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Ch. 29. Agricultural Research Strategy for More Enduring Productivity in Fragile Areas – Jock R. Anderson and N.S. Jodha.

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Chapter 29

Agricultural Research Strategy for More Enduring Productivity in Fragile Areas

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The negative trends in the state of the natural resources used for agricultural purposes, particularly forests, rangelands and cultivated soils, are all too apparent, especially in "fragile" areas of the world. Many of the agricultural systems in these areas appear to be inherently unsustainable in their recent patterns of resource use. This topic is elaborated in the following section and then a brief review is made of approaches and strategies that have been taken to resource use and management in the past. Approaches that could be taken to deal more adequately with research opportunities in these areas are then considered and the virtue of greater understanding of the mechanisms used by traditional resource custodians is emphasized. A research strategy that might usefully be adopted may require an explicit equity rationale—or at least an augmented efficiency rationale—to warrant a high place on the agenda of both concerned national agencies and relevant international organizations. These matters are taken up in the concluding sections of this chapter. Whatever may drive such an agenda, the position taken here in outlining more appropriate stances on the better functioning of research is that research per se, that is, the systematic assembly of new technological and socioeconomic information relevant to these areas, will be just one small albeit important element of the main strategies for more responsible and more enduring exploitation of these areas for their most effective contribution to human welfare.

29.1 CONTEMPORARY FEATURES OF AGRICULTURE IN SOME FRAGILE AREAS

Sustainability, broadly interpreted here as a system's ability to maintain (or, as necessary, to enhance) performance (in terms of output of goods and services) without compromising its long-term potential and its ecological integrity, is no longer a matter of debate but rather is an urgent practical issue, at least in the context of fragile resource zones that, by definition, are readily degraded through human intervention. In terms of potential productivity and resource-usage opportunities, these regions are showing persistent declines according to several key

indicators. Indicators of emerging unsustainability imply reduced prospects per individual human being for present (and future) generations, compared to those of the past. Intergenerational inequity is hence a reality rather than a probability for residents of those zones. The particular fragile zones on which we concentrate our attention are mountain areas and dry tropical areas (initially in the following two paragraphs, respectively, by way of introduction), reflecting our own first-hand experiences; but there are other zones too (e.g., coastal wetlands and tundras) for which similar generalizations surely apply (Smith 1990) and also other agricultural ecologies that are not usually regarded as being particularly fragile (e.g., Chapter 21).

In the more detailed documentation of the indicators from which these summary remarks are drawn, Jodha (1991a, Table 4) cross-tabulated the indicators according first to the degree of visibility of change—from directly visible, through those that are concealed by contemporary responses to change, to less certain but potential effects associated with "development" initiatives—and second, to what the change most strongly relates—namely, the natural resource base, production per se or management practices. For brevity here, we note that some of the major indicators in mountain areas include: (a) increased landslides, gully erosion, terrace abandonment, botanical diversity loss in pastures and forests, (b) substitution of cattle by sheep and goats and of deep-rooted crops by shallow-rooted ones, (c) persistent negative trends in partial productivity measures of most agricultural enterprises, (d) increased distance and time involved in gathering fodder and fuelwood, (e) increased seasonal migration and (f) reduced fallowing, intercropping and crop diversification.

These negative changes are more easily felt and observed than they are quantified and documented. The evidence assembled, for example, through the ongoing studies of ICIMOD focusing on the dynamics of natural resource status in selected areas (i.e., on "unsustainability indicators" for critical areas) in parts of Nepal, India and China indicate that, even over a period of three to five decades, the situation seems to have worsened. This is manifested by: (a) a reduced range and quality of production (and consumption) options, covering items of food, fodder, fuel, roofing material, composting material and water supply, (b) an increased degree of desperation reflected through inappropriate and over-extractive landuse practices, inappropriate choice of crops and resource-use practices, land abandonment and migration, (c) reduced levels of flexibility and degree of regeneration in the system, as indicated by reduced size of gene pools (for crop varieties and other sources of biomass) and reduced scope for land fallowing (Jodha 1992).

