THE CHANGING ROLE OF EXTENSION IN TECHNOLOGY TRANSFER

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Abstract

This paper focuses on the changing role of extension in the transfer of technology, including emerging technologies that may have an impact on the capacity and effectiveness of developing country extension systems to meet the technology needs of their farmers, especially resource-poor farmers. As the private sector takes on more responsibility for technology transfer in the form of production inputs, the public extension system will have to focus on system-based, knowledge-intensive, and sustainable technologies that the private sector will be unable to provide. These technologies and others are described in the first part of the paper, followed by a discussion of their implications in terms of how national extension systems may need to realign their approach to technology transfer, including clientele, programs, and new institutional partnerships.

Changes in Agricultural Technology

The role of extension in technology transfer has changed substantially over the past four decades. Extension policies and approaches have not kept pace with the types of technology to be disseminated; at the same time, important worldwide differences exist. In large part, these changes in extension's role have been driven by new developments in agricultural technology and their application. For example, in the 1960s, the United States Agency for International Development (USAID) gave emphasis to building national extension systems. This strategy was built on the faulty premise that agricultural technology from North American and European research institutions could be directly transferred into less developed countries. Therefore, when the so-called Green Revolution technologies emerged from the International Maize and Wheat Improvement Center (CIMMYT) in Mexico and the International Rice Research Institute (IRRI) in the Philippines, this development pointed to the need for further investments in agricultural research (Dalrymple & Srivastava, 1994; Hayami & Otsuka, 1994). Consequently, during the 1970s, many donors began investing in research systems that would generate technologies appropriate for the agro-ecological and socio-economic conditions of developing countries.

Green Revolution Technology

Green Revolution technology that emerged during the mid-sixties was a combination of high-yielding varieties (the genetic component), plus a concomitant set of broad-based recommendations (crop management practices) that could be widely disseminated within an agro-ecological region. The high-yielding wheat and rice varieties quickly spread throughout Asia and beyond, but the complementary set of crop management practices diffused more slowly and unevenly, resulting in the inefficient use of production inputs. Therefore, the introduction of the Training and Visit (T&V) extension approach during the mid-seventies appeared well suited for disseminating these broad-based recommendations. By 1988-89, nearly 75 countries had adopted T&V Extension, due to the promotion and financial support provided by the World Bank (Swanson, Farner & Bahal, 1990, p. 48). Experience has shown that the T&V approach can effectively deliver general extension messages (Bindlish & Evenson, 1993, p. 29); however, its top-down management structure and inadequate technical capacity is not well suited to (a) the transfer of location-specific recommendations, (b) solving complex technical problems, and (c) disseminating system-based technologies, especially those associated with heterogeneous cropping systems in rainfed areas.

System-Based Technologies

Given the lack of progress in disseminating Green Revolution technologies into rainfed areas, starting in the late 1970s, some agronomists and rural social scientists turned their attention to Farming Systems Research (FSR). In theory, this approach was expected to strengthen research-extension-farmer linkages and to develop location-specific technology for more complex farming systems. In practice, researchers first described and then began improving different farming systems within an agro-ecological zone (AEZ), especially those cropping systems utilized by resource poor farmers in rainfed areas (Brush & Turner, 1987). In some cases, the focus was on intensifying existing farming systems, including interactions between crop and livestock systems. As a matter of practice, however, the more common pattern was to carry out on-farm, adaptive research trials with the goal of developing more location-specific recommendations, especially for different socio-economic groups of farmers within an AEZ (Byerlee, 1994).

During the 1980s, considerable progress was made in developing FSR methodologies, particularly in carrying out on-farm, adaptive research trials (Byerlee, 1994; Preston & Leng, 1994). However, the diffusion of location-specific technology for most farming systems has not been widespread. This is due to several reasons, including (a) inadequate FSR capacity within most developing country research systems, (b) the relative high cost of conducting FSR, especially on-farm trials, during a period of declining research budgets, (c) the fact that interdisciplinary FSR is both difficult to implement and not highly valued within the scientific community, and (d) the difficulty of transferring these more complex technologies to different groups of farmers, many of whom have very limited technical knowledge and management skills.

Although research-farmer linkages were strengthened through FSR, especially through the use of rapid rural appraisals (RRAs) and on-farm, adaptive research trials, linkages between research and extension remain weak (Byerlee, 1994). One apparent reason for this "disconnect" is the widespread adoption of T&V Extension. As a matter of design, most T&V extension systems have inadequate numbers of subject matter specialists (SMSs). In addition, most SMSs have insufficient technical training and experience, especially in systems-based technologies. Consequently, the transfer of technologies resulting from farming systems, integrated pest management (IPM) and other types of systems-based research has been fairly limited (Byerlee, 1994).

