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Traditional Agriculture and Agricultural Research in Southeast Asia

Gerald G. Marten

Small-scale agriculture in Southeast Asia has always changed in response to changing conditions through the years, but there is widespread agreement that change will be particularly rapid during the coming decades. Population growth, reduction in land/man ratios, expansion of agricultural markets and opportunities for consumption, introduction of new technologies, and numerous aspects of development cannot be ignored. At the same time, some conditions of small-scale agriculture, such as the limited supply of energy and other inputs for agriculture and the highly dispersed nature of agricultural production based on a large number of small holders, cannot be expected to change quickly in the near future. The average farm size in Southeast Asia is 1.8 ha, with one-third of the farms having less than 0.5 ha (Harwood and Price 1976), and 80 percent of the farmers depend solely on their own labor, with or without animal power (Andrews and Kassam 1976). There is no significant quantity of energy or new land of proven agricultural value available to change that situation.

Agricultural scientists in tropical countries face a dilemma: there are so many ways they might undertake improvements, it is difficult to know what to do. Agricultural policies (see Appendix) can help with this dilemma by setting goals and strategies that assist scientists in setting priorities for their research. Unfortunately, however, policies are not always so easy to interpret. Policies are not only formal statements in official government documents but also the unwritten, and sometimes unspoken, guidelines behind what is actually happening. Policies exist at all levels of social organization, often contain numerous internal contradictions, and are constantly changing.

This chapter outlines some trends in agricultural development policies during recent years, their implications for agricultural development research, and some difficulties to be overcome for the research to be successful. This leads to conclusions about the role that traditional agricultural technology could have in agricultural research and a new relation that may be necessary between scientists and farmers.

RECENT TRENDS IN AGRICULTURAL DEVELOPMENT

Changes in tropical agriculture have been particularly rapid during the past century under the impact of colonialism and other forms of contact with Western culture and technology, but the pace of change has quickened even more during the past few decades in the context of an international development effort aimed at increasing global food production. The agricultural goals and strategies of many nations during the 1960s and 1970s are well summarized by FAO's *Indicative World Plan for Agricultural Development* (FAO 1970). The motivation for the plan stemmed from a gap that was developing between global food production and a demand for food that was steadily increasing because of population growth. Food production was increasing, but as the increase in production was barely keeping pace with population growth, calorie production per capita was showing no improvement, and protein production per capita was gradually declining (FAO 1970).

According to the *Indicative World Plan*, the primary goal for agricultural development was to increase production. The major staple grains (e.g., rice, wheat, and corn) received the highest priority as the most effective way to produce as many calories as possible while making a significant contribution to protein needs. A secondary priority was assigned to legumes, which are high in protein and supply key amino acids complementary to those in grains. There was also a priority to increase the production of animal products to meet a rapidly increasing demand as people changed their dietary habits due to urbanization and westernization. Increases in agricultural production from World War II to the 1960s had been due largely to increases in the area under production. Although there were isolated instances of increasing yields per unit of land area, primarily associated with the expansion of irrigation, many areas had roughly the same production per unit of land area in 1960 as had prevailed prior to World War II (Grigg 1980). Because the possibilities for expanding the land area under agriculture were reaching their limits, the overall increase in agricultural production was starting to level off by the end of the 1960s.

The new strategy, often called the Green Revolution, was to increase production per unit of land area. This strategy of agricultural intensification was based on improved varieties of the major grain crops, supported by high energy inputs, modern water management, and numerous other elements of Western technology. The strategy was organized around two major objectives. One was to produce more than one crop a year by growing crops specially bred to mature more rapidly or crops capable of year-round cultivation due to their freedom from the photoperiod sensitivity that often restricts traditional varieties to a single period of the year. This provided the opportunity to produce two or possibly even three crops each year, if sufficient water could be provided. The second objective was to increase yields per unit of land area by developing varieties that responded well to fertilizers and other inputs. The new strategy demanded heavy labor or other energy inputs because of the intensive care improved varieties require to realize their yield potential.

The Green Revolution also required extensive infrastructure and services to help farmers provide optimal growing conditions for the new crop varieties. This included dissemination of technical information; provision of irrigation, fertilizers, and pesticides at reasonable prices; credit to facilitate the purchase of inputs; and, where appropriate, mechanization to overcome labor limitations. Implementation of such an ambitious agenda implied not only massive capital investments but also the development of an enormous professional manpower force to design, disseminate, and implement the new technology.

