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Institutional Reforms for Getting an Agricultural Knowledge System to Play Its Role in Economic Growth

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While alarmists shriek the crisis of accelerating soil erosion and declining water quality as the major impediment to the future of global agriculture in supplying the needs of humanity, the argument here is that, although resource degradation is indeed a threat to achievement of satisfactory crop yields over the next several decades, the main threat is not degradation of natural resources. Rather, it is degradation of the capacity of societies, particularly those in the less-developed countries, to develop the knowledge embodied in people, technology and institutions necessary to meet the challenge of higher yields and intensified agricultural production. Dealing with this threat of degradation of knowledge institutions and resources must be an important focus of economic development policy in agrarian societies. In short, the agricultural knowledge and information systems (AKISs) serving the developing world must be put in effective and stable shape to deliver the needful.

1. INTRODUCTION

Food needs calls for steady growth in agricultural production. Today, more than 80 low-income developing countries suffer from chronic food deficits, and about 800 million people live in hunger. By 2025, the world's population may exceed 8 billion and food needs in developing countries may nearly double. If unmatched by increases in food production, mounting demand for food will raise food prices and aggravate food insecurity worldwide, while swelling the ranks of the hungry.

Analysts of the global agricultural system are in general agreement about three characteristics of the system as it likely will evolve over the next several decades [e.g., Islam (1995)]. Global demand for food will double from 1990 to 2030. Over 90 percent of the increase will be in the less-developed countries (LDCs) of Asia, Africa and Latin America, reflecting relatively rapid population growth and steady increases in per caput income in most of those areas. Because of increasing scarcity of agricultural land around the world, most (75–90 percent) of the increased

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production needed to satisfy future demand will have to come from increased yields, that is, greater partial productivity expressed as increased crop production per hectare.

There is much less agreement about the obstacles that must be overcome if crop yields are to increase fast enough to meet global food demand at generally acceptable economic and environmental costs of production. One widely held line of argument—epitomised variously by Brown and Wolf (1984) and Pimentel *et al.* (1995), for example—is that degradation of natural resources, especially land and water, constitutes a major threat to achievement of the crop-yield increases that will be required. The position taken here is that resource degradation is indeed a threat to achievement of satisfactory crop yields over the next several decades [e.g., Crosson (1995)]. The **main** threat, however, is not degradation of natural resources [Crosson (1997); Crosson and Anderson (1999)]. Rather, it is degradation of the capacity of societies, particularly those in the LDCs, to develop the knowledge embodied in people, technology and institutions necessary to meet the challenge of higher yields. Dealing with this threat of degradation of agricultural knowledge resources should thus be one important feature of contemporary agricultural development policy. The issues are wide-ranging, and naturally include the functioning and governance of key public agencies such as national agricultural research institutes (NARIs).

2. NATURAL RESOURCE DEGRADATION IS NOT THE MAIN THREAT

Consider first the potential contribution to future yield increases of eliminating past and future degradation of the natural resources that earlier analyses by observers such as Crosson and Anderson (1992) have revealed as most constricting agricultural growth, namely, land and water resources; initially given present knowledge of how to manage these resources, then the potential yield-increasing contribution of advances in knowledge.

Land: Oldeman, Hakkeling and Sombroeck (1990) assessed that soil erosion by water and wind accounts for some 83 percent of the land degradation in the LDCs. Until the early 1990s, there was a strong consensus among students of the field that credible information about global rates of soil erosion, let alone its productivity effects, was lacking. Nelson (1988, p. 1) expressed the consensus view when, after a survey of the literature, he concluded that the evidence with respect to the rate, extent and severity of land degradation around the world was extraordinarily skimpy. Other specialists in land degradation had come to the same conclusion. Dregne (1988, p. 679) noted that estimates of land degradation, including his own, were based on few data and much opinion. Writing specifically of soil erosion and its productivity effects, Dregne (1988, p. 680) observed that “there is an abysmal lack of knowledge of where water and wind erosion have adversely affected crop yields”. El-Swaify, Dangler and Armstrong (1982, p. 1), noted that there is little or no documentation of the extend, impact or causes of erosion in tropical environments, a situation not radically changed today [El-Swaify (1999)].

Since these early authors wrote, two pioneering studies have been published that give promising first-approximation global estimates of the extent and severity of human-induced degradation of agricultural land [Dregne and Chou (1992); Oldeman, Hakkeling and Sombroeck (1990)]. The Dregne and Chou (1992) study was an effort to extend the knowledge frontier with respect to the extent and productivity consequences of land degradation beyond the narrow limits noted by Dregne (1988) and others.

Dregne and Chou estimated the spatial extend and productivity effects of land degradation in dry areas in most countries of the world. The estimates are for three kinds of agricultural land use: irrigated land, rainfed cropland, and rangeland. Drawing on data prepared by FAO, Dregne and Chou found 5.1 billion ha of dryland in the three uses, 88 percent of it in range, 9 percent in rainfed crops, and 3 percent in irrigated crop production. Degradation of rainfed cropland is mainly by water and wind erosion. Irrigated land is degraded mainly by salts carried and deposited by irrigation return flows and, to a lesser extent by waterlogging, a process that may occur in areas where shallow water-tables promote the movement of saline groundwater to the soil surface, leaving a deposit of salt in the soil when the water evaporates. Rangeland degradation is caused mainly by overgrazing and is almost entirely a matter of vegetation degradation, meaning a decline in the quality of vegetation for animal forage [Dregne and Chou (1992), p. 252]. Although overgrazing may also result in increased wind and water erosion, this is secondary relative to vegetative degradation.

