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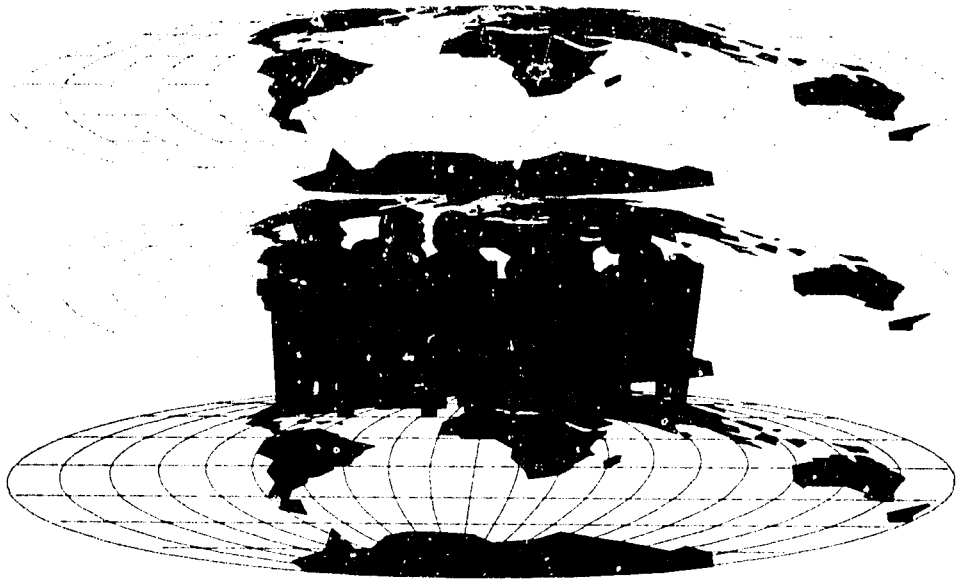
Proceedings of the international conference *Challenges and Opportunities for the NARS in the Year 2000: A Policy Dialogue*

Beriin, 12-18 January 1992



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Sponsors:

International Service for National Agricultural Research (ISNAR)
The Hague, The Netherlands

German Foundation for International Development (DSE)
Feldafing, Germany

Citation

ISNAR. 1992. Future Challenges for National Agricultural Research: A Policy Dialogue. Proceedings of the international conference entitled "Challenges and Opportunities for the NARS in the Year 2000: A Policy Dialogue," held in Berlin, 12–18 January 1992. The Hague: International Service for National Agricultural Research.

AGROVOC Descriptors

research; public research; research support; management; research policies

CABI Descriptors

agricultural research; government research; research policy; management

ISBN 92 9118 002 5

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Challenges Facing Agriculture in the Next Century: Issues for National Agricultural Research Systems

Keynote address by
Louis Emmerij
President
OECD Development Centre
Paris, France

When we look at the world agricultural and food scene today, we see that we are faced with several challenges which, most probably, will still be with us into the next century. First, there is the elimination of hunger, which is not so much a production issue as a redistribution issue, because the food supply will be sufficient to meet world demand. Second, there is the elimination of agricultural protectionism in OECD countries, which continues to be a major issue with significant implications for developing countries. Third, there is the need to increase agricultural yields in the developing countries.

In this paper, however, I shall concentrate on a fourth challenge: technological change and innovation in agriculture.

The Forces Influencing Technological Change and Innovation in Agriculture

To understand the forces influencing the pace and nature of technological change in agriculture, it is useful to view the agriculture sector — and agricultural technology — within the overall context of factors shaping technological change and innovation.

First, technological innovation is an essentially interactive process, involving linkages and networks ("network relationships") among different organizations and actors, particularly industrial enterprises. If they don't have these linkages, developing countries will be frozen out.

Second, innovation and diffusion are the result of a technological learning

process (learning-by-doing, learning-by-using, and learning-by-interacting) which involves both users and producers. The combination of learning and experience is an essential element in the process, which is termed "technological accumulation." A base of technological change must therefore be established in developing countries.