For instance, in the case of two studied catchments (and their villages) in Nepal, the evidence collected through field studies involving use of oral history and available (albeit limited) records, including old photographs and indirect evidence, revealed the following: Annual occurrence of landslides has increased from around 3 in 1951 to 19 and 31, respectively, in the two catchments in 1991. The corresponding extent of areas affected by landslides also increased proportionately. The proportion of such landslides is significantly higher cropped land than in pasture and forest lands.

The loss of cropland due to riverbank cutting has been of the order of 25 to 60 percent of the river flats in different villages. Vegetative cover in the grazing lands has been reduced by 20 to 35 percent in different villages; the number of fodder trees in community lands (CPRs) has declined by over 60 percent; the total number of types (varieties or species) of grasses, shrubs and even field crops (representing biodiversity) has declined by 20 to 70 percent. Some 40 to 60 percent of the previously food self-sufficient households in these studied Nepalese villages are now unable to produce enough food for the year. Seasonal migration (both in terms of frequency and duration) has increased in most of the villages. Crop yields (paddy, wheat, maize and millet) show a mixed picture in terms of decline or growth. However, animal productivity in terms of milk, wool, meat, manure and animal health (body weight) shows a decline ranging between 20 and 50 percent for the different categories of animals. Calving interval and age of first calving have also increased in response to insufficient supplies of nutritive fodder for the numbers being fed.

People's resort to inferior options, inevitably a sign of emerging problems, is indicated by more than a 100-percent increase in use of crop by-products as fuel (instead of fodder) and increasing use of traditionally discarded plants (e.g., *Eupatorium* spp.) as fuel material, cropping on steep slopes (i.e., above 30°), increased depth of annual cutting of the walls of terraces, permitting degradation of crop and grazing lands as indicated by increased presence of pine trees, *Eupatorium* spp. and *Lantana* (all "land-spoiling" species that contribute to increasing soil acidity). Practically the same situation is indicated by the data from catchments in the Uttar Pradesh Hills in India. In several pockets of Himarchal Pradesh (India), often considered a success story of mountain-area development, a number of the aforementioned negative changes were also identified. The data from areas in Tibet and West Sichuan in China also indicate the emergence of such negative prospects in those parts of the Himalayas.

For the dry tropical areas (Jodha 1991a, Table 1b), a similarly illustrative shortlisting of a much longer catalog of "unsustainability indicators" can serve to make the point that, while different in several respects from the typical situation of mountain areas, much of the dry tropics features analogous changes. Of the various forms of resource degradation at work, sheet water erosion, wind erosion and shifting sands are readily visible in some areas, while lowered water tables and ground-water salinization are slightly less obvious. Growing prevalence of inferior annuals and thorny and woody shrubs requires intertemporal observation to detect and to quantify, but affected farmers are certainly aware of the reduced availability of useful biomass, the declining productivity of their crops, the increasing severity of droughts with which they must deal and the decline in the common resources to which they have access.

More concrete data from arid and semi-arid parts of India have revealed several symptoms of a deteriorating situation. These include: (a) lowering of the watertable (the depth increased from 50 m in the early 1950s to over 100 m in the late 1980s), (b) discontinuation of cultivation of groundnut and sorghum in sandy-loam soils traditionally devoted to these crops, largely because of the decline in fertility, (c) reduced fallow periods for fertility replenishment (from 5 to 1 year, over less than 50 years), (d) reduced extent of crop rotation and cropping diversity, (e) use of inferior products, such as pearl millet husks for fodder and sesame stalks for fuel, (f) reduced supplies of biomass for fodder, (g) reduced resilience and self-help during droughts, as indicated by the absence of various adjustment devices during the drought of 1987 as compared to those of 1965-67, in parts of Rajasthan and Gujarat, (h) almost complete elimination of *Zizyphus numularia* (ber bush) from crop fields, which earlier served as a form of drought-period insurance for providing fodder and fuel at such times, and (i) increased dependence on public relief during droughts.

