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Research Article

A THEORETICAL APPROACH ON CURRENT AND FUTURE TECHNOLOGIES ADVANCEMENTS IN AGRICULTURE PRODUCTION AND ITS DISTRIBUTION

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ABSTRACT

The purpose of this paper is to discuss the impact of changing agricultural policies on the productivity and the distribution issues. As we move into the 21st century, it is needed a change in the way peoples' life quite drastically as a result of limited resources and, more significantly, because of the degradation of the environment and the state of the earth. The key terms to describe modern agriculture can be summarized as follows: mechanization, labor saving, yield (productivity) enhancing, intensification, specialization, concentration and economies of scale. This has resulted in more production with less effort in a shorter period of time. The exploitation of existing technologies and new scientific discoveries in technology will lead to such arrangemments. The focus should be to reduce the distribution losses through improved technology. The review of the domains where technological advancement is essential to ensure food security along with need for further improvement is presented below.

INTRODUCTION

Solving environmental problems in agriculture requires developing and diffusing new technologies. The Netherlands has been in the forefront of developing and applying new technologies to its farming systems, which makes this a highly appropriate location for this workshop. I also have a strong personal interest in the topic as I have been involved in the discussions on how to organize agricultural research efforts in The Netherlands in order to contribute to a viable productive service.

The policy framework Agriculture has changed dramatically over the past fifty years. It has succeeded in reducing food costs (although in many countries those costs are kept artificially high through support policies), feeding an increasing population, releasing labor from the farm and providing an ever greater choice of food throughout the year to consumers.(Sissoko,1998)

Technology has played a major part in these developments, and is also addressing today, in an integrated way, environmental and social concerns. At the same time, agriculture must be seen in the context of other developments in the world economy. Globalization, agricultural policy reform and trade liberalization all affect agriculture. Greater public awareness and emphasis on sustainable development also influence the way we view agriculture. Interactions between agriculture and the environment are now major elements shaping agro food policies in all the OECD countries. Agriculture is increasingly influenced by developments upstream and downstream. (Tiffen *et.al.*, 1994)

To ensure that agriculture produces sufficient food while respecting the environment, farmers need the right incentives, knowledge, and technology. It also means that coherent policies need to be in place — agricultural, environmental, trade and R&D policies in particular. It is vital to base policy decisions on robust, well-established scientific criteria so that the decisions are justified and can be explained to all stakeholders. (Udry, 1990)

The interactions between agriculture and the environment will also be an aspect of the forthcoming discussions on international trade in agriculture. International trade can no longer be discussed in isolation; other objectives and concerns have to be taken into account, without calling into question the commitment of both the WTO and the OECD to a freer, more open system of agricultural trade. The challenge is to find win-win solutions. When we speak of adopting technologies for sustainable farming systems we are taking about those technologies that are established and available, but not adopted by all farmers, and thosethat are new or under development. Let me say a few words about the latter, and the challenge of the impact of these new technologies on the environment. (Ruben *et.al*.2000)

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Many countries agree that new biotechnologies need to be assessed within a framework of sustainable agriculture, encompassing both economic and resource sustainability. There has been considerable discussion about the actual and future benefits of biotechnology and genetically modified (GM) crops. There is anecdotal evidence and scientific studies both supporting and questioning the benefits in terms of yields, costs and environmental impacts. Producer groups generally report favorable results but it is early days and experience is not widespread. Local climatic conditions may make a difference. Organic farmers, who represent a small but rapidly growing segment of agriculture, express concerns about potential damage from GM crops to neighboring farms and raise questions about measures of protection and liability. Farmer groups feel they should be protected by legislation against liability for any damage contamination by GM products. But the fact that the growing of GMO crops has spread so quickly in some countries shows that — often contrary to popular belief — farmers can adopt new technologies very rapidly.(Triomphe,1996)

The OECD has and will continue to look at the environmental impacts of GM technology. We now recognize the enormous potential of new information technologies, especially the Internet, in providing access to direct, timely and world-wide information. Farmers and policy-makers are exploring the scope of Internet communication as a means of adjusting to scarce public funding for dissemination of information or development work. However, this development goes hand in hand with the necessity to ensure that information can be converted to accessible knowledge of relevance to end users. One can point to plenty of examples of researchers using the Internet to communicate with different client groups. The possibilities, for example, of e-commerce in the agricultural sector — which is often characterized by problems of farms being physically distant from markets — to get information, to sell their products and to advertise their other non-food outputs (such as farm tourism) are enormous.(Van Keulen, 1982).

