Mobilising Science and Technology to Get Agriculture Moving in Africa

Norman E. Borlaug and Christopher R. Dowswell*

Introduction

The impact that science-based agricultural development has had on the well-being of all humankind during this century has been enormous, although it has been partially masked by the rapid increase in human numbers. Over the past 80 years the world population has grown from 1.6 billion to 5.6 billion people. Nevertheless, the so-called Green Revolution in cereal production over the past three decades in many developing countries has produced tremendous benefits. It has not, however, solved the problem of chronic undernutrition for hundreds of millions of low-income, poverty-stricken people around the world, who are unable to purchase the food they need for adequate nutrition, despite the abundance of food in world markets.

During the 1960s and early 1970s, the world's famine-plagued regions were South and East Asia. These regions have become essentially self-sufficient in basic food supplies. Sadly, the Green Revolution has not progressed at the same rate everywhere, nor has it reached all crops or all farming areas.

Table 1 compares trends during the 1980s in per capita food production and in fertiliser consumption in different regions of the world. Per capita food production has increased most in East and South Asia where fertiliser consumption has increased nearly five-fold over the last 20 years. In contrast, sub-Saharan Africa recorded the worst performance, with the per capita food production index actually declining. Not coincidentally, sub-Saharan Africa also has the lowest fertiliser consumption rate — 20% that of Latin America and 5% that of East Asia.

To reverse these alarming food production trends in Africa its small-scale farmers need access to science-based agricultural technology, just like similar farmers in Asia and Latin America three decades ago. Even though most of the technological components required for a Green Revolution are already available, because of various constraints, e.g., discriminatory economic policies, non-

* President and Director for Program Coordination, respectively, of the Sasakawa Africa Association, Tokyo. Based on a Plenary Lecture given at The Second Roundtable of Science Advisors for Science-led Development in Africa, Maputo, Mozambique, 20 July 1994, this is the text of an address given at the Overseas Development Institute, London, in 1994.

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Table 1
Food production and fertiliser consumption

	Index of food production per capita[a] *1988–90*	*Fertiliser kg/ha of plant nutrients*[b] *1970/71*	*1989/90*
Low and middle-income economies	115	26	83
Sub-Saharan Africa	94	3	9
East Asia and Pacific	127	36	190
South Asia	116	14	69
Europe	102	88	142
Middle East and North Africa	101	14	65
Latin America and Caribbean	106	20	47
High-income economies	100	102	122
Other economies[c]	113	46	110
World	112	49	97

[a] Average index of food production (1979–81 = 100).
[b] Kilograms of plant nutrients per hectare of arable land.
[c] This classification includes the former Soviet Union, Cuba, and the Democratic People's Republic of Korea, for which inadequate and/or unreliable data are available.

Source: *World Development Report 1992*, Tables 4 and 26.

availability at the farmgate of seed of improved varieties and appropriate fertilisers, and inadequate transport, marketing and credit systems, the Green Revolution will take some time to get going in sub-Saharan Africa.

The global food production challenges

There are two key problems involved in feeding Africa's — indeed the world's — people. The first is the complex task of producing sufficient quantities of the desired foods to satisfy needs, and to accomplish this Herculean feat in environmentally and economically sustainable ways. The second task, equally or even more daunting, is to distribute the food equitably. The impediment to equitable food distribution is poverty — lack of purchasing power — resulting

from unemployment or underemployment, which, in turn, is made more severe by rapid population growth.

In 1990 global food production of all types stood at about 4.6 billion metric tons of gross tonnage and 2.4 billion tons of edible dry matter (Table 2). Of this

Table 2
World food production, 1990

	Production, million metric tons			
	Gross tonnage	*Edible matter*[a]	*Dry protein*[a]	*% increase 1980–90*[b]
Cereals	1,970	1,640	165	20
Wheat	600	528	62	29
Maize	480	422	44	13
Rice	520	353	30	31
Barley	180	158	16	10
Sorghum/millet	85	76	7	–4
Roots and tubers	575	154	10	5
Potato	270	59	6	0
Sweet potato	125	37	2	–7
Cassava	150	55	1	22
Legumes, oilseeds, nuts	300	204	68	29
Sugarcane and sugarbeet[c]	125	125	0	20
Vegetables and melons	450	53	5	26
Fruits	345	47	2	17
Animal products	850	168	74	24
Milk, meat, eggs	750	141	56	18
Fish	100	26	18	33
All food	4,615	2,390	397	20

[a] At zero moisture content, excluding inedible hulls and shells.
[b] 1979–81 and 1989–91 averages used to calculate changes.
[c] Sugar content only.