People familiar with these fragile areas (e.g., Dixon, James and Sherman 1989, esp. chs. 2, 3) know also that they are characterized by great diversity[1]—mountains more so than dry tropics—and thus bold generalizations such as the above can only be just that. Particular niches, favored by climate, edaphic or other location-specific bequests, are seemingly just as sustainable in agricultural production as some of the world's finest producing areas although, for reasons of accessibility, may be of limited use in contributing to the gains in productivity that, in principle, might reduce the pressures on the more marginal elements of those zones.

There is no shortage of material dealing with definitional points concerning "sustainability." The questions raised by these points are also ample in number and difficulty and are seemingly something of a growth industry as increasing resources are devoted to such concerns (Allen and Van Dusen 1990). Such issues cannot be effectively addressed in isolation from the wider socioeconomic environment in which they are embedded (Graham-Tomasi 1991). Notwithstanding the difficulties of such work, the immediate challenge in the areas under question is to reverse the trends and thereby move to restoring an enduring and productive agriculture. There is a clear albeit possibly small role in this for agricultural (and natural resource) R&D as one of the initiatives that possibly may help to redress the situation—a role taken up in Sections 29.4 and 29.5. Given the conjunction of the human aspects of the occupancy of these areas and the resource economics of these situations, the contribution of social science research in this work will be considerable. The biophysical resource base has some primacy in determining the limits to progress (Pezzey 1989) and thus makes fragile resource areas a prime candidate for emerging problems of unsustainability because it is in these areas that resource and environmental limitations tend first to become operative.

29.2 POPULATION DISPOSITIONS AND LINKAGES WITH FRAGILE AREAS

Policy analysts must stand well back from the immediate areas, however, to see the wider picture. Because of strong biophysical (including hydrological) and economic linkages, these fragile areas act as hinterlands for the more robust agricultural areas for various visible and invisible supplies of productive factors and thus also for overall sustainable resource management. For instance, the largely inorganic fertilizer-based Green Revolution areas of the Punjab and Haryana in India will suffer if the traditional organic input is not available after the wheat harvest through the once regularly migrating sheep and goats from the Rajasthan desert; reduced supplies of animal products (milk, meat, hide) will adversely affect urban centres if the livestock-based mixed farming collapses in dry areas; the crisis in pulses and oilseeds in countries such as India is also a direct impact of low research-resource allocation to these crops, whose natural habitats (and their comparative advantage) are the drylands.

In the case of mountains, such links are even more significant—as the mountains are net donors of commercial resources (water, electricity, timber, tourism services)—to the neighboring plains. The consequences of degradation of mountain ecosystems for lower neighbors are

[1] Chambers, Pacey and Thrupp (1989) coined the compact qualifier "CDR" (for "complex, diverse and risk-prone") as a convenient term in this regard.

profound (e.g., silting of dams that sustain prime-land agriculture).

Many of the above instances from India may be found in other countries and continents where fragile and non-fragile areas coexist. Once viewed in the above "interdependency framework," the importance of fragile areas becomes rather greater than would be suggested merely by their geographical area (which, at any rate, is not insignificant). With their perhaps wrongly perceived potential, they are marginalized through the application of assessment yardsticks evolved in a prime-land context, with inadequate understanding of their fragility and human carrying capacity.