Third, the transition to globalization of economic activities has been an important trend. An increasing proportion of worldwide production and distribution occurs within a system of interlinking private networks. The major participants in this new configuration are large multinational corporations (MNCs) which deploy their resources and activities worldwide. Within some industrial sectors, oligopolistic rivalry is giving rise to new types of long-term alliances and agreements with other firms (network corporations), including former rivals. Whereas, in the past, concentration was measured by domestic market shares, with globalization the only meaningful measure of concentration is the share in world markets, developed through international mergers and takeovers. This is giving rise to what can be described as "international oligopolies," and raises new questions of access to scientific and technological information, particularly for developing countries.

Technological change and growth

If we agree that technological change is basic to long-term economic growth, continuing differences in output must be linked to variation in the ability of countries to acquire and diffuse new techniques. In the light of the recent widespread emergence of structural adjustment, not only in developing countries but also in the hitherto centrally planned economies, it is useful to consider how far spontaneity can be expected to stimulate technological change in agriculture and the ways in which — particularly in low-income countries — the increased emphasis on market incentives may or may not be conducive to technological change.

The "catching-up" hypothesis developed for industry suggests that the larger the initial technological gap in the use of "best-practice" techniques, the greater the potential for catching up. While in some situations the catching-up concept may be applicable (for example, wheat in the Punjab), in others catching up can be inhibited by a combination of technological backwardness and lack of what has been described as "social capability."

It can be argued that the success of late-industrializing countries is due to learning and imitation rather than to domestic innovation. Following this reasoning, technologically backward countries should devote more effort to "development" (rather than "research") and to adapting technologies designed elsewhere.

Explanations of technological accumulation, innovation, and diffusion in industry may not be directly applicable to agriculture, however. Natural resource endowments (climatic and soil conditions) are still important in the production of food crops. In addition, technology transfer and imitation may be inhibited by the location-specific character of agricultural technology.

No one denies that there is a very wide technological gap between many developing countries — particularly in sub-Saharan Africa — and the rest of the world. Can this be accounted for by technological backwardness and lack of a "critical mass" of scientists, technologists, and infrastructure? Might it be accounted for, at least in part, by social capability and, if so, is it possible to begin to define and measure this?

In agriculture, producers might be expected to respond to market and price incentives by introducing minor, incremental technological change (introducing better seeds, improved implements, and better storage facilities) which would have considerable impact on output. Public participation is essential to provide roads, credit, agricultural research, and extension services. Public provision of agricultural services can be expected to result in a higher rate of growth than would result from spontaneity or "laissez-faire." The development of research capacity requires education and infrastructure, suggesting that market incentives must be supplemented with public investments if the challenges of technological development are to be met.

New Biotechnology and Agriculture

New biotechnology lies at the center of the debate over the influence of institutions on technological change and, conversely, the influence of technological change on institutions. It is also an important element within the debate concerning sustainability, in which expectations of environmentally friendly plant and animal nutrients and biological controls are seen as an appropriate response to growing concerns about fertilizers, pesticides, and other chemical compounds increasingly viewed as unsustainable pollutants. Can it be anticipated that environmental pressures are likely to stimulate the development and diffusion of biotechnologies for more sustainable agricultural production systems? Or will regulatory processes, problems related to the protection of intellectual property rights, and public fears over the new technologies in food and agriculture inhibit their development? And what are the implications for developing countries and their agricultural research systems?

It can be argued that the high prices and protected markets in OECD member countries stimulate biotechnology innovations which could further distort markets. However, it is at present unclear, particularly with respect to plant biotechnologies, which techniques will be profitable and how structural

adjustment and liberalization might affect profitability. Environmental concerns are also expected to alter the criteria governing production, consumption, and trade, with non-tariff barriers associated with chemical residues and food regulations increasingly acting as a form of barrier to developing-country exports.

Except in the field of health care, few new products have yet reached the market. The first important wave of biotechnology products is expected from 1992 to the year 2000. In the longer term (50 years hence), biotechnology may be essential in helping to preserve the physical environment, coping with possible climatic change, and feeding growing populations.