Source: *FAO Production Yearbook*, 1990.

total, 98% was produced on the land; less than 2% came from the oceans and inland waters. Plant products constituted 92% of the human diet, with about 30 crop species providing most of the world's calories and protein. These included 8 species of cereals, which collectively accounted for 68% (edible dry weight) of the world food supply. Animal products, constituting 7% of the world's diet, come indirectly from plants.

Had the world's food supply been distributed evenly in 1990, it would have provided an adequate diet (2,350 calories, principally from grain) for 6.2 billion people — nearly one billion more than the actual population. However, had the people in Third World countries attempted to obtain 30% of their calories from animal products — as in the United States, Canada, or the European Community — a world population of only 2.5 billion people could have been sustained, less than half of the present world population.

During the 1990s, world population will grow by another nearly one billion people and then again by another one billion people during the first decade of the 21st century. A medium projection is for world population to reach 6.2 billion by the year 2000 and about 8.3 billion by 2025, before stabilising, it is hoped, at about 10 billion towards the end of the 21st century (see Table 3).

Table 3
World population projections (millions)

	1990	*2000*	*2025*	*1990–2025*
Low and middle-income economies				
Sub-Saharan Africa	495	668	1,229	148
East Asia and Pacific	1,577	1,818	2,276	44
South Asia	1,148	1,377	1,896	65
Europe	200	217	252	26
Middle East and North Africa	256	341	615	140
Latin America and Caribbean	433	515	699	61
Sub-total	4,146	4,981	7,032	70
High-income economies	816	859	915	12
Other economies[a]	321	345	355	11
World	5,284	6,185	8,303	57

[a] This classification includes the former Soviet Union, Cuba, and the Democratic People's Republic of Korea, for which inadequate and/or unreliable data are available.

Source: *World Development Report 1992*, Table 26.

At best, the governments of most low-income, food-deficit nations have the foreign exchange to import only the minimum amount of food required to avoid hunger and social unrest in the cities. Yet the problems of hunger and famine are greatest in the rural areas, where 70–85% of the people usually live. Even if the governments had the resources to import food for distribution in rural areas, they would be confronted with the enormous problems of physically transporting and distributing these commodities among a dispersed rural population without access to adequate roads or railroads. Clearly, then, if the problem of world hunger is to be solved it must come through expanded food production in the food-deficit, low-income countries, where the majority of the world's hungry people live.

As in the past, humankind will rely largely on plants, and especially cereals, to supply virtually all of our increased food demand. Even if current per capita food consumption stays constant, population growth would require that world food production increase by 2.6 billion gross tons, or 57%, by 2025, as compared with 1990. However, if diets improve among the hungry poor — estimated to be at least 1 billion people — annual world food demand could increase by 100%, or 4.5 billion gross tons.

Table 4
Poverty[a] in the developing world, 1985–2000

	Percentage of population below the poverty line			*Number of poor (millions)*		
	1985	*1990*	*2000*	*1985*	*1990*	*2000*
South Asia	52	49	37	532	562	511
East Asia	13	11	4	182	169	73
Sub-Saharan Africa	48	48	50	184	216	304
Middle East and North Africa	31	33	31	60	73	89
Eastern Europe[b]	7	7	6	5	5	4
Latin America and Caribbean	22	26	25	87	108	126
All developing	31	30	24	1,051	1,113	1,107

[a] US$370 annual income per capita in 1985 purchasing power parity is used as the poverty line; it is based on estimates from a number of sources. In 1990, the poverty line would be approximately US$420.
[b] Does not include the former USSR.

Source: *World Development Report 1992*, Table 1.1, p.30.

South Asia and sub-Saharan Africa are the regions with the most poverty (Table 4). By the year 2000, South Asia will still have the largest absolute numbers of poor people, although sub-Saharan Africa will have the highest percentage — 50% of the total population — in such dire straits.