The present distribution of populations in the fragile ecosystems of the world, particularly the less-developed world, can easily be called into question. Despite health-care facilities that in most cases could only be described as poor, the revolution in the control of several major diseases that not so long ago caused high rates of mortality has led to rapid population growth. Some 118 million people lived in the Himalayas (Hindukush Himalayan region covering mountain/hill parts of India, China, Pakistan, Nepal, Bhutan, Afghanistan, Myanmar (Burma) and Bangladesh (Chittagong Hill tracts) in 1991 (Sharma 1992) with average population density of 35 persons/km^2. The highest was in Nepal with 126 persons/km^2, followed by the Indian Himalayas (73), Bangladesh (Chittagong Hills tracts: 57) and Pakistan (56). China (Tibet and parts of West Sichuan and Yunan) had the lowest density of 12 persons/km^2. During the latter part of the 19th century and early 20th century, population growth rate was low. However, since the 1950s, there has been rapid growth in population and during the 1970s, it was higher than in the preceding two decades with annual percentage growth rates of 2.60 in India, 2.66 in Nepal, 3.12 in Pakistan, 5.64 in the Chittagong Hill tracts, 1.60 in Bhutan and 1.5 in China. The implication of these magnitudes for mountain/hill agriculture can be understood by the fact that more than 70 percent of the labor force in most of these areas directly depends on agriculture. The per capita cultivated land in these countries, except Bhutan (with 1.04 ha), is around 0.1 ha. With little scope for area expansion, the only agriculturally-based possibility—and it is just that—of sustaining agricultural populations of these magnitudes is the development and implementation of agricultural technologies that can improve productivity while protecting and enhancing the resources. Non-agricultural developments, including emigration to urban areas together with the fostering of non-agricultural industries, must play their role but, presently perceived, the realistic options are highly circumscribed.

For dry tropical regions, such focused assessment of the situation is not so readily available. The population of the dry tropics of India and Africa, for instance, is rising rapidly. Even within a single state, such as Rajasthan, the growth rate of population in the arid west is higher than in the climatically better-endowed areas. Such population burdens, in turn, have not permitted the institutional and technological coping adjustments such as were made in the past and, for various reasons, the traditional mechanisms that had been used are no longer effective. It is also contended that, through the disregard of their complementarities with prime lands, these areas have also been largely bypassed by public interventions, including agricultural R&D. Efforts have too often been made to impose options evolved for prime lands rather than to evolve new ones more in keeping with the resource endowments of these areas.

The state policies in various countries have usually been guided by (a) extraction from niches in fragile areas for the mainstream economy, (b) intensification of resource use with disregard for vulnerability to permanent degradation and (c) substitution of what was appropriate for these areas by what has evolved for prime areas. The generalizations about policy apply also to the case of R&D (Jodha 1991b). In some cases, particularly in semi-arid landscapes, it seems that most of the people who remain are effectively trapped in such environments, lacking the physical or human capital accumulations to be able to relocate in more favored areas. In other fragile landscapes, such as steep lands near mountains, there may be other attractive forces that contribute to the present population densities in such regions. The reduced scope (occasioned by political boundaries and more effective government ordinances) for outmigration from steep slopes in critical watersheds has, for instance, sparked Forster's (1992) concern for land policies that draw peasants away from such areas.

Whatever may be the forces that underpin such present population distributions and the circumstances leading to further population buildup (Jodha 1991b, Sharma 1992, Metz 1991), the consequences for future pressure on the land resource in such areas are clear as population growth continues unabated. Thus it is relevant in a quest for better policy to include a search for an agricultural research strategy that may either assist in the rehabilitation of lands already damaged or contribute to the potential reversibility of the declines inevitable through continuance of recent land-use practices.

Considerable substitution of the land resource by other factors of production such as irrigation and fertilizer has taken place in more-favored agricultural areas, but in many fragile areas the technological possibilities that are economical through such means are extremely limited. Indeed, as Jodha (1991a, p. A19, 1991b) has set out in one of his typical tabular schemes, there is a preponderance of extremely limited possibilities for achieving more sustainable systems unless resource-use practices and technologies are focused on diversification and regenerative processes. The confining specificities include (a) inaccessibility (especially in mountain areas), (b) the already-mentioned fragility and the thus closely consequential (c) marginality of these areas as agricultural producers, (d) the mentioned diversity of constraints within zonal areas and (e) the growing inadequacy of traditional mechanisms, such as folk agronomy, ethno-engineering, collective security and self-provisioning.

Accordingly, it is necessary to look to science-based innovations that may be able to ease the pain of exploring intensification options that do not lead to further resource degradation. One guiding consideration in looking for more sustainable systems should be not to confine the search to the primary production sector but rather to involve also the sectors concerned with processing, manufacturing and providing services, in order to harness the niches of the fragile area and their complementarities to prime-land areas (Jodha 1992). Before turning to such a search, it may be useful to reflect on past experiences, as is done in the next section.

