# MOBILIZING SCIENCE AND TECHNOLOGY FOR A GREEN REVOLUTION IN AFRICAN AGRICULTURE

by

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It is a pleasure to attend this workshop to explore policies and strategies to achieve greater impact from investments in agricultural research and technology generation in Africa. I am now in my 51st year of continuous involvement in food production programs in developing nations. During this period, I have seen much progress in increasing the yields and production of various crops, especially the cereals, in many food-deficit countries. Clearly, the research that backstopped this progress has produced huge returns.

Yet, despite a more than tripling in the world food supply during the past three decades, the so-called 'Green Revolution' in cereal production has not solved the problem of chronic undernutrition for hundreds of millions of poverty-stricken people around the world, who are unable to purchase the food they need, despite its abundance in world markets. No region has been more by-passed in the Green Revolution than agriculture in sub-Saharan Africa. 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.

Poets--and city folk--love to romanticize agriculture, portraying it as some sort of idyllic state of harmony between humankind and nature. How far this is from the truth! Since Neolithic women domesticated our food crop species some 10,000 to 12,000 years ago, agriculture has been a battle between the forces of natural biodiversity and the need to produce food under increasingly intensive production systems. Yet through advances in science--mainly during this century--world food supplies have increased more rapidly than population, and in general, have become more reliable.

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World population will grow by nearly one billion people during the 1990s 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 hopefully stabilizing at about 10 billion toward the end of the 21st century.

Had the world's food supply of 4.6 billion gross tons 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 USA, Canada, or European Union countries--a world population of only 2.5 billion people could have been sustained--less than half of the present world population.

At least in the foreseeable future we will continue to rely on plants, and especially the 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 increases by 2.6 billion gross tons--or 57%--between 1990 and 2025. However, if diets improve among the hungry poor, estimated to be 1 billion people living mainly in Asia and Africa, world food demand could increase by 100 percent--to 9 billion gross tons--over this 35-year period. And we have to achieve this production increase in environmentally sustainable ways!

**Africa's Agricultural Development Challenge**

Unless recent production trends are drastically altered, sub-Saharan Africa will be producing less than 75 percent of its food requirements by the year 2000. While some economists claim that growing dependence by African nations on imports to meet food demand is not necessarily a problem, I beg to differ, at least at the present stage of development in most nations. How will the low-income African nations finance and distribute these imports? And how will the poor afford to purchase this imported food?

Sub-Saharan Africa's extreme poverty, poor soils, uncertain rainfall, increasing population pressures, changing ownership patterns for land and cattle, political and social turmoil, shortages of trained agriculturalists, and weaknesses in research and technology delivery systems all make the task of agricultural development more difficult. But we should also realize that to a considerable extent, the present food crisis is the result of the long-time neglect of agriculture by political leaders.

Even though agriculture provides the livelihood for 70-85 percent of the people in most African countries, agricultural and rural development has been given low priority. Investments in distribution and marketing systems and in agricultural research and education are woefully inadequate. Furthermore, many governments pursued and continue to pursue a policy of providing cheap food for the politically volatile urban dwellers at the expense of production incentives for farmers.

Despite the formidable development challenges in Africa, the elements that worked in the industrialized nations, Latin America and Asia will also work there. If effective seed and fertilizer 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.

There has been so much mis-information spread about the Green Revolution in Asia that it would take days to clear the air on what it was and wasn't. To me, the Green Revolution was the beginning of a process of applying science to Third World agricultural production. The introduction of yield-increasing, cost-reducing technology in Asia clearly improved the economic well-being of farmers--large and small. But the greatest beneficiaries have been consumers in the developing world, who have enjoyed a steady decline in the real cost of food over the past 25 years, which is an especially important benefit for the poor. This lesson must not be lost on Africa.

In addition to the potential to improve yields on the best existing farmlands through the introduction of higher-yielding seed-fertilizer technologies, sub-Saharan Africa--unlike Asia--still has large unused tracts of land which eventually can be brought under the plow. However, the lack of power--animal or motorized--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 tste-tste 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 can expand the size of peasant farms from the 1 to 2 hectares at present to 5 to 10 hectares, which is a more viable economic unit. Indeed, even doubling and tripling yields on a two-hectare farm will not provide adequate family income to improve standards of living significantly.