African agriculture in crisis

More than any other region of the world, agriculture south of the Sahara is in crisis. High rates of population growth and little application of improved production technology have resulted in declining per capita food production, escalating food deficits, and deteriorating nutritional levels, especially among the rural poor. Unless recent production trends are drastically altered, sub-Saharan Africa will be producing only 75% of its food requirements by the year 2000.

Sub-Saharan Africa's extreme poverty, human diseases (malaria, AIDS, river blindness, trypanosomiasis, guinea worm, schistosomiasis, etc.), animal diseases, poor soils, uncertain rainfall, increasing population pressures, changing tenure and ownership patterns for land and cattle, inadequacy of education systems, shortages of trained agriculturalists, weaknesses in research and technology delivery systems, and political and social turmoil, all make the task of agricultural development very difficult. But we should also realise that, to a considerable extent, the present food crisis is the result of the long-time neglect of agriculture by political leaders during both the colonial and post-independence periods. Even though agriculture provides employment and a livelihood for 70–85% of the people in most countries, rural and agricultural development have been given — and are still being given — low priority. Investments in primary education, agricultural research and extension education, input distribution and crop marketing systems are woefully inadequate. Furthermore, many governments have pursued — and continue to pursue — cheap food policies to mollify the politically volatile urban dwellers at the expense of production incentives for farmers.

Many of the lowland tropical environments — especially the forest and transition areas — are fragile ecological systems. The soils of these areas are mostly various types of deep loam to clay loam latosols, with good physical properties, but highly leached of nutrients. They are strongly acidic, some have toxic levels of soluble aluminium or manganese, with most of the phosphate fixed and unavailable. When cleared of the native vegetation and cultivated repeatedly, they rapidly lose their fertility. The traditional slash-and-burn shifting cultivation systems and complex cropping patterns permitted low-yielding, but relatively stable, food production. Expanding populations and food requirements have pushed farmers on to more marginal lands in some areas and have also led to a shortening in the bush/fallow periods previously used to partially restore soil fertility. With more continuous cropping on the increase,

organic material and nitrogen are rapidly depleted while phosphorus and other nutrient reserves are being depleted slowly but steadily. This is having disastrous environmental consequences, such as serious erosion and weed invasions leading to impoverished fire-climax vegetations in many areas.

The Sasakawa–Global 2000 programme

Since 1986, a joint programme, Sasakawa–Global 2000, has been involved in projects for the transfer of food crop production technology in sub-Saharan Africa, sponsored by the Sasakawa Foundation and its Chairman, Mr Ryoichi Sasakawa, and enthusiastically supported by former US President Jimmy Carter. The programme currently operates in seven African countries: Ghana, Benin, Togo, Nigeria, Tanzania, Ethiopia, and most recently, in Mozambique. Previously, there were similar projects in Sudan and Zambia.

The heart of these projects has been dynamic field testing and demonstration programmes for major food crops. Although improved technology had been developed by national and international research organisations, for various reasons it was not being adequately disseminated among farmers. Working with national extension services during the past eight years, small-scale farmers have been encouraged to cultivate more than 200,000 half-hectare production test plots (PTPs). Most of these PTPs have been concerned with demonstrating improved technology for basic food-crop production of maize, sorghum, wheat, cassava, and grain legumes. The packages of recommended production technology include: (i) the use of the best available commercial varieties or hybrids, (ii) proper land preparation and seeding dates and rates to achieve good stand establishment, (iii) proper application of the appropriate fertilisers, including green manures and animal dung, when available, (iv) timely weed control and, when needed, the use of crop-protection chemicals, (v) moisture conservation and/or better water use, if under irrigation. We also work with participating farm families to improve on-farm grain and tuber storage, both to reduce post-harvest losses and to enable farmers to hold stocks longer in order to be able to exploit periods when prices in the marketplace are more favourable.

Virtually without exception, the PTP yields obtained by the participating farmers are two to three times higher — and occasionally four times higher — than the control plots employing traditional methods. Only rarely has the PTP plot yield failed to double that of the control. Hundreds of field days, attended by tens of thousands of farmers, have been organised to demonstrate and explain the components of the production package. In project areas, farmers' enthusiasm is high and political leaders are taking much interest in the programme. From our experience over the past eight years, we are convinced that, if there is political stability and if effective seed, fertiliser supply and

marketing systems are developed, the nations of sub-Saharan Africa can make great strides in improving the nutritional and economic well-being of their desperately poor populations. Success in achieving this target will, in large part, be determined by the political will of the leaders 'to make it happen'!

