastructure investments to improve market access and cut access costs;
- liberalization of input markets where input use has become established;

- institutional change to secure, and in some cases redistribute, land rights and to regulate large-scale land acquisitions to safeguard smallholder rights and livelihoods

There is much opportunity – increasingly recognized by African governments and civil society – to strengthen knowledge, institutions and infrastructure for the growth of small farms in sub-Saharan Africa, based on scientific developments yet taking account of specific local and environmental conditions. Successful pursuit of this path requires that all African governments commit to the CAADP target of a 10 per cent budget commitment to agriculture. Donors should translate their 2008 pledges at the G8 summit in L'Aquila into support for the many initiatives to strengthen agriculture which are now being promoted within the continent.

APPENDIX: MEETINGS IN THE AFRICAN AGRICULTURE SERIES: AN AFRICAN GREEN REVOLUTION?

10 July 2008

Boosting Smallholder Agricultural Production in Africa: Learning Lessons from SABMiller Small Scale Farming Projects

Speakers: Andrew Smith, PWC Sustainability Team
Andy Wales, Head of Sustainable Development, SABMiller
Discussants: Michael Lipton, Research Professor of Economics, Sussex University and Steve Wiggins, Senior Research Fellow, Overseas Development Institute

20 November 2008

An African Green Revolution?

Akin Adesina, Vice President, Alliance for a Green Revolution in Africa (AGRA)
Ousmane Badiane, Africa Director, International Food Policy Research Institute and lead economist, African Union's Comprehensive African Agriculture Development Programme

3 July 2009

Science and Technology: GM Crops and Inorganic Fertilizers versus Organics and 'Natural' Farming

Olojede Oluwafemi, Bowen University, Nigeria and Research Fellow, Rothamsted Research
Michael Gale, John Innes Foundation Research Fellow; member of the Science Council of the CGIAR
Peter Hazell, Visiting Professor, Imperial College London
Camilla Toulmin, Director, International Institute for Environment and Development (IIED)

8 October 2009

Agriculture in Africa: Improving Markets and Institutions

Steven Were Omamo, Deputy Director Policy, Planning and Strategy Division, UN World Food Programme
Steve Wiggins, Programme Leader, Rural Policy and Governance Group, Overseas Development Institute

16 February 2010

African Agriculture: Land Reform or Land Grab?

Lorenzo Cotula, Research Fellow, International Institute for Environment and Development

Michael Lipton, Research Professor, University of Sussex and author, *Land Reform in Developing Countries: Property Rights and Property Wrongs* (2009)

Discussant: Andrew Dorward, Professor of Development Economics, SOAS

ABOUT THE AUTHOR

Diana Hunt is a development economist with long-standing experience as a researcher and an independent consultant on rural development in Africa and a range of publications on this topic. She recently retired from a teaching post in the Economics Department at Sussex University.

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