Sustainable Technologies

The worldwide recognition of natural resource depletion and environmental degradation resulted during the 1990s in a growing concern for the development and transfer of sustainable technologies (Byerlee, 1994). To some researchers, sustainable technologies imply the development and use of low input technologies that are in ecological balance with production outputs (Tansey & Worsley, 1995). For others, sustainable technologies imply the more intensive use of inputs, in combination with system-based technologies, including soil and water conservation, and other types of natural resource management (NRM) technologies. In the final analysis, continued population and economic growth will create an increasing demand for more and higher quality food outputs that will result in the expanded use of production inputs, and land and water saving technologies. Therefore, the challenge facing extension in the 21st century will be to disseminate sustainable technologies that will make more efficient use of land, water and production inputs, while maintaining the natural resource base over time.

Knowledge-Based Technologies

Most sustainable and/or system-based technologies, such as those emerging from FSR, IPM, and NRM research programs, are knowledge intensive. Therefore, farmers need higher level management skills and technical knowledge to successfully adopt these technologies. For this reason, better-educated commercial farmers have the capacity to more quickly incorporate these knowledge-based technologies into their farming systems, particularly if there are economic incentives to do so. The enormous challenge confronting the public research and extension system is how to develop and transfer these location-specific, system-based, and sustainable technologies to nearly one billion resource poor farmers; farmers who pose the most immediate threat to the natural resource base.

Given that system-based and sustainable technologies are both knowledge intensive and location-specific, it appears essential that national extension organizations stop functioning as top-down technology delivery systems that disseminate broad-based technical recommendations. Rather, extension needs to emphasize farmer training that focuses on the development of technical knowledge and management skills. Such an extension system would concentrate on teaching crop, livestock, and farm management skills, including the technical knowledge necessary for the adoption of productive and sustainable technologies.

Precision Technology

The next decade will see the integration of farming systems and sustainable research in the form of precision farming technology that is rapidly gaining acceptance in North America. North American farmers use both Global Positioning Satellite (GPS) systems and Variable Rate Technologies (VRT) to accurately apply production inputs across each hectare of large farms. In short, the goal of precision farming is to accurately manage each part of a field based on actual need, rather than managing whole fields or farms based on average needs (Mangold, 1996, p. 40). While VRT has little direct relevance to most developing country farmers, other tools associated with precision technology, such as Geographic Information System (GIS) software, combined with periodic soil testing and adaptive research findings, appear directly relevant for application in most developing countries. For example, crop management researchers and subject matter specialists can work together, using a combination of recently developed computer software programs (GIS/yield mapping software), adaptive research findings, and soil test results from farms within a recommendation domain to more accurately specify input levels for different cropping systems within an AEZ. In fact, it would be technically feasible and economically viable for farmers with less that one hectare to get precision recommendations for the different crops within their farming systems. In short, precision technology has the potential of enabling different types of farmers to gain more accurate management control over production input use and, thereby, increase the production efficiency of their cropping systems. The aspect of precision technology that appears most relevant to developing countries is the use of comprehensive soil test results, on-farm research findings, and GIS/yield mapping software to develop site-specific management recommendations for both individual and groups of farms within different recommendation domains of an AEZ. Although decisions about the most appropriate variety or hybrid might be specified for each recommendation domain, the plant population, soil nutrients, and agro-chemicals to be applied can be more accurately specified for each hectare of a farmer's field, given a particular yield target.

Precision technology is also more ecologically friendly, because it adjusts input use to reflect both soil type and crop requirements. For example, farmers can avoid using too much fertilizer and/or agro-chemicals on lighter soils and inputs that might leach into underground aquifers or find their way into streams and reservoirs downstream. Furthermore, by replenishing soil nutrients based on crop output data and periodic soil tests, farmers can avoid long-term soil nutrient mining - a serious problem in many Asian countries.

Finally, farmers can decide whether they want to maximize income at a higher level of risk, or pursue a more conservative yield target with less risk. Therefore, precision technology allows farmers to make informed economic decisions about input use, while reducing long-term environmental degradation. Combined with IPM and NRM technology, precision technology appears to be a logical step toward helping farmers adopt or utilize more cost-effective, intensive, and sustainable technology.