Dregne and Chou reported estimates of 3884 million ha degraded irrigated land, rainfed cropland and rangeland in dry areas of the LDCs, by estimates of the severity of degradation. For each of the categories of severity of productivity loss Crosson (1995) assumed that the loss is at the mid-point of the range given by Dregne and Chou, that is, slightly degraded irrigated and rainfed cropland has lost 5 percent of its productivity, moderately degraded land has lost 18 percent, and so on. He then weighted these estimates of productivity loss by the amount of land in each degree-of-severity category in each of the three land uses to calculate the weighted average loss in each use. These averages are 11,14, and 45 percent, respectively. Finally, because in terms of lost productivity a 1 ha loss of irrigated land imposes a higher social cost than a 1 ha loss of rainfed cropland, which imposes a higher cost than a 1 ha loss of rangeland, he calculated the weighted average loss of the three land uses taken together by weighting the percentage loss for each use by its per hectare value of production. According to Dregne and Chou, these values (in prices around 1990) were $625 for irrigated land, $95 for rainfed cropland and $17.50 for rangeland. His calculation thus showed that the average loss for the three land uses together was 12 percent. Over, say, four decades, the annual rate of productivity loss would thus be 0.3 percent.

The study by Oldeman, Hakkeling and Sombroeck (1990), conveniently summarised in Oldeman (1992), found that, of the LDC total of 6164 million ha of land in annual and permanent crops, permanent pasture, and forest and woodland, 1548 million ha (25 percent) was degraded to some extent. Water and wind erosion were responsible for 83 percent of the degraded land (i.e., 1292 million ha). The other 17 percent was degraded by chemical processes (e.g., soil nutrient loss or salinisation) and physical processes (e.g., soil compaction caused by animal traffic). Oldeman, Hakkeling and Sombroeck (1990), as reported in Oldeman (1992), show the LDC degraded land by severity of degradation only for the land degraded by water and wind erosion. Crosson used the data of Oldeman (1992) to calculate that 4475 million, 582 million and 235 million ha are lightly, moderately and strongly eroded, respectively.

Oldeman, Hakkeling and Sombroeck (1990) did not estimate the percentage losses of soil productivity for each of their categories of degradation. Crosson estimated these losses, using the percentages of loss by degradation category from Dregne and Chou (1992), to give an average productivity loss on the 6164 million ha of land of 4.2 percent. This is the cumulative loss over 45 years from the end of World War II to about 1990 [Oldeman, Hakkeling and Sombroeck (1990)], so the average annual rate of loss is only about 0.1 percent, an estimate of productivity loss dominated by the assumption that 75 percent of the 6164 million ha of LDC land in crops, permanent pasture and forest/woodland has suffered no productivity loss because of soil degradation.

***Water**:* Degradation of water resources considered here is confined to water used for irrigation. Irrigation water is degraded primarily by the uptake of salts from the soil as the water moves downstream and is used and reused by one farmer (or other user) after another. Waterlogging, while less important generally than saline irrigation return flows, is the other main form of degradation of water for use in irrigation. Both of these processes lead to the build-up of salts in the soil that, unless checked, will in time reduce crop yields.

Totally reliable information about current rates, extent and productivity consequences of degraded irrigation water is scarce. The problems of defining and measuring the magnitude of irrigation-related salinisation and waterlogging are considerable. Dregne and Chou (1992) concluded that 30 percent of the 145 million ha of irrigated land in dry areas (globally, not just in the LDCs) is moderately to very severely degraded by salinisation and waterlogging seemingly on the high side of reality. Alexandratos (1995, p. 138) gives an estimate close to that of Postel (1992, pp. 35–54), some 25 million ha of irrigated land according to her, saying that about 10–15 percent of the irrigated land *in the LDCs* is “to some extent”degraded by waterlogging and salinisation.

Using the Dregne and Chou (1992) magnitudes because they give quantitative estimates of the effects of salinisation and waterlogging on yields of irrigated land, a weighted average cumulative yield loss on this land, in dry areas of the LDCs, of 11 percent. Most of this land was brought under irrigation over the past 30 to 40 years. Taking 40 years as the period over which the loss occurred, the average annual rate of loss would be about 0.3 percent, a conservatively high estimate for the present purpose.