A Conseptual Model Analysis to the Role of Technoliogies on Agriculture Sector

Why is the adoption of technologies important? Until recently, the choice of technologies available to farmers was largely determined by the need to increase production, profits and productivity. The main constraints were the availability of capital, knowledge of how to use the technology and market risks — risks that in many countries policies were shielded by government policies. In the past, "good policy practices" was therefore rather straightforward, relating primarily to increasing output and the aim of agricultural policies was to increase productivity in agriculture. Agricultural research and extension services could concentrate, for example, on improving the productivity of small farms. Now agriculture has to fulfil diverse objectives: it needs to be internationally competitive, produce agricultural products of high quality while meeting sustainability goals. In order to remain competitive, agricultural producers need rapid access to emerging technologies. (Altieri, 1995).

Farmers are faced with many more constraints — and also more opportunities. In addition to being profitable, they need to meet environmental standards and regulations, as well as deal with direct and indirect consumer and lobby group pressures. They may also be flooded with information from various government and industry sources, that make choosing appropriate technologies more difficult.

Farmers also need to change their production and management practices in response to agricultural policies that include environmental conditions. (Barrett, 1991)

Uncertainty may increase even more in the future. There may also be uncertainty related to the future policy environment, especially with respect to support, trade and pressures from the agro- 16 food sector. Adopting technologies by farmers is an investment. It takes time, however, for the rewards to flow and farmers may be reluctant to invest in an uncertain climate with more constraints, where some of the benefits are for society. Should it be the farmer or society that pays? Technological change has been the basis for increasing agricultural productivity and promoting agricultural development. Research affects the productivity of farming systems by generating new technologies which, if appropriate to farmers' circumstances, will be rapidly adopted. Historically, researchers and extension workers have been primarily responsible for identifying and injecting economic and environmental factors into the process of developing and introducing an agricultural innovation. This is typically characterized as a top-down process, whereby researchers develop the innovation, extension workers promote its use, and farmers either adopt or reject the innovation based on the features important to them.(Besley,1995)

Technological advances in the science of pest control are expected to continue to produce chemical control agents that over time are at least as effective in controlling pests as the ones they replace, but which are also less toxic, less persistent and less mobile through the soil. The greater application of monitoring and knowledge-based systems, aided by reductions in the costs of electronic sensors and computers, should also enable farmers to be more economical in their use of pest control agents, especially insecticides: applying them only when and where necessary, rather than according to predetermined dosages and schedules. (Binswanger *et. al.*, 1987)

Technologies that administer nutrients more efficiently. Farmers have traditionally relied on two main practices to supply nutrients to root zones: manuring and burning. Inorganic fertilizers allowed the separation of crop production from animal husbandry, restored fertility to depleted soils, and contributed to the development of livestock production based on grain and other feed ingredients. Research into the specific needs of particular crop-soil combinations and livestock have led over the years to more scientifically formulated fertilizers and feeds. (Hazell, Fan, 2000)

Wider application of technologies that administer fertilizers only at the times and in the amounts needed can be expected to increase crop yields further while reducing leaching and runoff of nutrients.(Ruben *et.al*., 2000)

Technologies that administer water more efficiently. Many of the technologies still used for irrigating crops are as old as civilization itself. The problem — today just as in ancient Mesopotania — is that conveying water through open channels and furrows is wasteful: much of the water evaporates before it reaches the root zone. In OECD countries, much of the water used in agriculture is carried to fields by pipes; but technical efficiency could still be improved through greater application of technologies that, like precision fertilization, combine more accurate measurement of actual crop needs with means to deliver the water more accurately and in more precise dosages. Technologies that reduce wastage following harvesting. The demand for primary agricultural commodities is a derived demand, which is determined in part by wastage between producer and final consumer. (Besley, 1995)