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, unappetizing. 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."

**Tackling the Soil Fertility Management Issue**

Without doubt the single-most important factor limiting crop yields in developing nations worldwide--and especially among poor farmers--is soil infertility. This problem is especially acute in much of sub-Saharan Africa and in the highland areas of Latin America and Asia.

Many of the lowland tropical environments--especially the forest and transition areas--are fragile ecological systems, where deeply weathered, acidic soils lose fertility rapidly under repeated cultivation. Traditionally, slash and burn shifting cultivation and complex cropping patterns permitted low-yielding, but relatively stable, food production systems. Expanding populations and food requirements have pushed farmers onto more marginal lands and also have led to a shortening in the bush/fallow periods previously used to restore soil fertility. With more continuous cropping on the rise, organic material and nitrogen are being 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.

Unless soil fertility is restored in these areas, farmers will gain little benefit from the use of improved varieties and more productive cultural practices. Soil fertility can be restored effectively by applying the right amounts of the right kinds of fertilizer--either chemical or organic or, preferably, a combination of the two--according to the requirements of different crops, soil types, and environments.

Of course, scientists, extension officers, and farmers should strive to attain better efficiency in fertilizer nutrient use. In particular, where intensive cropping is practiced improved monitoring of secondary nutrients and minor element deficiencies is needed to increase crop yields and to reduce fertilizer costs. But we should not lose sight of the fact that

as much as 50% of the increase in crop yields worldwide during this Century is due to the adoption of chemical fertilizers. In the future, integrated soil fertility management strategies can reduce wasteful fertilizer use, and should be encouraged.

I am convinced that the most environmentally friendly action that can be taken in sub-Saharan Africa--given available knowledge and technology transfer possibilities--is to promote moderate and proper use of chemical fertilizers in an aggressive manner. Increased chemical fertilizer use should help to reduce soil erosion by increasing plant biomass and vegetative ground cover and, assuming that crop residues are returned to the soil, contribute to improving the organic matter content of the soil.

Sadly, this view is not in "fashion" these days. A common assumption among some environmentalists, social scientists and a few agricultural researchers--especially those from privileged countries--is that the next step for small-scale Africa farmers toward improving soil fertility and crop production is to introduce so-called 'low-input' technologies. Over time, the argument goes, Africa's resource-poor farmers will reach the point where they can adopt modern technologies involving the use of purchased inputs.

While such low-input approaches have some appeal, they nonetheless have serious drawbacks. An important one is that low-input technologies often turn out to be knowledge-intensive, requiring that farmers possess more than the ordinary skills in crop management. A further prerequisite is that levels of literacy be raised in rural communities. Until this happens, few of the so-called "environmentally friendly" technologies now available--such as use of new crop rotations, organic manures and crop residues, and integrated pest management--are likely to spread very far beyond research stations.

There is a message for Africa in the decisions made to invest heavily in chemical fertilizer by China--the most skillful efficient and extensive user of organic fertilizer--and also for those poorly informed environmentalists and neo-agriculturists who believe that if all of the organic wastes, animal manures, human excrement and crop residue were used as fertilizer, the world could produce all the food needed without the use of chemical fertilizer. The ill-founded faith by some influential individuals that organic fertilizers alone can provide the plant nutrients to revolutionize agricultural production in sub-Saharan Africa is misleading policy makers and contributing to a worsening of per capita food availability in most African countries. There simply is not enough organic fertilizer available

to provide sufficient nutrients to the soil to satisfy the growing food demand of Africa. Moreover, there is competition for animal manure, which is also dried and used as a cooking fuel.

We must also acknowledge that in many of the most productive areas--especially the warm irrigated areas--there are problems of soil erosion and declining water quality which, if left unchecked, can lead to the permanent loss of prime agricultural land. In most cases, the root causes of this environmental degradation has been inadequate investments (especially in drainage systems in irrigated areas) and mistaken economic policy--not modern, science-based technology. Low profits (mainly in developing countries) have kept farmers from investing as they should in resource conservation, while excessive subsidies (mainly in industrialized countries) sometimes have caused over-use of agricultural chemicals, with consequent environmental damage.