Yield Consequences of Land and Water Degradation: Putting data limitations aside then, under *the present state of knowledge*, elimination of all forms of degradation of land and of irrigation water, and total restoration of presently degraded land and water to their full potential productivity, would add little to the food production increases that will be needed over the next several decades. For example, Crosson and Anderson (1992) projected a 170 percent increase in LDC demand for grain (which they take as a (50 percent) proxy for all food energy) between the average for 1988-89 and 2030. The estimates of degradation-induced losses of land productivity based on the Oldeman, Hakkeling and Sombroeck (1990) data indicate that immediately bringing current rates of degradation in the LDCs to zero would increase yields in 2030 by some 4-5 percent. Restoration of all presently degraded land to 100 percent of its potential productivity would add another 4-5 percent to yields.[1]

By this reckoning, therefore, total elimination of past and future degradation-induced losses of land productivity would add only some 8-10 percent to yields of the land by 2030. Even this estimate is high because it assumes that it would be economical to eliminate **all** productivity effects of land degradation. This surely would not be the case because it is likely that the incremental costs of achieving the objective would rise sharply as the effects approached zero. Elimination of all past and future effects of land and water degradation on land productivity in dry areas of the LDCs could increase yields in those areas by only about one-quarter over the 40 years 1990 to 2030, still far short of the yield increases that will be needed to satisfactorily meet the 170 percent growth in demand indicated in the Crosson and Anderson demand scenario.

This argument could be said to understate the advantage of reducing land and water degradation in the LDCs because, under the pressure of rising populations and pervasive poverty, many farmers may be driven to ever higher rates of exploitation of their land and water, thus accelerating the degradation of these resources. In this case, measures to reduce degradation now would have higher payoff over the next 30-40 years than is implied by the conclusion. This scenario of accelerated degradation was considered explicitly by Agcaoili, Perez and Rosegrant (1995) [summarised by Scherr and Yadav (1996), p. 7]. The scenario is not implausible. However, it is at least as plausible to assume that rates of land degradation in the LDCs are more likely to decline than to accelerate [Malik (1998); Anderson (1999)]. There is increasing evidence in those countries that, when fast population growth is accompanied by advances in agricultural technology and commercialisation, the

[1]The arguments above are couched in terms of LDCs in total, but since Pakistan seems representative of the total in many important respects, it seems likely that the conclusions apply in this key specific case too.

economic value of agricultural land rises, giving farmers stronger incentive to adopt land-conserving practices. The evidence suggests that this combination of events leads to the strengthening of property rights in the land, an important institutional condition for farmers to undertake investments, such as in land conservation, with long-term payoffs [e.g., Pingali (1989); Migot-Adholla *et al*. (1991); English, Tiffen and Mortimore (1993); Tiffen, Mortimore and Gichuhi (1993)].

3. THE IMPORTANCE OF KNOWLEDGE RESOURCES

If it is correct that, in the present state of knowledge, total elimination of all past and future yield effects of land and water degradation would contribute only modestly to the increase in yields that will be needed over the next several decades in the LDCs, then the yield challenge will be met only if the supply of knowledge resources can be increased enough to do the job. The importance of knowledge as an economic resource has long been recognised [Schultz (1964) and Machlup (1984)]. Knowledge is a key resource for agriculture, as it is for every other economic sector, and it is clear even from anecdote that knowledge-based increases in yields can economically compensate for the small yield-increasing potential of eliminating land and irrigation water degradation. More generally, the stock of knowledge into which research feeds is a resource contributing to productivity that can substitute to an important extent for the natural and manufactured resources that constitute the conventional factors of agricultural production, even though it may be difficult to measure the knowledge contribution explicitly [Alston and Pardey (1996)].

Consider certain well established facts about the experience of global and LDC agriculture since the end of World War II. One is the enormous increase in the general and agriculture-specific education of farmers all around the world. The increase in this human capital, the improved skills embodied in these people, must have been a major source of the post-war increase in the knowledge resource in agriculture. Similarly, the knowledge embodied in the technologies farmers now have at their disposal—the Green Revolution is an example—represents an unmeasured but surely major increase over the technical knowledge available to farmers 40 or 50 years ago. Knowledge embodied in institutions also has increased, e.g., the increasing recognition of the importance of designing institutions and policies to strengthen farmer incentives to adopt more productive technologies and management practices.

That these increases in knowledge greatly exceeded the increases in supplies of agricultural land and water is implicit in the substantial increases in plant and animal output per unit of land area achieved over the past 45 years. And this relative increase in supplies of knowledge suggests that the payoff to increased investments in knowledge was higher than the payoff to investment in increased supplies of land and water. It surely was the case that, at any given time over the past 40–50 years, farmers, and those persons and institutions providing services to farmers, had the option to respond to rising demand for agricultural output by employing more knowledge, or more land and water. They, of course, did some of both, but they opted to increase the employment of knowledge far more than of land and water.

Resources are substitutes for one another in production when they have positive marginal productivities and when it is possible to achieve a given output with varying combinations of the resources. The specific combination will depend on the relative prices of the resources, as producers will choose to employ relatively more of the cheaper resource. In agriculture, the increase in the supply of knowledge relative to land and water over the past 40–50 years is consistent with the hypothesis that, across a broad range of combinations of resources, knowledge has indeed been a substitute for land and water. This is not to say that there are no circumstances when natural resources and knowledge are technical complements, but the dominant natural resource/knowledge relationship is one of substitution.