The new strategy was based on the centralized design of new cropping systems, in part because the professional manpower for agricultural development in tropical countries often was inadequate. Improved varieties to be deployed over entire continents were developed by scientists at a few international research centers such as IRRI (the International Rice Research Institute) in the Philippines and CIMMYT (the International Maize and Wheat Improvement Centre) in Mexico. Improved varieties were disseminated to national research agencies for testing, where the details of optimal planting densities, fertilizer applications, and crop protection could be determined under the soil and climatic conditions of each region. The result was standardized packages for dissemination to millions of local farmers. The basic premise was that local farmers should attempt to provide the optimal conditions required by the improved varieties; the scientists did not adjust the new technology to local conditions. This implied not only a massive effort on the part of farmers to provide the conditions demanded by improved varieties, but also a massive effort on the part of governments to develop the infrastructure for assisting them to do so.

This strategy for increasing agricultural production has been successful in many of the more favorable wheat- and rice-producing areas of Asia, but the gains appear to be leveling off. Moreover, some serious limitations in the strategy have become apparent. It has not been practical to use improved varieties on lands of marginal agricultural suitability or in areas so remote that the infrastructure for providing optimal cropping conditions is not practical. There also have been some undesirable social side effects. Improved varieties appear to give a competitive advantage to wealthier farmers in a better position to make full use of them, so wealthy farmers often have expanded at the expense of others. Moreover, the labor demands of agricultural intensification often have far-reaching effects on village social organization and quality of life (Ramitanondh 1985). A massive technical change of this sort entails numerous social and cultural adjustments that people are often unable or unwilling to make.

There are also environmental complications that have raised questions of how long the gains from improved varieties can be expected to last. There have been soil changes, such as salinization in irrigated areas, depletion of micronutrients, soil erosion due to increased tillage, and depletion of soil organic matter, as well as pest problems that arose because large areas were planted continuously to the same crop variety. Some of the problems could be corrected by appropriate technical measures, but others would be expensive or impossible to correct, from a practical point of view. Even those problems that are rectifiable often imply a scientific and professional overhead beyond the means of the nations involved.

In recent years the agricultural development policies of many Southeast Asian nations have begun to modify the Green Revolution paradigm. Priorities have shifted from a focus on food production in particular to rural development in general and from simply increasing production to assuring greater equity as well. These priorities have changed and expanded as professional manpower to deal with them has expanded. Many national development plans in Southeast Asia now direct explicit attention to poorer regions of the country and poorer segments of the population. In some cases "secondary food crops," particularly legumes and starchy root crops, have been elevated to a priority closer to that of the major grains. This is a particularly significant change for starchy root crops, which formerly were regarded as low-quality food but are now increasingly recognized as an efficient means of producing calories on marginal land. Kitchen gardens also have received a higher priority as a means of producing vegetables to correct deficiencies in key vitamins and minerals.

There also has been a shift in recent years from the expectation that local farmers should adopt standardized cropping packages to a recognition that new cropping systems will have to be adapted to local environmental and social conditions if they are to be adopted by the majority of farmers in marginal areas. Agricultural scientists have become increasingly concerned with farming systems—the entire farm enterprise within which a new cropping system will function—in order to assure that new cropping systems fit the conditions where they will actually be employed (Biggs and Tinermeir 1974, Zandstra et al. 1981; see also farming systems references in Chapter 2).

A ROLE FOR TRADITIONAL AGRICULTURE

Neither modern Western agriculture nor indigenous traditional agriculture, in their present forms, are exactly what will be needed by most small-scale farmers. The challenge for agricultural research is to improve agriculture in ways that retain the strengths of traditional agriculture while meeting the needs of changing times. Improvements should be integrative if they are to address the realities of small-scale farming (Jansen 1974, Altieri et al. 1983). Because it is impossible to change one component of an ecosystem without affecting other components, and because traditional agroecosystems often form a coherent whole, a viable strategy for improvement should consider the whole system, striking a balance between productivity, stability, and sustainability. Traditional practices of subsistence farmers form an integrated system that by design or evolution serves many functions simultaneously: pest control, nutrient cycling, food production, efficient distribution of labor among tasks, and the flexibility to deal with environmental and social fluctuations.