In addition to the potential to improve yields on the best farmlands through the introduction of higher-yielding seed-fertiliser technologies, sub-Saharan Africa still has large unused tracts of land which eventually can be brought under the plough. However, the lack of power — animal or motorised — to bring these uncultivated lands into production has been a major constraint. The expansion of animal traction has been constrained historically by animal health problems, such as trypanosomiasis transmitted by the tsetse fly throughout the forest zones of tropical Africa and East Coast Fever transmitted by ticks in East Africa. A much more concerted effort is needed to control these diseases so that animal traction (especially by cattle which would also produce meat and milk) can be used to expand the size of peasant farms from the present 1 to 2 hectares to 5 to 10 hectares, which is a more viable economic unit. Indeed, even doubling or tripling yields on a hand-hoe-operated, two-hectare farm will not provide an adequate family income to improve standards of living significantly, nor to make farming an attractive livelihood.

The appropriate technology debate

Unfortunately, agricultural science, like many other areas of human endeavour, is subject to changing fashions and fads, both generated from within the scientific community and imposed upon it by external forces, especially the politically induced ones that affect the actions of financial donors. In the 1930s and 1940s plant improvement by the development of polyploid varieties (doubling of chromosomes) was promoted as the panacea. By the 1950s and 1960s, mutation genetics was the rage. In the 1970s and 1980s, anther culture, somatic tissue culture, and farming systems research were the craze. In the late 1980s and 1990s, biotechnology and genetic engineering, computer modelling of cropping systems, maximising biodiversity, low-input sustainable agriculture, and farmer participatory research have become in vogue. While each of these lines of research has had some beneficial aspects, all have had one thing in common: their proponents, certainly partly driven by the desire to secure more research funds, have exaggerated the potential for benefits, especially in the short term.

In seeking to push forward the frontiers of scientific knowledge, some researchers often lose sight of the most pressing concerns of farmers and cease to develop products that extension workers can promote successfully. There is a crying need today for creative pragmatism in research and extension organisations, not only in Africa but in many other parts of the developing

world. Researchers must focus on helping farmers to solve near- and intermediate-term problems. Impact on farmers' fields should be the primary measure by which to judge the value of their work, rather than by a flood of 'learned' publications that often serve primarily to enhance the position of the scientist — and mislead the policy-maker — but do little to alleviate hunger.

Some sociologist–anthropologists, economists and other agricultural professionals contend that small-scale peasant food producers can be lifted out of poverty without the use of modern agricultural inputs, such as improved seed-fertiliser and crop-protection chemicals. They envisage soil fertility strategies based on organic fertilisers, farmer-bred and maintained indigenous varieties, biological or mechanical — but not chemical — control of all weeds, diseases and pests, and only human power to carry out all farm operations. In our experience, small-scale farmers are loath to adopt such 'low-input, low-output' technologies since they tend to perpetuate human drudgery and the risk of hunger and misery.

However much they may respect traditional farming practices, agricultural scientists must resist the temptation to romanticise them. They must not succumb to the illusion that, confronted with explosive population growth, Africa's food needs can be met through the improved 'low-input sustainable' systems that are based largely on traditional practices but require much more from farmers in terms of labour, knowledge, and skill.

We are convinced that the single most economically sound and environmentally friendly action that can be taken in sub-Saharan Africa — given available scientific knowledge and technology transfer possibilities — is to promote moderate and proper use of chemical fertilisers in an aggressive manner. Greater use of the appropriate chemical fertilisers can replace slash-and-burn shifting agriculture with sedentary production on the same land, while increasing crop yields, reducing soil erosion by increasing plant biomass and vegetative ground cover, and returning crop residues to the soil contribute to improving the organic content of the soil.

Over the last decade, extremists in the environmentalist movement in the affluent nations have created consumer anxiety about the safety of food produced using agricultural chemicals. Unfortunately, in their anti-chemical campaigns, these environmentalists often 'lump together' chemical fertilisers with pesticides; this is totally incorrect. Pesticides (insecticides, fungicides, and herbicides) are several orders of magnitude more toxic to human beings than the nitrogenous, phosphatic, or potassic fertilisers. There is no danger in eating food that has been grown with the use of such fertilisers.