4. DEGRADATION OF KNOWLEDGE RESOURCES

If increasing the supply of knowledge is the only way to achieve the yield increases that the LDCs will need to satisfactorily meet future demands for food, the critical issue with respect to resource degradation is the threat of degradation of knowledge resources. Machlup (1984) tackled the subject of degradation of knowledge as an issue in economic development perhaps more comprehensively and at greater depth than any others. Machlup approached the subject of knowledge as an economic resource from essentially a human-capital perspective, as have others such as Becker (1995), but he brought to the subject many analytical insights from related fields of applied economics. Among the most important of these is a systematic treatment of the issue of "depreciation" of knowledge which, if not matched by more than compensating investments, amounts to what could be called knowledge degradation. The role of education in the process of both human-capital formation and knowledge creation is appropriately highlighted in Machlup's formulation of the issues.

To focus on the depreciation aspect of knowledge-based resources, such as human capital, Machlup refers to four major categories: (a) termination of the carrier of the knowledge as a participant in productive enterprises; (b) deterioration of a provider's personal characteristics (such as loss of memory); (c) obsolescence of the knowledge that had hitherto been acquired; (d) diminution of the scarcity value of any specific category of knowledge. He also identifies a further potential set of issues related to disruption of the employment of trained workers, which could be tagged as category (e). There is no real controversy about the nature of these forms of knowledge depreciation, but their relative importance among countries and over time clearly would be open to question. Moreover, some of the categories are potentially controversial because of a lack of clarity about their dimensions, which, in the case of something as sophisticated as knowledge obsolescence, is understandably difficult to investigate at an empirical level.

It is a great tragedy that Machlup did not survive 1983 to flesh out, in the manner he had promised, some of the conceptual issues he defined. This would have made the present task rather easier. Fortunately, others have taken up some of the kindred themes [e.g., David (1993) and Romer (1993)] but, while the field is receiving renewed attention by both economists and philosophers of science, there seems little effort to address such issues as they pertain to the state of the world's agriculture.

Even casual observation and anecdote can be quite telling about contemporary trends in the agricultural knowledge system in the less-developed world. These trends raise a serious question about whether future supplies of agricultural knowledge will be sufficient to provide the yield increases the LDCs will need to meet future demands for food at satisfactory economic and environmental costs. A related question concerns knowledge of the economic, social, and technical aspects of natural resource management underpinning agricultural production [e.g., Biot *et al.* (1995)].

Investments in Agricultural Research Systems*:* in many countries, especially the less-developed, are considerably reduced from the levels of the early 1980s [Pardey, Roseboom and Anderson (1991)] and have stagnated in the institutions making up the Consultative Group on International Agricultural Research (CGIAR) [Anderson (1998)] as well as in many industrial countries, including the U.S. [Alston and Pardey (1996); Alston, Pardey and Smith (1997)]. Moreover, in many LDCs, research institutions have responded to reduced funding by seeking to maintain salaries, so that the brunt of the reduction in research resources has fallen on non-human components of the research enterprise. The result has been, inter alia, greatly reduced support for field investigatory work and failure to maintain libraries [Pardey, Roseboom and Beintema (1995); Purcell and Anderson (1997)]. The productivity of these research systems in developing new agriculturally relevant knowledge is thus bound to be degraded. And there are other problems of governance, management and incentives that compromise the productivity of research investments! These are taken up in didactic style in Section 5.

The threat to the capacity of the LDC agricultural research systems and the CGIAR institutions to expand the supply of knowledge resources may be made more critical by emerging trends in the kinds of knowledge that will be needed in the future. Those trends indicate growing need for attention to the environmental, or off-farm, consequences of agricultural production, e.g., losses of wild plants and animal habitat when farmers clear forests and drain wetlands to produce crops. Keeping the costs of these kinds of consequences within socially acceptable limits will require increased knowledge of institutional forms that provide farmers incentives to give these costs their proper weight in farm management decisions. This kind of knowledge is in short supply, and the existing agricultural research institutions are not well-placed to increase the supply on the necessary scale [Crosson and Anderson (1993)]. For several decades, those institutions, both in the LDCs and in the CGIAR, have focused on developing technologies and management practices that would increase on-farm productivity. The Green Revolution in wheat and rice production exemplifies and provides a measure of the great success of this research. Policies to assure farmers more profitable access to the component inputs of that revolutionary change in productivity, and to output markets, were an important part of this success. But these policies did not require increased knowledge of how market institutions work, only the political will to let them work.

In contrast, dealing with environmental consequences of agriculture presents problems precisely because of institutional failure arising from difficulties of establishing and enforcing property rights in environmental resources, e.g., plant and animal wildlife, or the quality of water in streams, lakes and reservoirs. The acknowledged skill of agricultural research institutions is not well-adapted to developing the kinds of knowledge needed to overcome this type of institutional failure. Hence, the emerging importance of dealing with the environmental consequences of agriculture would heighten the challenge to these institutions, even if their level of funding and their efficacy of operation were not under threat.

5. TOWARDS AKIS REFORM

Most of the above remarks have been addressed specifically to agricultural research in the LDCs. But there are other key elements of the knowledge system pertaining to agricultural development and, in the section, suggestions for reforming all these key elements—agricultural research, agricultural extension and agricultural higher education, the constituents of an ***agricultural knowledge and information system*** (AKIS)—are set out in normative style. They represent lessons drawn from recent reviews of World Bank of experiences in the sector [Purcell and Anderson (1997); Byerlee and Alex (1998)], as well as deliberative consensus emerging among a Working Group formed between the Bank and FAO.