In plant biotechnology, the major techniques currently being investigated involve genetic modification for various kinds of stress resistance, plant breeding, plant production, and enhancement of plant quality, in turn linked to food quality. Contrary to earlier expectations, developments have been more rapid in animals than plants: animal health (diagnostic tests and kits, vaccines, therapeutics), growth, and lactation; animal feeds; embryo multiplication; genetic engineering of animals.

In food processing, among the many new techniques being developed are monoclonal antibodies used to enhance food safety and prevent contamination, enzymes, bio-preservation, new foods, and new plant cell cultures for flavors, fragrances, etc. It is anticipated that consumer preferences, as well as food safety concerns and regulations, will be of overriding importance in the diffusion of new food-processing techniques.

For developing countries, biotechnology presents both opportunities and threats. The opportunities include prospects for raising production, enhancing nutritional properties and quality, lowering dependence on agrochemical inputs, and helping to conserve biodiversity. The threats stem from the possibility of a widening technological gap due, on the one hand, to an inability to develop or utilize the new technologies, and on the other hand, to the lack of an appropriate legal framework for protecting intellectual property rights.

It is interesting to compare some of the essential characteristics of the new biotechnologies and their potential impact with those of the more traditional technologies. It is also worth noting that earlier predictions that biotechnologies, particularly plant biotechnologies, would be commercialized by 1990, have not been realized.

Although the plant biotechnologies at present being developed will control some stress factors, they will not increase yields. This will require complex techniques of multiple gene transfers which have not yet been mastered.

The Green Revolution technological package was introduced at a time when there was considerable pent-up derived demand by farmers. At least with respect to crops, no such derived demand exists for the new biotechnologies, particularly because cheaper ways of coping with stress factors may be available. At present the early plant biotechnologies appear to offer little profit incentive for farmers. It can therefore be argued that incentives to the R & D and farm supplies industries may be required in order to diffuse the new technologies at the farm level.

As with earlier technologies, biopesticides, disease resistance, etc., will be mainly embodied in germplasm and will therefore pose no particular adoption problem by developing-country farmers. However, the situation is quite different with respect to animal biotechnologies. Apart from some of the animal vaccines and improved feedstuffs, the use of techniques such as bovine growth hormone and improved reproduction techniques for animals will require relatively sophisticated management capability on the part of farmers.

One positive aspect of the new biotechnologies for developing countries is that they would not have the same dramatic impact on labor utilization as the earlier mechanical technologies. The new biotechnologies are perceived as being less labor-saving and, if appropriately marketed, essentially size-neutral.

In contrast to the Green Revolution technologies, which were developed as a public good with the support of philanthropic foundations and the early international agricultural research centers (IARCs), a large proportion of research and development (R&D) on the new biotechnologies is being carried out within private-sector firms. Because the research effort will likely be highly capital-intensive, firms will make more effort to protect research results. This raises questions of the potential for monopolistic behavior by private firms and of access and control for farmers.

The combination of privatization of the new biotechnologies, and emphasis on market forces as an outcome of structural adjustment, implies that the prospects for biotechnology will be most favorable in developing countries whose private involvement in innovation is already developed and/or where the private sector has incentives.

Biotechnology and Industry

Recent research for the OECD Development Centre focusing on the investment strategies of leading agro-food companies suggests that involvement in biotechnology is an essential aspect of competitive strategies. However, because of the high level of uncertainty among the major actors themselves, the uncontrollable nature of key scientific, economic, and other variables,

and difficulties in establishing R&D priorities, network relationships have become a permanent feature of negotiations in assessing the costs of introducing and developing the new technologies. At the same time, there appears to be stronger emphasis on in-house competence. This is a result of a perceived need to control markets through intellectual property rights protection and, more specifically, through patenting.

Differences can be observed in the way biotechnology is perceived upstream and downstream. Upstream, biotechnology is an essential component of competitive restructuring in the seed and agrochemicals industries. Downstream, biotechnology is one of a series of options dominated by the need to establish competitive strength in global markets, which are increasingly segmented according to quality.

The interest of the major firms in developing countries is concentrated on those countries which already have a strong agro-industrial base. The impact of trade liberalization in the context of the GATT negotiations does not enter into their calculations. The major firms favor markets in which they are already present and operating, where currency is stable, inflation is controlled, and intellectual property rights are respected.