Technologies used in OECD countries to harvest, transport, store, process and distribute farm commodities are already highly efficient, and result in much lower levels of wastage than in countries where the requisite capital and infrastructure is in much shorter supply. Virtually every part of most crops and animals are recovered for some commercial use — if only for feed, fertilizer or energy. Some further reduction in post-harvest losses is achievable, but the most wastage (in proportion to the quantity purchased) takes place at the point of final consumption. Technologies that disseminate knowledge. Historically farmers relied on their own experience and that of their neighbors with regard to adopting "good farming practices". Advice and information from publicly funded agencies and agri-food industries is increasingly focused on environmental effects. The Internet provides further developments in the dissemination of information on sustainable technologies.

Sustainable Technologies Policy Implications Issues

The type and uptake of environmentally sustainable technologies is influenced by a range of policies, providing incentives or disincentives: − environmental policies (constraining what farms can do); − agricultural policies (encouraging expansion of output or requiring environmental conditions in return for support); − Trade policies (which influence the location and type of production, and appropriate technology); − structural policy (which affects the scale of farm, the type of technology applied and the specialization); and − technology and R &D policy (which encourages research and dissemination of technologies in light of current priorities). Much of the recent debate has been on the kind of incentives and disincentives that policies should give. For example, if it is not profitable for a farmer to adopt environmentally sustainable technology, should the government encourage farmers with financial incentives? This question can also been explored in the context where environmentally sustainable management practices contribute to positive externalities in agriculture (e.g. enhance biodiversity). (Altieri, 1995).

These issues give rise to a whole new paradigm — including debates on the joint links between agricultural production and environmental outcomes and public good aspects of agriculture — in that technologies have to serve both for increasing the efficiency of production and the environmental performance. The issues are less controversial when there is a mutual benefit to adopting a new technology — that is to say, when it is financially profitable to adopt it, and its adoption also improves the environmental performance of the farm. Factors affecting the adoption of technologies Diffusion is the process by which a new idea, practice or technology spreads in a given population. (Binswanger *et. al*., 1987)

The characteristics of technologies, such as relative advantage, complexity, divisibility, observability and compatibility affect their diffusion. Farmers will be encouraged to adopt appropriate technologies for sustainable farming systems if the dissemination of information is efficient. There is a paradox here one must bear in mind, however. On the one hand, experience in other sectors undergoing the transition to less polluting or more resource-conserving practices shows that it is inefficient for governments to be too prescriptive. Those environmental policies that set performance standards, as opposed to forcing the use of particular technologies, tend to encourage innovation of a sort that lowers the cost of achieving a given result. Yet when a really important, useful technology comes along there may be an interest in encouraging its quick adoption. At that point, it is too late to start educating the educators, the extension agents and others responsible for explaining to farmers the merits of the technology. It is thus important to facilitate the dissemination of improved farming system technology to farm households through farmer-participatory methods and to strengthen existing resource-planning capability and improve the research and extension capability. (Van Keulen, 1982).

Assimilation and adoption of new and available technology at the farm level is a function of science, economics and human behavior. One or more of the physical sciences or biology serves as the foundation for technology development, and economics usually serves as a strong motivator for adoption. The psycho-social and human behavioral aspects of technology adoption are less tangible, but clearly influence the potential adoption of any technology to change.(Udry,1990)

Technology and change will most likely be assimilated and implemented when: the benefits of implementation will be quickly realized (within one to two years), the tools for implementation are readily available and accessible in the local marketplace, the risk of the implementation are small and the change or new technology can be comfortably integrated into other basic on-going aspects of daily life. Several "barriers" have hindered the assimilation of new agricultural technology through extension: − A perceived fundamental inability to demonstrate a linkage between profitable technology adoption and sustainable production at the farm level. − The limited movement away from a discipline-based or uni-dimensional approach to a broader systems may have reduced the ability to evaluate the economic and environmental components of technology uptake. − The instruction and demonstration of new technology within the controlled setting of a university research farm may not encourage farmers to adopt the technology for their own farms, which have distinct and different resources. − The failure to recognize and address the psychological component of technology adoption as part of the educational process, because generating knowledge is not always synonymous with diffusing and adopting knowledge. The adoption process involves an interrelated series of personal, cultural, social and institutional factors, including the five stages of: awareness, further information and knowledge, evaluation, trial, and adoption. Characteristics of a technology, such as simplicity, visibility of results, usefulness towards meeting an existing need and low capital investment promote its eventual adoption and should be considered when transferring any technology). (Altieri, 1995).