Since the green revolution, a steady stream of impressive technological advances has resulted from investment in AKISs, including crop varieties with greatly increased resistance to pests and diseases and vastly improved tolerance of abiotic stresses (such as drought). These improvements have reduced poverty among rural people while providing affordable food for the urban poor and limiting environmental degradation. Further advances are expected—stemming, for example, from biotechnology and other areas of molecular biology, from techniques of integrated pest management, and form no-till soil management.

Advances in the agricultural sciences are clearly crucial, but other advances are also needed. Recent accumulations in human, social, and institutional capital have combined with important advances in the social and natural sciences to expand our potential for meeting the challenge. Three areas of progress are key: in the changing relationships between governments and people; in information and communication technologies; and in new concepts of learning and problem solving.

Relationships are changing between government and people. Worldwide, although surely not uniformly, political and institutional developments are fundamentally altering the relationships between government and people, and governance issues are high on many political agenda. With increasing economic liberalisation, governments increasingly no longer provide services that can be more effectively offered by the private sector or civil-society organisations. The public sector is now generally concentrating on creating a policy and regulatory environment that catalyses private-sector initiative, and on improving the quality of services that only the government can offer. Through democratisation and decentralisation, local authorities and a wider range of community members are gaining a stronger voice in setting priorities for government actions. These developments can contribute to the potential for farmers (particularly the poor) to have greater access to inputs and better options for marketing their outputs. They also provide greater opportunities for farmers and their communities to determine the nature of services offered to them by government.

Communications and information technology are rapidly advancing. New developments are making it possible to share information widely, quickly, and cheaply. Except in extremely remote areas, most rural communities have access not only to national radio, but also increasingly to local and regional educational radio stations. The increase in access to telephones has been spectacular in recent years, particularly in very poor countries. Consequently, verbal and visual forms of communication are ever easier to establish and exploit. In this sense, rural people are becoming much less isolated from each other and from access to sources of advice and information. Rapidly increasing numbers of education, research, and extension institutions have fax and the Internet, thereby expanding access for rural people, and those seeking to help them, to written and electronic forms of information and communication. Researchers, extensionists, and educators, through their own increased access to radio, telephone, fax, and the Internet, are progressively able to reduce their isolation from professional dialogue and developments.

These developments are providing everyone within the broad AKIS—rural people as well as those who seek to assist them—with a steadily growing capacity for gathering, sharing, and exploiting information available beyond their immediate communities and daily environs. At the same time, however, there is a growing risk of exclusion. Rural areas are less served than urban areas, and rural women and youth in particular have less access to new information and communication technologies. The risk of increasing "information poverty" among vulnerable groups is growing. New concepts are emerging for ***participation in learning and problem solving***. A range of participatory methods and tools has emerged to help rural people diagnose problems, gather information, explore options, and commit themselves to action. Education and training are no longer seen simply as processes of transferring knowledge or information, but rather as means to help people become critical thinkers and problem solvers who are better able to help themselves, but also better able to engage with others in order to learn, share information, and address problems and priorities.

Too many farmers, however, still fail to benefit from technological and other advances. In too many countries, the productivity and incomes of the poorer farmers have stagnated or even decreased. This can be traced to a number of causes, such as poorly functioning markets for inputs, products, or credit; it is not solely due to a lack of investment in education, research, or extension. But it does seem to be true in general that the existing AKIS institutions have not realised their full potential. The AKIS institutions have not been responsive enough in addressing the problems and opportunities facing farmers. This, together with related shortcomings in the existing AKIS institutions, has become increasingly clear in the light of advance described above. For example: farmers' needs do not sufficiently drive the orientation of research and extension, and labour-market requirements are not sufficiently translated into curriculum design. Some AKISs are therefore not as relevant to the rural poor as they might be. The know-how and technologies that are produced by AKISs, even when relevant, are not widely taken up by farmers, suggesting a lack of effective technology transfer.

Public research and extension have trouble ensuring their financial and economic sustainability. Public decision-makers are often unaware of the actual results achieved and the long-term resource allocations needed. Many public decision-makers are frustrated by the disappointing levels of coverage—of actual, face-to-face contacts between farmers and extensionists and researchers. However, the same decision-makers often constrain outreach programmes through budget cuts that further limit coverage. In many settings, the level of human capital in AKISs is low, suggesting that investments in human capital formation are inadequate and that the training and educational institutions themselves are unresponsive. A lack of systematic collaborative interface among researchers, extension staff, educators, and farmers has limited their effectiveness and relevance to the agricultural sector.

With the institutional and people-oriented advances described above, it is now becoming clear how AKISs might respond directly to these shortcomings. However, research, extension, and education institutions, particularly in the public sector, have been slow to exploit the potential of economic liberalisation, democratisation, and decentralisation. Market opportunities for added value, product diversification, and niche marketing, along with increased input availability, have hardly affected research and extension agendas; in addition, the social and economic sciences are still missing from many agricultural curricula. Very few extension and research institutes have been proactive in exploiting the advances in communications and information technology, for example by using them to establish links to each other, to the outside world, and to farmer organisations. Too many remain very top-down, with little room for meaningful participation by clients in guiding the direction of the programme. "Talk and chalk" remains the usual mode of teaching at institutes for agricultural education, while curricula lag behind the needs of the agricultural sector. Few agricultural education programmes have pioneered new, participatory concepts of learning and problem solving.