29.3 PAST APPROACHES AND STRATEGIES

The most pervasive historical trend in evidence in fragile areas has been a process of intensification of land use, usually aided and abetted by public intervention (Jodha et al. 1992). The motivations for this are clear. Increasing population pressure has obliged the managers of traditional farming systems to endeavor to intensify in order to supply the needed flow of agricultural produce. This has led to increased cropping and livestock-raising intensities and usually to an increase in input use, including both labor inputs and purchased items. The model for all this has been the successful intensification that has characterized more-favored areas in recent decades. The unstated presumption has been that, notwithstanding the greater "buffering capacity" of favored areas, such methods can be applied in more-fragile regions without necessarily incurring irreversible damage to the resources, particularly the land resource.

Traditional measures for coping with increasing intensity of land use and related agronomic practices have evolved through largely informal experimentation by many generations of farmers. This had the consequence that the practices were well adapted to the local resource situation, at least under past population pressures. Social organizations at the local level have provided sanctions against practices that have been known to be harmful and the generally lower levels of population, eased by matching emigration rates, have all contributed to a level of resource-use intensity that has been conducive to sustaining productivity under the low demand for land services. The problem with these traditional strategies is that their applicability under much higher populations is questionable indeed, and the consequences for the state of the resources may be profoundly negative.

The scope for traditional farming systems to deal with increasing pressures on resources has been limited. It has worked in part because of the high degree of diversification and the interlinking of many activities. Such diversification has effectively spread the exploitation of the resources more evenly over time and space and thus facilitated local resource regeneration largely by using nature's own mechanisms. In the process it has made agricultural performance more enduring (and more durable) than would have been the case with less benign practices (Jodha 1991b, 1991c). The intergenerationally refined practices used were demonstrably resilient under such low population pressures. While many natural resources were left in pristine condition, diversity of the ecosystems remained high and renewability, as such, was not an issue. The march of conventional development interventions has encountered difficulties on most of these scores. More intensive land use has led to growing problems of waterlogging and salinization, physical erosion of soil and mining of soil components that contribute to productivity, such as organic matter and available macro- and micronutrients, particularly phosphorus and potassium. The agronomic responses arrived at through conventional interventions may be clear in principle, such as increasing the use of purchased inputs from the petrochemical and mineral extraction industries but, depending on the social infrastructure in place, may not be economically feasible for most of the resource-poor operators of small farms. The real landed cost of inorganic nutrients in either hill or desert areas is typically much higher than that confronted by farm operators in more favored zones that are better served by road and rail systems.

29.4 FRESH APPROACHES TO RESOURCE-ORIENTED R&D

More broadly-based approaches to agricultural R&D in recent times have expanded the scope of agricultural investigations, at least into looking at perennial shrub and tree species, for instance, through interventions variously labeled as agroforestry and socioforestry (e.g., SPWD 1990) and, most recently, through incorporating forestry as a major theme within the CGIAR. There has also been increased attention to indigenous knowledge systems to identify elements for incorporation into formal R&D-based technologies and to the need for integrating diversified land-based

activities in a watershed context.

What separates the early-emphasized conventional science-based approaches from what we think may now be needed is, unfortunately, not particularly precise. Although it covers a multitude of sins, it seems that more of a "systems" approach to planning technological interventions must be taken. In casting the technological net wider than has traditionally been the case, it will be necessary to take a sweep of biological materials that is wider than either what was traditionally grown or what has recently been conventionally and commercially grown. This will mean, amongst other things, an examination of ratoonable perennial species of shrubs and trees that may yet be of little commercial importance. Choosing species that have yet undeveloped commercial prospects, involving such products as medicinal-base chemicals and materials that may be of value in the cosmetics industry (e.g., seabuck thorn in cold dry mountain areas, tea-tree oil harvest from wetlands, jojoba from semi-arid areas), for example, is a risky and rather long-term business but probably has much to offer. Such a development strategy brings into play trade policy. Witness the demise of the gowar crop-growing industry in Rajasthan because of substitution for its use in the textile industry by high-tech chemical-industry products from abroad, as an example of trade-induced technological negativism for agriculture. Removal of several medicinal plants/herbs from mountain areas and their propagation under protected agricultural facilities (often near urban centers) thus constitutes "stealing" the niche from marginal areas and people—but such are the local "costs" of many forms of human progress!