Breeding programs that incorporate research on modern biotechnology are increasingly concentrated in the industrialized countries. Nevertheless, many firms express interest in the direct transfer of research capacity to developing countries to conduct programs defined by governments or international bodies. This may open the way for new models of technology transfer, but may also imply privatization of important segments of biotechnology research in developing countries.

Structural Adjustment and Technology

The possible negative effects of structural adjustment on poor farmers, particularly in African countries, is a source of great concern. In these countries the need to cushion small farmers — and consumers as well — from greater price variability during stabilization and adjustment is the most pressing, but in them the lack of cost-effective institutions to manage risks, particularly for small farmers, is most apparent.

In the past, risk management was inherent in different public-policy instruments. With adjustment, farmers are likely to be exposed to greater price variability, and it is therefore important to investigate ways and means of risk management. In practice, whereas the public sector may continue to have an important role, a role for the private sector may also be nurtured; for example, through drought and crop insurance.

In examining the impact of the structural adjustment and liberalization

process, it is important to make a distinction between stabilization measures that are designed to address short-term imbalances in external trade and the internal budget account (which involve large-scale reductions in public expenditure, sharp increases in interest rates and devaluation), and structural adjustment proper, which is longer-term and would involve a shift in production to tradable sectors, divestment of state resources, measures to encourage private-sector involvement, liberalization of markets, deregulation of prices, and subsidy removal.

Whereas in the 1980s stabilization tended to dominate the policy arena, in the 1990s structural adjustment is expected to be manifest in a fundamental liberalization of markets and a shift in the public-private balance. Thus farmers in developing countries will increasingly be faced with deregulation of prices, subsidy removals, and the privatization of public enterprises. Public investment in infrastructure and research is also expected to be severely curtailed.

The findings of research on the impact of stabilization and structural adjustment concur in some respects but diverge in others. Structural adjustment can have major effects on the structure of agricultural incentives and on price relativities between internationally tradable and nontradable outputs. In general, the effects are pro-agriculture. In principle, the broad impact on the use of resources in the agriculture sector would be to encourage the use of nontraded resources such as labor and land rather than fertilizer, chemicals, energy, and machinery. In the aggregate, it might then be expected to be pro-poor.

Evidence also points to problems of transition, which can have quite dramatic implications for technology in Africa. Improved high-yield varieties that require storage and chemicals treatment may be abandoned. Mechanization and large-scale irrigation schemes may also be abandoned or reduced in intensity. Technological regression—such as the abandonment of hybrids for open-pollinated varieties—may then occur. On the other hand, changing input-output price relationships may serve to revive certain export crops; for example, cocoa.

Research examining the range of macroeconomic policies and institutional changes brought into play has tried to trace these through to the microeconomy and to smallholders. In some countries, and in some respects, the desired changes have taken place. From the evidence available, smallholders producing tradables have benefitted from adjustment. And, in contrast to the popularly held view, not only export-oriented farmers have gained; producers of food crops have benefitted from a reduction in the competitiveness of imports.

On the other hand, evidence suggests a sharp decline in the rural services

that are very important to small farmers: equipment supply, hire, storage, transport, animal health services, plant-protection services. This raises questions about withdrawal of public funding for such services and the extent to which private-sector involvement can be expected.

Another important effect of stabilization and structural adjustment programs is their inevitable impact on public research. Public-sector agricultural research has been a sheltered area in adjustment because it has been argued, first, that this is a genuine area of market failure where private supply would be socially suboptimal and, second, that the inventory of "on-the-shelf" technology has been smaller than originally thought. In most countries, an inordinate proportion of funds is absorbed in salaries, and underfunding and management problems are endemic. In principle, institutions should be made more sensitive to cost recovery and more accountable to client demand. However, there may be limited scope for divestment of public research institutions, except in the seed industry.

In Africa, in particular, public-sector agricultural research is likely to suffer from problems of donor fatigue and coordination failures. These problems are compounded by the lack of domestic technical and managerial capacity to ensure implementation.