If AKISs stick to business as usual, support for them will be threatened. Although governments have continued allocating resources to support public agricultural research and extension programmes, many have been frustrated by the perceived failure of these programmes to alleviate the ongoing plight of poor farmers. Even if governments should indeed place priority on meeting the challenge of rural poverty, their confidence in research and extension programmes might understandably wane without clear evidence that these programmes are having a strong impact. Moreover, as public resources continue to flow and the associated opportunity costs mount, issues of accountability within these programmes will loom ever larger, ultimately threatening their support.

Building on the advances described above, AKISs can now be transformed. Despite past shortcomings, AKISs can help rural people improve their livelihoods, and it is becoming ever clearer how they can be designed to do so better. Today, through advances in agricultural technology, in rearranged public-private responsibilities, in information and communication technologies, and in concepts for participatory learning, AKISs can help the rural poor to benefit more than ever from agricultural research, extension, and education programmes. The following offers a strategic vision for what might be accomplished through AKISs, together with principles and guidelines for realising the vision.

In an ideal world, well-informed farmers would make sound decisions on their farms, well-designed AKISs would help farmers build their decision-making capacity, and key players would each play an important role in AKIS programmes. Specifically, farmers of all types would have the capacity—in terms of knowledge, skills, attitudes, information, and technologies—to run their farming businesses productively, profitably, and sustainably. An AKIS would function to (i) generate new technology; (ii) transfer technology to and from farmers, researchers, and educators; (iii) mobilise and organise rural people; and (iv) educate farmers, researchers, and extensionists. Within an AKIS, the public sector, the private sector, and civil society would each play important roles in the design, implementation, funding, and evaluation of programmes, with roles context specific and boundaries between the players changing over time.

A concensus is emerging on how to design an evolving AKIS to yield more satisfactory results. An AKIS that realises its aims is a system that identifies opportunities and constraints faced by male and female farmers and herders and their communities, engaging scientific methods to generate appropriate and sustainable economic and technological responses; helps farmers marshal technologies and knowledge to augment their productivity, manage their natural resources sustainably, raise their incomes, collaborate effectively with one another in addressing their common problems, and become meaningfully involved with all major stakeholders in determining the process of further technology generation and adoption; enables governments to carry out activities for the public good—e.g., ensuring food safety, conserving the environment, reducing poverty, and promoting private research, education, and extension; and provides education and ongoing training opportunities for researchers, extensionists, educators, and farmers alike, allowing them to work together effectively in the process of technology generation and adoption.

A results orientation is vital for a sustainable AKIS. The pursuit of the vision for an AKIS that achieves its aims requires a strategic emphasis on making the whole of the AKIS—including the farming communities, research, extension, and education—financially, socially, and technically sustainable (for instance, agriculture must be profitable, technologies must be productive, and production systems must be sustainable); improving the relevance as well as the effectiveness of the processes of technology generation, transfer, and uptake; heightening relevance and effectiveness through more demand-driven AKIS programmes that empower rural people to play an expanded role in managing the AKIS programmes that serve them while making AKIS programmes more responsive to the needs of their clients; maximising the interface and integration among the various research, extension, and education activities; and building accountability in AKIS programmes so that deviations from intended services and outcomes are identified and appropriate responses undertaken.

To achieve their aims, ***some guiding principles*** are relevant. AKIS programmes must become sustainable, relevant, effective, responsive, and accountable. The key is to incorporate advances in agricultural science, in the changing relationships between governments and people, in information and communication technologies, and in new concepts of learning and problem solving. To do so will require securing and maintaining public-sector support for agricultural research, extension, and education programmes that are grounded, more rigorously than in the past, upon a commitment to these guiding principles. Incentives and institutional structures within AKISs encourage and ensure ***cooperative integration*** among farmers, extensionists, researchers, and educators. Institutions are tailored to create a system that effectively delivers agricultural information. Within AKIS programmes, authority and responsibility are distributed among ***empowered stakeholders*** in a pattern commensurate with their role in the system. In particular, farmers play a central role in determining AKIS priorities and activities. AKIS programmes are held accountable for their performance. Actors within the system are ***motivated by incentives*** to produce the practical results desired. AKIS programmes are ***financially manageable*** and tailored to a scale commensurate with expected outcomes that justify their costs, thus contributing to sustainability.

AKIS programmes will be based on the guiding principles outlined above. Programmes in agricultural research, extension, and education that incorporate sound guiding principles will begin to achieve AKIS objectives—poverty reduction, agricultural productivity gains, food security, and environmental sustainability. Such programmes will display the following characteristics:

Economic Justification: The benefits of AKIS programmes are shown to be commensurate with costs, and programmes are tailored to a scale that is commensurate with, and justified by, expected outcomes.

Public-sector Focus on Core Functions: The rationale for the public-sector's involvement in AKIS programmes is clearly stated and accords with the concepts of efficient production of valuable public goods.