Science, however, surely has much to offer that is positive for fragile areas but it needs a sustained level of investment to provide the intellectual and material store from which successful elements of technological progress can be drawn. The global investment in such peripheral activities that are of direct relevance to the fragile areas has been minuscule—no matter how it is measured—relative to the aggregates applicable to more-favored areas or relative to the levels of production that emerge from the different agroecologies. The success of contemporary R&D work in addressing these more challenging issues has also been less than encouraging. The considerable investment in farming systems research activities, in whatever the ecology, has been patchy at best, particularly with due regard to the high costs that have been incurred in implementing such work (Anderson 1991).

Amongst the challenges that face future investigators striving for research findings of relevance to the fragile areas must be a deliberate search for greater resilience in the farming practices that are examined and tested. This, in itself, creates new tensions for the investigative process as it takes time to test novel activities under diverse climatic experiences and it is costly to test them under diverse spatial and agroecological circumstances (Chapter 18). It is hypothesized that the intensity of niche differentiation is typically higher in some of the most fragile systems, such as hill farming systems, than is generally the case. This, in turn, implies a greater degree of locational specificity than would be confronted in the typically more favored and more uniform environments. All this means that the costs of R&D are likely to be greater than has typically been the case and that investors, if they are serious about producing results of real worth to these increasingly pressed populations, need to be bold, caring and patient in their commitment of scarce research resources to the task. It also means, as Farrington and Mathema (1991) argue at length, that novel forms of effective involvement of farmers themselves in the R&D processes must be found (Chambers, Pacey and Thrupp 1989).

Systems views of the threatened farming systems need to be wide also in geographic scope so that interrelationships between exploiters of different niches can be capitalized upon to add to the overall sustainability of more-widely defined systems. Whilst at a very local level, under existing and prospective populations, an element of a system may be clearly unsustainable, taken in conjunction with other niches the opportunities for exploiting both complementarity of activities and comparative advantages of the different elements may lead to stronger opportunities and better prospects for a sustainable agriculture. Any niche-based comparative advantage depends closely on intersystem linkages such as trade. Intersystem linkages, in turn, call for particular attention to secondary (processing) and tertiary (service) sector activities that are linked to the primary production sector of fragile areas. Hence, enhancement strategies for more sustainable use of fragile areas must be addressed to all three sectors rather than to a blinkered focus on the primary sector.

The implications for R&D for fragile areas thus mean not only identification and harnessing of niches (in a production sense) but also the development of agroprocessing technologies and improved product marketing. Chinese experience in agroprocessing involving both conventionally grown and less-well-known plant genetic resources demonstrates such possibilities, where subsistence-oriented cottage industries are converted to modern export-oriented small-scale, rural-based enterprises (Liu Zhaoguang and Wu Ning 1992). The most impressive example of this approach is the harnessing of seabuckthorn, a shrub/tree species found in the trans-Himalayan area. In countries such as India, Nepal and Pakistan, this species from the cold desert is used only for fuel and fencing. Chinese R&D and other interventions not only used this nitrogen-fixing, soil-binding tree for stabilizing fragile mountain slopes, but developed processing facilities for producing more than a dozen commercial products, including fruit juices, powder, wines, cosmetics and medicinal items (Rongen 1992).

29.5 DISCUSSION OF R&D OPTIONS

Whether or not contemporary agricultural R&D can really deliver the requisite novelty and resilience-building products to underpin continued technological performance of fragile but precious resources remains to be seen. One thing is certain: it will not happen unless it is well resourced itself and any such new commitment of research endeavor will represent a significant departure from past allocations. The justification for such a commitment hinges in the prospective growth of dependent populations and the realistically achievable rates of emigration from such fragile areas. Even with such investment in R&D and the associated infrastructural elements that will help the R&D-based processes work, alternative radical policy options must be addressed, such as heavier-handed roles for government through major population relocations to areas that future generations can be more confident of successfully using.