Surely, raising the average use of plant nutrients in sub-Saharan Africa from less than 10 kg/ha of arable land, nearly all applied to export crops — the lowest of any developing region in the world —, to something like 30 kg/ha cannot be an environmental problem, as some utopian neo-environmentalists would have us believe, but only part of an environmental solution. Moreover,

the relevant economic question is not whether Africa can afford to import chemical fertiliser but rather how such imports can be financed and facilitated. All would agree that it is better to import fertilisers to produce more food than to import guns to quell hunger-induced riots.

For those who contend that African agriculture can be transformed without the use of chemical fertilisers and other modern inputs, permit us briefly to review the spectacular progress achieved by the Chinese in cereal crop production over the past 30 years, where average cereal yields have increased from 1.4 to 4.4 t/ha. Had China tried to produce its current annual cereal production of 400 million tons with its 1960 yield levels, it would have needed to treble its cultivated area. Clearly, China does not have the land available for such an expansion.

Today, China has become the world's largest cereal producer, and Chinese farmers have markedly closed the yield gap with the United States. Admittedly, the development of high-yielding varieties and improved irrigation systems has also played a major role in China's agricultural success story. But perhaps even more important have been its efforts to improve and maintain soil fertility.

For centuries China has led the world in the use of recycled organic matter, animal manure, human excrement, and composted crop residue. However, in the early 1960s it realised that it could no longer depend exclusively on organic fertiliser to restore and maintain soil fertility in order to increase crop yields and food production. By the mid-1960s it launched an aggressive programme to develop hundreds of small-scale, widely dispersed, nitrogen and phosphate fertiliser factories. By 1974, there were more than 1,200 of these small fertiliser factories in operation. Nevertheless, domestic demand had outstripped supply and China had become the world's largest importer of nitrogen — in the form of urea from Japan. The petroleum embargo imposed on Japan by OPEC in late 1973 drastically reduced urea production so that Japan could meet only its own agricultural needs and had to advise China that it could no longer supply it with urea.

Despite the gloomy outlook for supply and the rocketing prices of petroleum and gas, within six weeks of the imposition of the embargo the Chinese Government contracted with several of the world's best fertiliser engineering companies to construct ten 1,000-ton-per-day ammonia factories and urea converters. These and subsequent huge investments in infrastructure for the fertiliser industry, e.g. gas wells, pipelines, etc., have paid off handsomely, making it possible for China to become self-sufficient in basic foods, as well as an important exporter of some cereals. Today, China is the world's largest producer, importer and consumer of synthetic nitrogen fertilisers, and ranks second and third, respectively, in the consumption and production of phosphate fertilisers.

There is a message for African policy-makers in the decision taken by China — the most skilful, efficient and extensive user of organic fertiliser — and for

the poorly informed environmentalists, neo-agriculturalists and planners who believe that if all the organic wastes, animal manure, human excrement, and crop residues were used, the world could produce all the food needed without the use of chemical fertiliser. This ill-founded faith on the part of some influential individuals that organic fertiliser alone can provide the plant nutrients to revolutionise agricultural production in sub-Saharan Africa is misleading policy-makers and contributing to a worsening of per capita food availability in most African countries. The time for change in fertiliser policy is now!

The need for public sector reform

The World Bank recently (1994) released a report entitled *Adjustment in Africa: Reforms, Results and the Road Ahead*, which reviews the impact that structural adjustment has had on the economies of some 29 African countries. It concludes that overall economic policies in these countries are getting better: exchange rates are more realistic, trade is allowed to operate more freely, and in agriculture, most countries are taxing their farmers less.

However, the report also states that efforts to reform the public and financial sectors have been disappointing, partly because of the powerful vested interests that have been created through government intervention, which work against reform, but also because there is much less consensus on how to proceed. Even with a clearer picture on how to proceed in public sector reform, the huge external debt in most African countries is simply too great for them to cope with. Clearly, partial debt forgiveness is essential, although this must be tied to sound performance standards in economic reform. We believe that the excessive reliance in the past on expatriate staff to manage development projects is one of the central reasons why institutional capacity building has progressed so slowly in Africa. It is time for African leaders to look more to their own professionals and intellectuals to come up with the policies needed to transform agriculture and then to enforce the requisite institutional actions needed to implement them.