Decentralised Authority and Responsibility: Operational authority and responsibilities for AKIS programmes are allocated among central governments, local governments, and communities of beneficiaries. The allocation is based on the principle of subsidiarity, whereby decision-making with respect to public-sector service delivery devolves to the lowest possible level of government consistent with efficient use of funds. Resources, including funds, are assigned to each level based on its allocated responsibilities.

Cost Sharing: The main stakeholders in AKIS programmes share the burden of funding AKIS activities. The central government assumes a share of the cost burden, covering the cost of public goods. Increasingly, however, local governments and the beneficiaries themselves (farmers and agribusinesses) also shoulder part of the burden.

Separation of Public Funding from Public Delivery: Even though central and local governments help fund AKIS programmes, they do not necessarily directly deliver programme services. Some AKIS services and products are contracted to outside providers. Outsourcing of AKIS services not only broadens the scope of service providers, but also makes AKIS programmes more operationally efficient and AKIS workers more accountable for their performance and results.

Effective Linkages among Farmers, Researchers, Extensionists, Educators, and other AKIS Stakeholders: AKIS programmes and institutions are explicitly designed to create synergies and collaboration among stakeholders in all three AKIS areas (research, extension, and education). Farmers and their partners in each AKIS programme area are provided with resources and/or the authority to purchase and/or influence the services provided in each of the other programme areas.

Incentives for Building Human Resources: AKIS programmes incorporate resources and incentives for training and retaining a new generation of staff capable of empowering their rural clients to fully exploit the latest advances in agricultural technology, in rearranged public-private responsibilities, in new information and communication technologies, and in concepts for participatory learning and problem solving.

Sound Monitoring and Evaluation: AKIS programmes have rigorous systems for monitoring progress toward achieving goals and for evaluating outcomes. Monitoring and evaluation are based not only on economic criteria for calculating cost-effectiveness, but also on human-resource, institutional, and environmental criteria to ensure comprehensive impact accounting.

6. CONCLUSION

From the perspectives sketched above, the principal threat of resource degradation to achievement of sustainable agricultural systems in the LDCs is not the threat to their natural resources but degradation of their capacity, and even that of the CGIAR institutions, to develop the quantities and kinds of knowledge that will permit them to respond adequately to future demands for food. It follows that, in thinking about policies to deal with resource degradation in the agriculture of the LDCs, top priority should go to building defences against the threat to knowledge resources and institutions. Needless to say, as development economists, we have a key role to play in this process not only through attending to the sustenance of our disciplinary knowledge base, but to raising the broader sectoral "knowledge defence" issue as an important element of policy-making for agriculture at local, national, regional and international levels. We must remain alert to the governance and design issues that, if not well handled, may compromise the value of our investment in public AKIS institutions. The new century must see agricultural services provided to rural communities at their empowered behest in accountable, efficient and socially productive ways. Definitely easier said than done, but do it we must.

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Comments

Jock Anderson has made very valuable suggestions to consider for the improvement of agriculture and rural development. He has informed us of the global food situation likely to develop in the next 30 to 40 years. According to him, the situation is going to be rather bleak; while population is growing fast, production will not be growing at the same rate, and there will be problems by 2030. He has mentioned a number of factors that would be responsible for this. However, I shall try to discuss things in relation to Pakistan because the overall global situation might not be quite relevant to us. He has mentioned that land would be the limiting factor. But I do not think so, so for as Pakistan is concerned. At the moment, about nine million hectares of land is cultivable waste, lying uncultivated because of the unavailability of water. We have about one hundred and forty million acres-feet of water that flows from the rivers. And if we add the precipitation that occurs during the year in the Indus basin, which varies from 25 million acres-feet to 40 million acres-feet, we have a total supply, roughly, of 165 to 180 million acres-feet of water. Out of this, at the moment, roughly 105 million acres-feet are being utilised. Even if we can tap one-fifth of what flows into the sea, I think we shall not have the water shortage to the extent that is envisaged by many who do not have the correct information available to them. This would help to bring more area under cultivation and help improve the intensity of cropping. Dr Anderson has also warned us about the degradation of land and erosion of nutrients from the soil, which means that the fertility of the soil is going down because the crops are using much more of nutrients than what is going back into the soil. This has a reflection on the yield per acre; in fact, this is the main reason that the crop yield is not improving at the rate envisaged, even with the use of fertiliser and other inputs. Hot climatic with low rainfall induces aridity in the soil, and unless there is sufficient organic matter in the soil, the farmer does not get proper yield. Therefore, the question is of improving the fertility of the soil by putting more human-secretion or organic matter into it. This is another side to the degradation of the soil. The problem has become even more acute with the mechanisation of agriculture. Previously we had bullocks, almost roughly one pair of bullocks for about 12 acres of land. Now with mechanisations, the bullocks have almost vanished. The farm that used the manure and other associated matter going into the soil and making it fertile is no longer there. As for water, if canal water is used continuously over a certain period of time, the injurious salts in the soil increase. Unless we have a remedy to counteract the adverse effect these salts, the soil cannot produce the same level of yield, as it would have done without these.