The needed further interventions include enhancing skill levels for off-farm activities and the promotion and linking of secondary and tertiary-sector activities to primary products to raise the labor-absorption capacity of fragile zones. The politics of resettlement interventions are complex (Cernea 1991) and beyond the scope of this chapter. We take the position that, since the political wherewithal is unlikely to materialize, a "technological fix" must be actively sought and society at large must come up with the needed resources for the requisite research portfolio. If it

is one "balanced" with appropriate attention to work in fragile areas, there will surely be some major and possibly highly frustrating investments in agricultural R&D, broadly defined, but such investment risks must be confronted in the pursuit of progress.

Investors in the resource-oriented CGIAR international agricultural research centers that have been addressed to more marginal areas, such as ICRISAT and ICARDA, seem already to be growing impatient with the slow rate of the progress of such focused resource-oriented R&D. It may be, however, that part of the slow progress is attributable to the approaches often adopted in the early years of endeavor at these centers, wherein "conventional" techniques of agricultural improvement were pursued to the neglect of careful examination of more traditional methods and their possible extensions. Whatever may be the complete explanation, it is likely that things will get rather worse before interventions that might eventually turn the situation around can even be politically contemplated (Crosson and Anderson 1992), although it is to be hoped that this pessimism is misplaced.

Meantime, it would be helpful to encourage investors through seeking to find novel ways of reducing the unattractiveness of further investment in such work. Among the possibilities would be to emphasize the comparative advantages of particular niches in fragile areas that ought usefully and productively be engaged in production of specialized oilseeds, pulses, medicinal plants and some livestock enterprises, for example. Another theme that should be explored more vigorously in such remedial work is to take a wider "systems" approach that emphasizes the productivity of the whole ecosystem and to indicate more persuasively how environmentally friendly such a more broadly-based approach could be. This should probably include more attention to and integration of production with processing R&D. If the boundaries of the system are also defined more expansively so as to include the production of "environmental goods" such as tourism and landscape preservation and suitable institutional means can be invoked to put real economic values (as well as the undeniable but somewhat obscure social values on such goods) the prospects may not be as dim as they presently appear.

In spite of the volumes that have been written about soil degradation and related processes, it seems that considerable further research is needed to define better an adequate base of knowledge that can reliably be used to guide effective intervention, whether this be by national public and non-governmental agencies or through international donor activity (Anderson and Thampapillai 1990). An agenda for such research seems urgently needed to clarify priorities and selective targets (Farrington and Mathema 1991) and to identify what might best be explored in what is potentially a very large field—in both geographical or disciplinary terms.

One way of dissecting the possibilities is to consider work on understanding more completely (a) the incentives that individuals face in addressing resource-management issues from their own perspectives and (b) the related but more complex field of how people may act together to harmonize through group activity on decisions that require multi-farm and multi-household cooperation—even throughout a watershed (Dani 1986)—for success. From a methodological perspective, such latter matters are intrinsically more challenging and require additional social-science perspectives to operationalize effectively, such as details of organization, participatory enforcement, transferability of rights and other subtleties that influence transactions costs related to resource custody.