Vertically Integrated Systems

A long established approach to technology transfer that is taking on renewed importance in this period of trade liberalization is the use of vertically integrated systems for high value commodities within some countries. These systems operated successfully from the mid-19th to the mid-20th century as colonial governments exploited the natural resources and cheap labor in many developing nations to produce high value commodities, such as tea, coffee, sugar, and cotton, to meet the requirements of the colonial nation. These vertically integrated production, processing and/or marketing systems are demand driven. However, worldwide competition for specific markets, rather than a colonial government, will now determine the winners and losers. Those countries with the comparative advantage, including agro-ecological conditions and efficient production technologies, along with processing capacity and/or marketing arrangements, will eventually dominate these growing export markets.

Developing countries, with relatively cheap agricultural labor, have an important advantage in penetrating rapidly expanding export markets that can both generate foreign exchange and increase farm income. In addition, many high-value commodities are labor intensive and have the potential for value-added employment. Therefore, nations need to pursue policies that will encourage their farmers to diversify into those high value commodities where they have a comparative advantage. In some cases, the initial research and development (R&D) work might be carried out by the national research system (Jarvis, 1994). However, in most cases, private companies are more effective in establishing these vertically integrated systems.

First, private companies better understand the demand structure for different products, especially export markets in Europe, North America and East Asia. Second, private sector firms are more efficient in establishing the necessary processing capacity and/or market arrangements to exploit this export market demand. Third, these companies are better able to organize a more comprehensive technology transfer system, including input supply, credit, and "contract extension" to ensure that participating farmers utilize the recommended production technology. And, finally, companies are prepared to finance the cost of establishing these vertically integrated systems, including most research and extension costs.

Implications for Extension Systems

Intensifying and Diversifying the Farming Systems of Resource Poor Farmers

To more effectively address the food security issue and the need to achieve broad-based, sustainable agricultural development, the technology and educational needs of small farm households must be more adequately addressed. Targeting resource poor farmers with appropriate technology offers an important opportunity for rural households to increase their productivity and incomes, and to slow rural-urban migration. Also, targeting this vast group of low resource farmers can increase efficient use of the land, labor, and capital resources within rural areas.

The most effective means of bringing small and marginal farmers into a market economy and increasing their farm income is to help them intensify their farming systems and/or diversify into high value crop or livestock enterprises. These modifications must (a) be appropriate for the agro-ecological and natural resource conditions of the area, (b) reflect the resource endowment of predominant farm households, and (c) anticipate new and/or expanding market opportunities, including agro-processing. Assisting large numbers of resource poor farmers to intensify and diversify their farming systems will require an interdisciplinary team approach, with an appropriate mix of research and extension specialists, who can work together to assess, validate, and transfer more productive farming systems and sustainable technologies to different socio-economic groups of farmers.

On the other hand, if governments leave research and technology transfer largely to the private sector, large-scale commercial farmers will be the primary beneficiaries, resulting in larger and more capital and energy intensive crop and livestock systems. In the process, resource poor farmers will be further marginalized, leading to accelerated environmental degradation, deteriorating socio-economic conditions, and rapid rural-urban migration.

Developing and Transferring Sustainable Agricultural Technologies

As the private sector takes more responsibility for production inputs, the public technology system will need to allocate more resources to those technologies that will result in sustainable agricultural development. These technologies include those management practices and systems that will increase production efficiency, yet conserve the nation's soil and water resources. These technologies range from improved conservation tillage practices to new farming systems that will maintain soil, water and other natural resources. As noted earlier, IPM is an example of a sustainable technology that can reduce crop protection costs and minimize the use of agro-chemicals. IPM technologies are urgently needed since agro-chemicals can threaten the health of farmers, the safety of a nation's food supply, and contribute to long-term chemical degradation of a country's soil and water resources. (Roling & Pretty, 1997).

In most Asian countries, such as India, further expansion of irrigated agriculture will be limited. Therefore, there is an urgent need to improve soil and water management practices to reduce waterlogging and salinization (knowledge-based technologies), and to improve water use efficiency that will help conserve each nation's water resources. In addition, more attention is needed to improve the productivity of rainfed agriculture, through improved watershed management and tillage practices. Finally, soil erosion and soil nutrient mining are having a serious long-term impact on the land resources of many countries. Therefore, farmers need to be trained in appropriate soil, water, and crop management practices that will reverse these long-term trends. Furthermore, the public research and extension system will need to allocate more resources to these sustainable technologies that will not be developed and disseminated by private sector companies.