Profitability is a major concern to farmers. But given the vast array of available technologies, the uncertainty of their effects and the policy and market context, it is difficult to decide where and in what to invest. The opportunity to witness an investment in profitable technology by a fellow producer with similar facilities and resources often helps in decision making and can guide the changes ultimately adopted. Surveys show that in most OECD countries farmers are becoming better-educated and are continuing their education and training throughout their careers. This is good news, since bettereducated and informed farmers have always been at the forefront of technology adopters. Traditionally, publicly funded extension services have played a leading role in dispensing information and advice. However, in many countries extension services have been privatized since the mid-1980s. (Hazell, Fan, 2000)

Privatization has brought about a number of changes. The influence of farmers' representatives on the extension service is increasing. In the Netherlands, for example, provincial offices for agricultural affairs have been created, which effectively separates Extension adviceon farm management from the provision of information on government policy by provincial offices.

Technological change is possibly the single most important factor driving globalization and the development of world agriculture. The following observations can be made: − the gap between rich and poor countries is often a technology gap; − the changing relations between farmers and society are often a result of changes in technology used by farmers; and − new technology is increasingly at the forefront of international trade conflicts.(Udry,1990)

Farmers face a highly competitive global market place. They operate within a food chain dominated by a few large multinational companies and they work within a complex system of government regulations. They are also faced with falling government support for the farm economy. In order to survive, farm production must be cost/price driven. New technology is therefore needed in order to increase productivity. Farmers must keep up with improvements in technology in order to stay in business. The 'challenge of sustainability', however, is not only an economic question. Although farmers must maintain a positive balance with their environment in order to ensure the production on which their immediate livelihood depends, and the long-term survival of farming as an economic activity, the concept of sustainability in a policy context is much broader than this, and differs from country to country. In developing countries, the priority is to adopt technology that helps to achieve food security and economic development. In the OECD area, sustainability is viewed more in terms of food safety and quality, the management of natural resources and maintaining rural communities. There are therefore several dimensions to the sustainability of farming systems. Agriculture has the potential to make a unique and central contribution to a more sustainable society. Not only can it assure the continued development of an environmentally-sound supply of food to meet the needs of the rapidly expanding world population, it can also provide for the conservation of the rural environment with its wildlife habitat, genetic biodiversity, landscapes and cultural traditions. The ability of farmers to deliver this contribution is affected by market forces and by government policies.(Altieri,1995).

Impressive gains have been made in farm productivity, particularly through the adoption of improvements in plant and animal genetics. Only 50 years ago, wheat yields in Europe averaged about 2 tons per hectare whereas today the average is 7 tons per hectare, and it is not uncommon for some farmers to produce 10 tons of wheat per hectare. Typically, market-driven technological progress has led to the intensification of farming systems, the use of more industrial inputs and the adoption of management methods that stress low costs and high yields. However, this pursuit of productivity and efficiency has, in many cases, put pressure on the natural resource base. (Binswanger *et. al.*, 1987)

It has also led to significant consumer concern about the safety and quality of food produced in modern, intensive agricultural systems, which in turn has led to the disappearance of many small farms. Thus, on the ecological and social sides, the technologies adopted after the war — which allowed Europe to emerge from food shortages — have become increasingly unsustainable in relation to changing objectives that society places on agriculture. Today, the adoption of new technology in agriculture is looked upon much more critically than it is in most other sectors. In many OECD countries, farmers are faced with consumers who are skeptical about the sustainability of modern farming systems. Many consumers, in fact, would prefer to go back to using more traditional farming methods. Farmers are sensitive to these concerns and most are actively involved in various strategies to achieve greater agricultural sustainability. Such strategies include better targeting the use of farm inputs and increasing the use of conservation farming methods. Where this has occurred, the following can be observed: − the use of pesticides has been reduced dramatically, by over 50% in some OECD countries; − the use of integrated crop protection methods has increased; − nutrient balance is being optimized, e.g. through nutrient bookkeeping. (Udry, 1990)