After three decades of disappointing performance by public sector organisations, many people are now looking to the private sector for new leadership. Experience in other parts of the world has shown that private enterprise is more effective in delivering improved technology to farmers and in developing marketing and credit functions. Of course, governments must create a conducive and enabling regulatory environment for private entrepreneurs to mobilise the capital needed to develop vibrant agribusinesses and to ensure that healthy competition develops. This transition from state socialism to market-oriented economies requires political and social stability, adequate time and big capital investments.

Notwithstanding its many virtues, we should also recognise that privatisation is not a panacea for all development problems and that there are many activities that the public sector must continue to undertake. In particular, most of the research and extension work for staple food crops, especially to serve small-scale farmers, will remain a public sector activity. Therefore, improving the quality and orientation of public spending on agricultural research and extension can help greatly to raise the productivity of African producers.

Although there are huge, largely self-serving, parasitic bureaucracies in other ministries, we must also face up to the fact that most Ministries of Agriculture are in need of far-reaching reorganisation. Many of the previous functions under the canopy of Ministries of Agriculture, such as crop marketing boards, input supply, and various regulatory activities, e.g., obsolete plant and animal quarantine regulations, have been, or should be, significantly modified and reduced. Yet the large numbers of personnel previously assigned to these activities frequently remain on the payroll. It is high time for national leaders to stop considering Ministries of Agriculture as employment agencies, and really begin to consider them as development agencies, and organise them accordingly.

While we may wish it was not so, the reality is that, given the size of budgetary resources, there are simply too many public sector employees (many of them poorly trained) engaged in agricultural research, extension, and production activities. In all probability, the numbers of research and extension staff should be halved, with the resulting budgetary savings used to bolster the operational budgets needed to achieve impact. These smaller research and extension organisations will need much better-trained, better-motivated and more mobile staff.

For the past three decades, a network of national and international institutions has been engaged in research and extension with the aim of modernising smallholder agriculture. The relatively limited impact of this work in sub-Saharan Africa (compared with that in other regions, e.g. South and East Asia) is certainly the cumulative result of many factors. However, we believe that the organisations involved must bear much of the blame.

Research managers and decision-makers — in both international and national research institutes — have all too often remained aloof from programme execution at the grass-roots level. They simply have not spent enough time in the field, to monitor what is happening — or not happening. Researchers themselves have also been too detached from the realities in farmers' fields, preferring to measure their achievements by the information and products generated — and learned papers published — rather than by the adoption of their appropriate technologies in the countryside.

In our view, impact in farmers' fields must become the paramount measure by which to judge the value of investments in agricultural research and extension and related production activities. Unfortunately, no matter how excellent the research done in one scientific discipline, its application in

isolation will have little positive effect on crop production. What are needed are a few venturesome scientists who can work across disciplines to produce appropriate technologies and who have the charisma and courage to make their case with political leaders in order to bring these advances to fruition. The linkages between research and extension organisations must also be markedly improved. Often, these two organisations are not even located within the same government ministry. Other barriers have to do with differences in levels of training and reward structures. These barriers must be reduced.

Despite substantial efforts by national governments and the World Bank to rehabilitate agricultural extension organisations in Africa, much more still needs to be done to transform them into organisations capable of being catalysts for agricultural modernisation. Low levels of training, inadequate mobility, and a virtual absence of operating funds seriously limit the effectiveness of agricultural extension. Moreover, there are frequently too many supervisory personnel sitting in offices in the national and regional capitals, and not enough staff working at the frontline with the farmers.

Thirty-five years ago, India and China recognised that their universities, as then organised, were not providing the kind of agricultural education needed to provide leaders capable of modernising agriculture. They took corrective action to reform the curricula (and in the case of China, they sent the professors to the countryside). As a result of these reforms, the universities began producing better-trained agricultural teachers, researchers, and extension workers who contributed greatly to the revolution in agriculture and food production that has taken place over the last three decades.