Emphasizing Technical Knowledge and Management Skills

As noted earlier, both system-based and sustainable technologies are knowledge-intensive. Therefore, to achieve farmer acceptance and adoption, farmers will need to increase their technical knowledge and management skills. In the future, extension should move beyond the simple dissemination of broad-based recommendations, currently being disseminated through approaches such as T&V Extension. The importance and value of sustainable technologies may not be readily apparent to farmers. Therefore, extension will need to organize educational programs that will explain the rationale and importance of these technologies, as well as the management practices necessary to adopt these technologies. In addition, appropriate government policies, including the regulation and pricing of water used for agricultural production, as well as incentives to encourage the adoption of soil and water conservation practices, can help support the dissemination of these sustainable technologies.

Location-Specific Technologies

The lack of research personnel who can carry out on-farm, adaptive research trials, and competent crop management specialists who can help refine agronomic practices, is a serious obstacle to increasing the productivity of major cropping systems within each AEZ of developing countries. To increase the efficiency and effectiveness of scarce research and extension personnel at the district or sub-regional level, selected precision technology tools could be utilized to help generate site-specific recommendations. To do so, the first step might be to differentiate a district into major AEZs and sub-zones. Next, using participatory rural appraisal techniques, a strategic research-extension plan for the district could be developed. The research dimension of this plan would outline a series of adaptive research trials to be carried out across different cropping systems within each AEZ. These on-farm trials would be complemented with a systematic (grid) soil testing program to be carried out across each AEZ, using low-cost GPS technology. The results of these trials and tests would then be accumulated and analyzed using GIS software to generate information on plant nutrient availability and yield response data within each sub-zone. By following a systematic program of multi-year trials, and developing soil test data across each AEZ, it should be possible within five years to generate location-specific findings for the major crops and cropping systems within a district or sub-region. These findings, along with the resulting GIS maps, could be used in training the extension field staff about location-specific recommendations to be disseminated to different groups of farmers and villages within their service area.

Organizing Farmers Into Groups

Most extension organizations in developing countries have done little to help farmers organize into functional groups, such as farmer or commodity associations, or use existing groups to enhance technology dissemination and feedback. To create a demand-driven technology system it is necessary to directly involve farmers in identifying problems, establishing priorities, and carrying out on-farm research and extension activities. The most effective mechanism in enabling farmers to become more effective partners in a national technology system is to help organize them into farmer associations (FAs). The experience of successful FAs in Asia, Europe and North America is that they must be voluntary organizations, organized around a specific commodity and/or support service, and they must be controlled by the members with the goal of increasing farm incomes and improving the living standards of participating households (Chamala & Shingi, 1997).

Creating New Institutional Partnerships

To meet the growing demand for food, and to sustain the natural resource base during a period of declining public investment in research and extension, new institutional partnerships will be essential. The publicly financed research system needs to cooperate with, rather than compete against, private R&D firms. Private sector firms have the resources and comparative advantage to develop, produce and distribute different types of proprietary technologies, such as improved varieties/hybrids and agro-chemicals. In the process, the development, production and transfer costs of these proprietary technologies can be passed along to farmers and ultimately to consumers. Therefore, the private sector component of a national technology system is generally sustainable.

NGOs are becoming important in many developing countries and are a valuable resource in helping farmers to get organized into functional groups. It is in the direct interest of both research and extension to work with NGOs in helping farmers organize into different types of FAs (Farrington, 1997). These FAs, in turn, can provide invaluable feedback to both research and extension in terms of problem identification, priority setting, program implementation, and evaluation. In the process, farmers and their FAs can provide invaluable policy support to maintain and even increase public investment in research and extension.

Conclusion

The expanding worldwide demand for food, combined with the land and water resource constraints faced by many countries, will require increased investment in agricultural research and technology transfer. Much of this new investment will come from the private sector and will be directed toward the development and transfer of proprietary technologies, including genetic, chemical, biological, and/or mechanical inputs. In this emerging institutional milieu, the public sector must concentrate its research-extension investments on serious socio-economic and resource management problems; problems that will not be addressed by the private sector. In particular, they should concentrate on those knowledge and system-based technologies that will enable resource poor farmers to increase their productivity and incomes through more intensive and diversified farming systems. This strategy will help reduce rural hunger, poverty and the socio-economic costs of rapid rural-urban migration. The public sector must also take primary responsibility for developing and disseminating sustainable technologies that will maintain the natural resources of each country.

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