The foregoing discussion has generally made the case that the so-called fragile areas present especially significant challenges to the development community generally and agricultural research and its associated service sectors most specifically. Some of the remarks may well be interpreted as "special pleading" on behalf of groups of national societies that tend to be relatively neglected and are probably absolutely neglected in a global perspective. To make this expression of concern more clearly and directly, it seems that the R&D challenge for fragile areas may have to be posed in an explicitly equity-oriented context to have any chance of receiving treatment that might be regarded as "fair." The problem in setting a global strategic agenda is that the numbers of people who presently survive in such areas and even more so those who look like being obliged to do so in the future, relative to the large aggregates of world population, are proportionally minor. Even so, they are yet to receive something approaching proportionate treatment in the global allocation of agricultural technology-improvement resources. Whether these potential beneficiaries of agricultural research initiative reside in remote mountain areas of the Hindu Kush, the Andes, or the Mandara Mountains of North Cameroon, for instance, they tend to be "invisible" to policy makers and their interests are correspondingly underplayed in international and other wide-ranging considerations of the allocation of scarce resources knowledge-generation. Similarly remote from the concern of most taxpayers and, indeed, from most politically-influential decision-makers around the world, are those who reside and more or less survive in dry, tropical areas. It thus seems that one key issue for the international community and key concerned institutions is whether all such groups of humanity that depend on such marginal agricultural resources should receive some special consideration in debates about resources that might possibly bring ultimate technological benefits.

The answer to a less-than-purely semantic question may modify this view, however. Many linkages tie the fragile niches to other populous areas of the world. Indeed, the extent of total population served by fragile areas may jump radically once people indirectly dependent on flows from and the security of fragile areas are considered. Some of those links are direct economic ties through trade in goods (involving energy as electricity) and in labor services, through seasonal and climate-driven migration and remittances. Other biophysical and economic complementarities may further and more realistically project the significance of fragile areas. Some of these links are more ecological in nature, such as the negative externalities imposed on downstream riparian and land users by (actions and non-actions of) resource users in fragile areas. A more comprehensive accounting of such linkages may, it is speculated, lead to greater recognition of the global significance of the fragile areas than has thus far been the case and thereby elevating the "efficiency" case, relative to that based on equity, for increased attention to these areas. To move from speculation, however, considerable progress is required in the conceptualization and measurement of national and regional accounting to accommodate a broadened spectrum of natural elements in the accounts.

29.6 CONCLUSION

However these matters may eventually be resolved, herein lies the classical dilemma of equity versus efficiency in productive allocation of scarce investment resources. The World Bank, as one institution explicitly concerned with the development imperatives of the weakest groups in society, thus needs to clarify its own priorities in this sphere of social investment. The CGIAR has increasingly devoted its scarce resources to these more challenging and necessarily long-term problems and perhaps other international and regional initiatives should be similarly oriented. We do not pretend to have the answers to these difficult questions but we are convinced that concerned development agencies must grapple with the issues in order to distill a strategy for long-term technologically- and institutionally-based improvements that will better reflect contemporary concerns and better meet future needs. This chapter thus constitutes a call for more research in order to inform more amply this dimension of the debate on agricultural technology policy.

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Chapter 30

Strategic Research in Heterogenous Mandate Areas: An Example from the West African Savanna

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The IARCs are faced with a situation in which most opportunities for achieving spectacular successes in broad geographical areas consisting of relatively favorable, homogeneous environments have already been exploited. The challenge now is to achieve high rates of return to research in less favorable, heterogeneous environments. Experience so far has shown that, if technologies are to be adopted, they must be tailored to the specific biophysical and socioeconomic conditions of target groups of farmers. If this is so, do IARCs have a role to play in heterogeneous mandate areas, or do NARSs have a comparative advantage in these environments?

While tailoring of technologies is important for adoption, it is also clear that opportunities for technological advances will be very limited if strategic research into biophysical and socioeconomic processes is not carried out. This chapter sets out an operational approach for providing feedback for strategic technology development from a heterogeneous mandate area. An application of the framework to resource management problems illustrates that the task is complex, requiring strategic systems research including well-focused, in-depth field research as well as the capacity for conceptual and dynamic model building.

30.1 A FRAMEWORK FOR FEEDBACK FROM HETEROGENEOUS MANDATE AREAS

The homogeneity of production systems in some parts of the world has been increased by using environmental management to overcome micro-habitat differences, for example through irrigation, fertilization or pesticide use. The success of the Green Revolution, which developed technologies that are highly responsive to environmental management, was based on this strategy. The more heterogeneous the mandate area the more difficult it becomes to successfully use this strategy. This is the case in West Africa, where, for example, irrigation is often