Huge investments have been made for manure storage and management in intensive livestock operations; − filter strips have become commonplace around water courses, where farmers use no chemicals; − water is used more efficiently in irrigation systems and waste water is being recycled; − crop land is increasingly being farmed under 'no-till' or 'direct seeding' systems; − greenhouse horticulture is moving towards a completely closed systems; and − precision farming techniques are being used more widely. (Hazell, Fan, 2000)

Farmers' organizations are also playing a role in facilitating transfers of technology and know-how through exchange of information and ideas among farmers and farmers' organizations. For example, such organizations have developed codes of good environmental farming practices, and have set up quality assurance schemes. In addition, they have taken the lead in voluntary, community-based initiatives (e.g. setting up water user groups or land care programs). It is clear, however, that despite these actions market forces alone will not be able to deliver the multiple functions expected by society from sustainable farming systems. There is usually little market incentive to develop technologies promoting the social and environmental aspects of sustainable farming systems.

Governments in OECD countries are therefore increasingly looking at technological innovation as a public policy issue.(Hazell, Fan, 2000)

Concluding Remarks

Public policy must approach agriculture in an integrated manner, in terms of the whole complex, diversified system of production, nature management and livelihoods in rural communities. It must strengthen this system by building on the knowledge of farmers and by helping farming systems to become more sustainable. Any public policy discussion in this area raises many issues. These include: − directing investments in research in the right direction; − better explaining technological developments to consumers, farmers and to society in general; − finding the appropriate balance between voluntary initiatives and the complex array of legislation on what farmers can and cannot do on their land; − bringing consistency and coherence to international regulations governing such items as intellectual property rights, health and safety standards, use of the precautionary principle, multilateral environment agreements and international trade rules; − strengthening competition policy; and − supporting the right of farmers to save their own seed for replanting on their farms. In terms of developing appropriate technologies for sustainable farming systems, IFAP views with serious concern the reductions that have occurred in government funding for agricultural research. The best research today is increasingly concentrated in the hands of a few large multinational corporations where it is protected by patents. The issue of who owns and controls research greatly determines who benefits from it. More funds need to be invested in the public sector so that highquality scientists will work on agricultural research that is available to all. A target should be established to increase public funding of agricultural research so that it at least matches that of the private sector. Increasing public interest in food and environmental issues should help to achieve this goal. OECD should encourage the establishment of research partnerships to help farmers preserve their land and water resources, and to meet other environmental, as well as social, objectives. Helping farmers in this area is not commercially attractive to private companies, but it should be a role of the public sector. Policy research is also important to guide and support technological change. It should cover such questions as intellectual property rights, biosafety and food safety. The need to better explain technological developments to consumers, farmers and others in society is also critically important. It is a paradox that more people are better fed today than at any time in history, that life expectancy is rising ever year and yet that public opinion is often negative. The current debate on the introduction of new technologies is too often driven by emotional considerations, thereby hurting farmers in the marketplace and causing conflict in international trade. Education is therefore an important factor for facilitating the smooth introduction of new technologies. Objective criteria are essential for the analysis and management of risks of new technology for public health, the environment and the social sustainability of the rural economy.

We look to scientists for an opinion, but they are mainly absent from the public debate. In future, they should be more involved in the public education process concerning technological innovations. Education is also critical in order for farmers to make progress in a ‘knowledge economy’. Farmers must be aware of the technological and policy changes on the horizon. Thus developments in research need to be accompanied by training for farmers on new developments and how they should adapt. Consideration should be given to establishing regional centers where information on best 27 practices or success stories can be accessed by farmer organizations and others.

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