Yet the message of the 250,000 small-scale farmers who have been involved in the Sasakawa-Global 2000 program is that they are loath to settle for "low input, low-output" technologies since they do not reduce the human drudgery of farming nor reduce the prospects for hunger and poverty. However much they may respect traditional farming practices, agricultural scientists must resist the temptation to romanticize them. They must not succumb to the illusion that--confronted with explosive population growth-- Africa's food needs can be met through the so-called "improved low-input sustainable" systems that are based largely on improved traditional practices that require much more from farmers in terms of labor, knowledge, and skill.

**Keeping Agricultural Science Relevant**

The capacity to transmit agricultural research findings to the small-scale farmer is heavily dependent upon the technology transfer capacities of publicly funded international and national research and extension systems. While privately funded agribusiness is playing an increasingly important role in technology generation and transfer in a few developing countries, publicly funded efforts are still central components in any strategy to reach the small-scale farmer with improved food crops technology in sub-Saharan Africa.

Thus, any strategy to maximize investments in technology generation and transfer must find ways to fund--adequately and with stability--the IARCs and the NARSs. In recent years, the effectiveness of virtually all of the NARSs has been severely reduced by inflation and real budget cuts. The IARCs have also suffered financial setbacks, but not to the same

magnitude as the NARSs. Funding one without the other will not result in significant impact. Rather there is a need to jointly finance both levels and to maximize the potential from scientific networking between IARC and NARS researchers. In particular, it is very important that outstanding national researchers have adequate funds to participate fully in international research networks.

One important IARC function is to serve as the hub of various research networks. In addition to research collaboration on specific problems IARC networking functions include germplasm and information exchange, which should include, I believe, a continuing program of practical in-service training for mid-career researchers from national programs as well as visiting scientist opportunities for senior level visiting scientists.

The key point here is that for a research network to function properly there has to be lots of interaction between the members. Even with all of the advances in information technology, there is a still a need for face-to-face contact. This means that NARS scientists need to visit the IARCs with fair frequency while IARC scientists need to spend significant time visiting national program scientists and touring agricultural areas.

Although IARC and NARS scientists certainly have advanced the frontiers of knowledge over the past three decades, I believe their more significant contribution has been the integration of scientific knowledge and application in the form of improved technologies to overcome pressing crop production problems. This should continue to be the primary mission of these publicly funded institutions in the foreseeable future. Moreover, impact on farmers' fields and alleviation of rural poverty--rather than the number of learned publications--should be the primary measure by which to judge the value of IARC and NARS work.

Unfortunately, agricultural science--like many other areas of human endeavor--is subject to changing fashions and fads, generated from both within the scientific community and imposed upon it by external forces, especially the politically induced ones that affect the actions of financial donors. In my own career, I have seen various "scientific bandwagons" come and go. 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 modeling of

cropping systems, maximizing biodiversity, low-input sustainable agriculture, and participatory farmer research are now the terms in vogue.

Each of these lines of research has had some beneficial aspects. But all have had something else in common: their proponents, certainly partly driven by the desire to secure more research funds, have exaggerated the potential for benefits, especially in the near-term. Increasingly, I fear, the IARCs and NARSs are falling prey to scientific bandwagons that will not solve Third World food production problems.

From my perspective IARC and NARS research managers and decision makers need to spend more time on the ground, monitoring what is happening--or not happening. Further, IARC researchers themselves must strengthen their interactions with national research and extension systems, and farmers. Too many have become 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 adoption of their technologies in the countryside. This should be changed.

**Will the Private Sector Be a Panacea?**

After three decades of disappointing performance by public sector organizations in the developing nations, 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 mobilize the capital needed to develop vibrant agribusinesses and to ensure that healthy competition develops. This transitional period 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 realize that privatization is not a panacea for all development activities 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 for agricultural research and extension can help greatly to raise the productivity of African producers.

Although large, self-serving, parasitic bureaucracies exist in other ministries, which are probably worse, we must face up to the fact that most Ministries of Agriculture are in need of far-reaching reorganization. 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 reduced, if not eliminated. Yet large numbers of personnel previously assigned to these activities frequently remain on the payroll. It is time for national leaders to stop considering Ministries of Agriculture as "employment agencies," and really begin to consider them as "development" agencies, and organize them accordingly.

While we may wish it wasn't 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 cut by one-third or more, with the resulting budgetary savings used to bolster the operational budgets needed to achieve impact. Of course, these smaller research and extension organizations will need much better-trained, well-motivated, and mobile staff.