If we look at the *barani* areas, the general thinking is that they are not giving us as good results as they should. But I think the *barani* areas have great potential to develop agriculture. What is needed is to tap the rainwater and to conserve the soil. These factors, amongst others, can help in increasing productivity and production. In the rainfed areas, there are possibilities to bring more area under cultivation if water is properly conserved and used. Construction of small dams will be useful in promoting cultivation of crops in such areas. So, from the point of view of land as well as water in the case of Pakistan, there could be horizontal as well as vertical increases in agricultural production. But I would agree with Dr Anderson that there should be more emphasis on improving the yield per hectare, which can be done by various means, e.g., by the use of balanced fertilisers and by the use of pesticides, land management, judicious use of water, and so on. The other three things which he has discussed are agriculture research, agriculture extension, and agriculture education. It has been alleged, even today, that there is a lack of coordination among these three areas. We have done a number of experiments in this country. Originally, agriculture research, extension, and education used to be under one head. Then idea came that education should be taken away, and that only research and extension should be done under the Agriculture Department. Agriculture universities were created, which were put under the Ministry of Education, but this did not work in some provinces. But, for the last .five or six years, agriculture research in the NWFP has been taken away from the Agriculture Department and has been passed on to the Agriculture University of Peshawar, a university with the Education Department. So the Agriculture Department is now left only with the extension work. Research and education are the responsibility of the university, under the Education Ministry, in the Frontier province (NWFP). The reports that we have received say that these arrangements are not working properly. There is jealousy among the Departments; whatever is produced as a result of research is hardly accepted by the Extension. Unless the extension people give their feedback to the researchers as to what the farmer's problems are in the field, the research cannot properly meet the needs of the farming community. There is another way of looking at things that we are trying. Earlier, we had the Village Aid Programme, Le., Village Agriculture Industrial Development Programme, which started in 1953 and was aided by the USAID. The USAID was withdrawn in 1959-60 and the Village Aid Programme was abolished. Then, we had the Integrated Rural Development Programmes, which we tried here and there-these did not work and had to be almost abandoned. Then we had what was called the T&V Programme (Travel and Visit Programme), and the feeling is that it has also not helped much in increasing the productivity of the farmers. We have the extension workers at the field level, called field assistants, one almost in each union [council area]. These field assistants are in direct contact with the farmers and are supposed to know their problems. The field assistant is appointed in the Basic Pay Scale of 5 or 6 and remains in that pay scale until his retirement or his death. He does not have any transport facility nor a place to live. So, he is willing to work for any *Jagirdar* or big landlord or someone else who could offer him a place to stay. But there are few field assistants who are really reaching out to the villagers and helping them in their work. I must say that field assistants are not provided any refresher courses to update their knowledge either. Without updating their knowledge they cannot face the farmers who know the practical problems better than the field assistants, who are not in touch with what is happening on the research side. This is another problem which I think must be looked at, and it can help the farmers improve their productivity. On the research side, our scientists have done a good job. They have discovered new varieties, which are high-yielding, disease-resistant, and can help farmers in getting more income. If farmers get a recommendation from the research workers that a given technique or a suggestion can bring higher returns to them, they will readily adopt it. Going back to the era when the Mexican wheat varieties were introduced, in Pakistan, which gave two to three times more yield per acre than the conventional ones, and the farmers saw that these varieties were giving a spectacularly high yield, within 3 to 5 years 70 to 80 percent of the area was sown with these Mexican varieties. In a country like England, a new variety of potatoes, evolved there, took 7 to 8 years to be sown in 70 percent of the area. In our country, if farmers get some varieties which give better returns than the original ones or are resistant to the diseases associated with conventional varieties, they certainly would go for the new ones. Take the case of CLCV (Cotton Leafs Curl Virus), which after 1991-92 has badly affected the cotton crop. Our scientists were given all facilities, financially and otherwise, to evolve new varieties which were tolerant of or resistant to this virus. They come out with varieties resistant to the virus. And the people are yearning to buy seeds of those varieties. Now, the question of reducing poverty in the rural areas. No matter how much or how good the crop produced. It is not good enough unless it is marketed properly and the farmers get a good price for it. No one can force them to grow the same crop the next year if they don't want to do so. You must have read in the newspapers about the cotton crisis. The farmers grew cotton because the prices were high enough last year to bring them better returns; and the crop production this year was higher than the last year. But this year, the prices in the international market have fallen considerably, and the farmers would not be getting the prices which could cover their cost of production. So, next year, they will not be that enthusiastic to grow cotton, with the result that the area and production might go down. We are getting into the cob-web theorem. Similar things have happened in the case of potato, onion, and basmati rice. The government has followed a policy of support price in order to safeguard the interest of the farmers. But during the past few years, this policy has not been implemented in letter or spirit. My whole submission is that if the government announces the support price of any commodity, it must see that it is implemented and the farmers do not suffer. Today I tell You the cotton farmers would suffer so much that they would not have the money next year to buy inputs. They would not even have any liquidity for the purchase of their household essentials, which in turn would adversely affect the industrial sector also. Now, unless sufficient and adequate investment is made in the agriculture sector in the future, everything spoken here would be a waste. There is a need for better saving, at the national level and at the individual level. There should be effective programmes for the alleviation of poverty, and more foreign exchange earnings. This will happen only when we strengthen the agriculture sector. At the end, I must say that marketing is one of the most important factors which can help in this respect.

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