Issues for National Agricultural Research Systems

Proponents of structural adjustment and liberalization argue that it will result in better price signals and in stimulating competition. This will be conducive to the development of agricultural systems that will have true comparative advantage in choice of crop, location, processed product, and technology. Proponents also stress the importance of links with international markets and of the role of foreign investment.

The hypothesis that widespread adoption by small farmers requires specific institutional interventions by the public sector, which should make major investments in extension, input supply, and credit, has also been challenged by the proponents of structural adjustment. Instead, they would advocate industry-based extension services and private suppliers of agrochemicals and seeds. Similarly, the proposition that price liberalization and the removal of subsidies would inhibit the adoption of new techniques by smaller farmers, who should therefore be provided with incentives to induce them to take the risk, has been questioned by advocates of structural adjustment. Ongoing work at the OECD Development Centre, and elsewhere, is assessing the impact of structural adjustment on agriculture and on agricultural technology and will throw light on the validity of these different hypotheses.

A central issue raised concerns the conditions necessary, for countries at different levels of development, for stimulating technological change and

diffusion. One important aspect of this issue is risk, or at least to the perception of risk, by farmers, and the consequent need, first, to identify the groups most at risk and develop ways and means of managing the risk.

A second aspect is the availability of profitable technologies for small farmers. One view holds that there is a dearth of technologies that would be both appropriate and profitable for small farmers. The other view argues that technologies are, indeed, available but the sets of policies in place do not provide incentives conducive to risk-taking by farmers.

An additional aspect, which is linked to developer/user questions, is that of the transfer of technology versus local research. To what extent does location-specificity inhibit the importation of biological techniques, or at least necessitate a period of adaptation to local agro-climatic conditions? Clearly, the responses would differ for different techniques and for plant and animal technologies.

It can be argued that productivity gains in developing countries will, at least in the short term, continue from the diffusion of traditional techniques rather than from new biotechnologies. With respect to plant crops, the new techniques will complement but not supersede those of Mendelian plant breeding.

The agro-food system is one in which a number of participants (markets, firms, farmers, governments) are linked, through technology and information networks, at the farm, firm, national, and global level. The essential question for developing countries is, then, whether the system is open or closed, and where "windows of opportunity" are to be found.

Conclusion

The structural reform process implies a larger role for the free market in the economy and diminished state intervention. Recent examination of investment trends in R&D in OECD member countries suggests that private firms are not prepared to assume the role, earlier considered to be the responsibility of the public sector, of investing in long-term basic research. A strong case has therefore been made for a continuing role of the public sector in the basic sciences underpinning the new technologies. It is also argued that government intervention is necessary to stimulate interactive networks at the national, regional, or local level to energize technological innovation and as a countervailing force against the globalization trends which to a large extent escape national control.

In some developing countries the problems of striking an appropriate public/private-sector balance are compounded by states that are weak and vulnerable, and do not have the administrative capacity to implement

structural reforms. Also, sometimes — but not always — in these countries, markets are so weak that the role of the state cannot easily be terminated. The proper role of government in agriculture, agricultural research, technology development and dissemination, and institutional infrastructure will, of course, depend on individual countries, on the "social capability" existing in each country, and on market structures already in place.

The ways and means of inducing the private sector to play a more active role, both in agricultural research and in the provision of agricultural services to small farmers, is an important research issue. One of the problems lies in the fact that producer groups in developing countries are seldom organized as clients of research to the same extent that they are in industrialized countries. Clearly, it is important to examine the potential for collaboration and complementarities in research between the public and private sectors.

The challenge for NARS in the coming decades will be to define their contribution to sustainable rural development in the context of economic liberalization and adjustment. This places an increased emphasis on the private sector and market forces. But, the private sector may be as imperfect as the state may be incapable. The comparative advantages of the state and the private sector need, therefore, to be carefully analyzed and the role for NARS identified as providing a public good. In particular, the NARS need to ensure that research reaches small and poor farmers, and that developing countries have the "network relationships" and the "technological accumulation" to ensure that they are able to grow. This responsibility is absolutely central to any development strategy.

With these strategic objectives and the domestic division of labor between private and public in mind, the role of NARS in the international, regional, and national research effort should be wholeheartedly commended and strengthened.