The real hope for private sector contributions to agriculture lies in seed production, input delivery, equipment supply, output marketing, and financial services. Over time, successful seed producers and input suppliers will also invest in research and development activities. But in the short- and intermediate-term, the primary suppliers of research information and products for small-scale food producers will continue to be publicly funded institutions.

**Confusion in Policy Circles**

Professor Robert Paarlberg of Wellesley College has written an IFPRI Policy Brief (No. 4, August 1994) which describes succinctly the consequences of the debilitating debate between agriculturalists and environmentalists about what constitutes so-called 'sustainable agriculture' in the Third World. This debate has confused--if not paralyzed--policy makers in the international donor community who, afraid of antagonizing powerful environmental lobbying groups, have turned away from supporting science-based agricultural modernization so urgently needed in sub-Saharan Africa, and parts of Latin America and Asia.

This policy deadlock must be broken. In doing so, we cannot lose sight of the enormous job before us to feed 8-10 billion people. We cannot turn back the clock and we must also recognize the vastly different circumstances faced by farmers in different parts of the Third World, and assume the appropriate policy postures. For example, in Europe or the US Corn Belt, the application of 400-500 kg of fertilizer nutrients per hectare of arable land can cause some environmental problems. But surely, increasing fertilizer use in sub-Saharan Africa from 10 kg of nutrients to 30 to 40 kg per hectare of arable land is not an environmental problem but a central component in Africa's environmental solution.

**The Professional Moral Responsibility of Scientists**

Agricultural scientists and policy makers have a professional and moral obligation to warn the political, educational, and religious leaders about the world about the magnitude and seriousness of the arable land, food and population problems that lie ahead. If we fail to do so in a forthright manner, we will be negligent in our duty and inadvertently will be contributing to the pending chaos of incalculable millions of deaths by starvation.

Twenty five years ago, in my acceptance speech for the 1970 Nobel Peace Prize, I said that the Green Revolution had won a temporary success in man's war against hunger, which if fully implemented, could provide sufficient food for humankind through the end of the 20th century. But I warned that unless the frightening power of human reproduction was curbed, the success of the Green Revolution would only be ephemeral.

It seem to me that we have failed to educate policy makers about the strong positive linkages in the Third World between agricultural development, poverty reduction, and environmental protection. Without doubt, the reduction of rural poverty is a necessary condition, not only for broad-based economic development but also for improved resource conservation. As Richard Leakey correctly points out, "you have to have at least one square meal a day to be a conservationist or environmentalist."

The introduction of productivity-enhancing agricultural technologies is a win-win-win solution. Modern technology can increase farm incomes and simultaneously lead to lower real food prices, thus benefiting all consumers, especially the rural and urban poor. Agricultural development can also reduce environmental degradation, which is primarily rural- and

poverty-based. With increased prosperity farmers can afford to invest more in protecting their soil and water resources.

As I have come to learn something about African agriculture over the past nine years I must say that I am extremely frustrated between the clear capacity for quantum jumps in food production and agricultural productivity and the continuing failure to realize this potential. Permit me to make an analogy. At the moment of conception each human being is dealt a genetic hand of cards that represents his or her potential. The extent to which that this inherent potential is realized is determined by good nutrition, health, and education, among other factors. Although virtually none of us utilizes our full potential, those from the more affluent nations have a much better chance of realizing more of their potential than those who begin and suffer life in poverty, hunger and poor health.

Africa is a continent of enormous agricultural potential. The bleak predictions of African famine, social chaos, and environmental destruction need not happen. Warm year-round temperatures and vast areas of potentially arable land are conducive to highly productive and environmentally sustainable agricultural systems. The challenge is to break out of this cycle of wasted human potential and help African farmers--and nations--rise up and achieve their full capacity.

Central to the solution is a concerted effort among national governments, international donor agencies, research and extension organizations, and the private sector to assist small-scale farmers to break out of the vicious cycle of poverty and wasted potential that they currently endure.

At my age I am impatient. If I am to see a Green Revolution in Africa, it must happen soon. I believe that if a dramatic change takes place in food production in one country others will follow. In recognition of the late Ryoichi Sasakawa's desire to help millions of African people live better and happier lives, the remainder of my life shall be dedicated to this task.