Africa's agricultural universities also require reform and strengthening. First, the education in agricultural sciences should be more relevant to the needs of an agriculture in transition between traditional and modern science-based methods. Second, the universities should stop being so élitist in their entrance requirements and become more flexible in accommodating mid-career professionals from research and extension organisations. For example, virtually no agricultural extension service in Africa has even the minimum requirement of a diploma for its frontline staff. The formal training of the best staff should therefore be upgraded. By the end of this decade, at least half the extension staff should have BSc. degrees. The leaders of Africa's agricultural universities should join hands with Ministries of Agriculture to develop mature-student programmes that can meet these human resource development targets.

Third, Africa's agricultural universities should develop, at a minimum, practical production-oriented MSc. programmes capable of supplying the technical personnel needed to support public and private research programmes. Agricultural faculty members should also have access to the resources needed to engage in more practical research themselves; they should venture out more into the countryside and work directly with farmers. Such changes will not only

add to the total scientific capacity of African nations but will also improve the quality of agricultural education.

While we are not opposed to sending a few African students to foreign universities, we believe that this number should be carefully restricted, for several reasons. First, the training given by foreign universities is too theoretical, too narrowly focused, and too sophisticated. All too often, when the students from developing countries return home, they quickly become frustrated and disenchanted with their home-country institutions and begin looking for employment elsewhere; hence the brain drain continues. Second, studying for a PhD at a university in an OECD country is extremely expensive, costing from $120,000 to $140,000. Imagine what could be done in developing Africa's institutional capacity for postgraduate studies in agriculture if even half this amount of money per student could be made available to build up selected African universities. Therefore, for PhD training, we believe that African governments should collaborate to develop several 'regional' postgraduate agricultural schools to prepare senior scientists for service to African agriculture.

Conclusion

Political leaders must not be duped into believing that African agriculture can satisfy the continent's future food requirements — and also serve as the engine of economic growth — by continuing to rely on traditional, low-yielding production systems. The main lesson of the Green Revolutions in Asia and Latin America is that the adoption of yield-increasing technologies is a 'plus–plus' solution, since it can increase food production and farmer incomes, while reducing the cost of food to consumers and improving diets, i.e., it can result in economic growth and poverty reduction simultaneously.

In contrast to the industrialised countries, where environmental degradation is largely urban-based and caused by high rates of consumption and waste, Africa's environmental degradation is mainly rural and poverty-based. Unless the underlying causes of environmental degradation in Africa — mainly rural poverty and explosive population growth — are addressed, little progress will be made in reversing the alarming trends. Agricultural development is the answer.

The message we have heard from the several hundred thousand small-scale African farmers who have worked with the Sasakawa–Global 2000 programme is clear and unequivocal: they want access to technologies that can reduce the drudgery of agriculture and dramatically improve crop productivity and income. Therefore, we vigorously reject the contention of some economists and agronomists that small-scale food producers can increase their productivity and be lifted out of poverty without the use of, at least, moderate amounts of purchased inputs, such as improved seeds, fertiliser, and crop-protection

chemicals. Rather, farmers on Africa's better lands should and must use modern research information and higher input levels to produce more food.

Nigeria's former head of state, Olusegun Obasanjo — himself a farmer — has identified the crux of Africa's agricultural development challenge:

> As long as farming remains, at best, marginally rewarding, young men and women will drift away from the rural areas to increase the battalions of the urban poor. The idea, therefore, that African agriculture should be based on a half hectare holding is, to say the least, unappetising. I want to see the evolution of young, emergent, commercial farmers who will be holding not half a hectare of land but 5 to 10 to 20 hectares of land, and for whom the city will have no big attraction.

We too dream of a commercial African agriculture made up mainly of small-to-intermediate-sized family farms that use modern science-based technologies. We envisage these farms clustered around bustling villages and towns that provide rural families with access to clean water, schools and health facilities, as well as markets and stores. Private sector agribusinesses facilitate the commerce of these communities, supplying farmers with the equipment, products and services they need to run a modern and productive commercial food-producing sector.

For those of us working on the food production front, let us all remember that peace in Africa — indeed peace in the world — will not be built on ignorance, empty stomachs and human misery. Deny the small-scale, resource-poor farmers of Africa access to modern factors of production, such as improved varieties of seeds, fertilisers and crop-protection chemicals, and the continent will be doomed, not from poisoning, as some say, but from starvation and social and political chaos.