The sustainability of traditional agriculture can be ascribed to "principles of permanence" (Clarke 1977) that have appeared repeatedly throughout this book:

- Low dependence on inputs from outside the farm system
- No "self poisoning" from accumulation of toxic substances within the agroecosystem
- High net energy yield because energy inputs are relatively low
- Effective use of resources accumulated over time (e.g., energy and minerals stored in forest biomass when it is burned for shifting cultivation)
- Equitable distribution of energy inputs and outputs with respect to the human population
- Maintenance of the natural resource base (e.g., soil quality) for sustaining agroecosystem function
- System diversity—farm systems based on several cropping systems, cropping systems based on a mixture of crops, and crops with varietal and other genetic variability
- Building on natural ecological processes (e.g., succession) rather than struggling against them

Along with the many advantages of these principles, there are compelling reasons why farmers may not retain them as their agriculture modernizes. For example, crop diversity in the form of mixed cropping can be incompatible with mechanization and can in general have a high management "overhead" (dealing with the problems of many crops instead of one) unless the diversity is in the form of an agricultural system already proved to function smoothly. Crop diversity also interferes with specialization in a single crop to take advantage of market opportunities, and attention to long-term sustainability may be at the expense of short-term gains.

A distinctive feature of agricultural ecosystems is that they channel a larger percentage of ecosystem production for human use than do natural ecosystems. When considering that the main thrust of agricultural modernization has been to carry this further (i.e., a further increase in per-hectare yields for human purposes), one must question how far the increase can be taken without undermining agroecosystem processes (such as soil fertility maintenance) essential to agroecosystem sustainability. Traditional agriculture varies from low yields per hectare in the land-extensive (but labor efficient) shifting agriculture where human population density is low to high yields in the highly land-and-labor intensive agriculture necessary for high population densities in areas like Java. But there are limits. For example, the intensive, high-output organic farming practiced in Europe (similar in many ways to some of the intensive traditional agriculture in Southeast Asia) would not be feasible on a large scale because it depends

upon large inputs of organic matter (e.g., manure) from outside the farm (Boeringa 1980). The same kind of "subsidy" in the form of kitchen wastes, animal manure, or crop residues may apply to traditional Southeast Asian agroecosystems that are particularly productive.

Principles of traditional agriculture may prove useful for designing new agricultural systems from scratch (Dickenson 1972, Kiley-Worthington 1981), but incremental improvements on existing traditional systems may be the easiest and least risky way to start. The feasibility of innovative, integrated farm systems based on the traditional agriculture of the area has been demonstrated at the Colegio Superior de Agricultura Tropical in southern Mexico (Gliessman et al. 1981). In addition, the Instituto Nacional de Investigaciones sobre Recursos Bioticos (INIREB) has adapted the traditional Mexican *chinampa* system of intensive marshland vegetable farming to areas beyond those where it originated (Gomez Pompa 1978). Productivity and sustainability can also be increased by carefully matching existing and incrementally modified agricultural systems to land capabilities in light of regional needs (Marten and Sancholuz 1982, Marten 1982).

NATURAL ECOSYSTEMS AS MODELS

The ultimate objective of holistic agroecosystem research is to design locally adapted agroecosystems that are acceptable to farmers, high in yields, low in risks, and sustainable under changing conditions. One approach is to build on the fact that traditional agriculture tends to mimic natural ecosystems. Ecologists have used their knowledge of the structure and function of natural ecosystems to suggest how ecosystems might be designed in harmony, rather than conflict, with nature's strategy (Holdridge 1959, Rappaport 1971, Dickenson 1972, Clarke 1976, Bishop 1978, Harris 1978, Gliessman and Amador 1980, Altieri et al. 1983). This approach for designing sustainable agriculture reflects the usefulness of natural ecosystems as models: insect damage is within bounds, outputs are diverse and continuous, inputs are low, material is recycled, and in general the ecosystem is adapted to local environmental conditions. The role of traditional agriculture in this process can be to suggest which aspects of natural ecosystem design merit attention because they already have proved useful in traditional agriculture.

It is important to avoid unproven generalities and stereotypes about the tropics when thinking about natural ecosystems as models for agroecosystem design in Southeast Asia. There is a great diversity of soils, rainfall regimes, and other environmental conditions; and there is a similar variation in the natural ecosystems and the traditional agroecosystems that have developed in those environments.

Hart (1980) has presented a methodology for employing a natural ecosystem as a model:

1. Establish the correspondence between elements of a natural ecosystem in the area and analogous elements in an agroecosystem

2. Construct a model to describe the interaction and functioning of relevant elements of the natural ecosystem
3. Design an agroecosystem by substituting agroecosystem elements for analogous elements in the natural ecosystem model

The design is concerned with three classes of information:

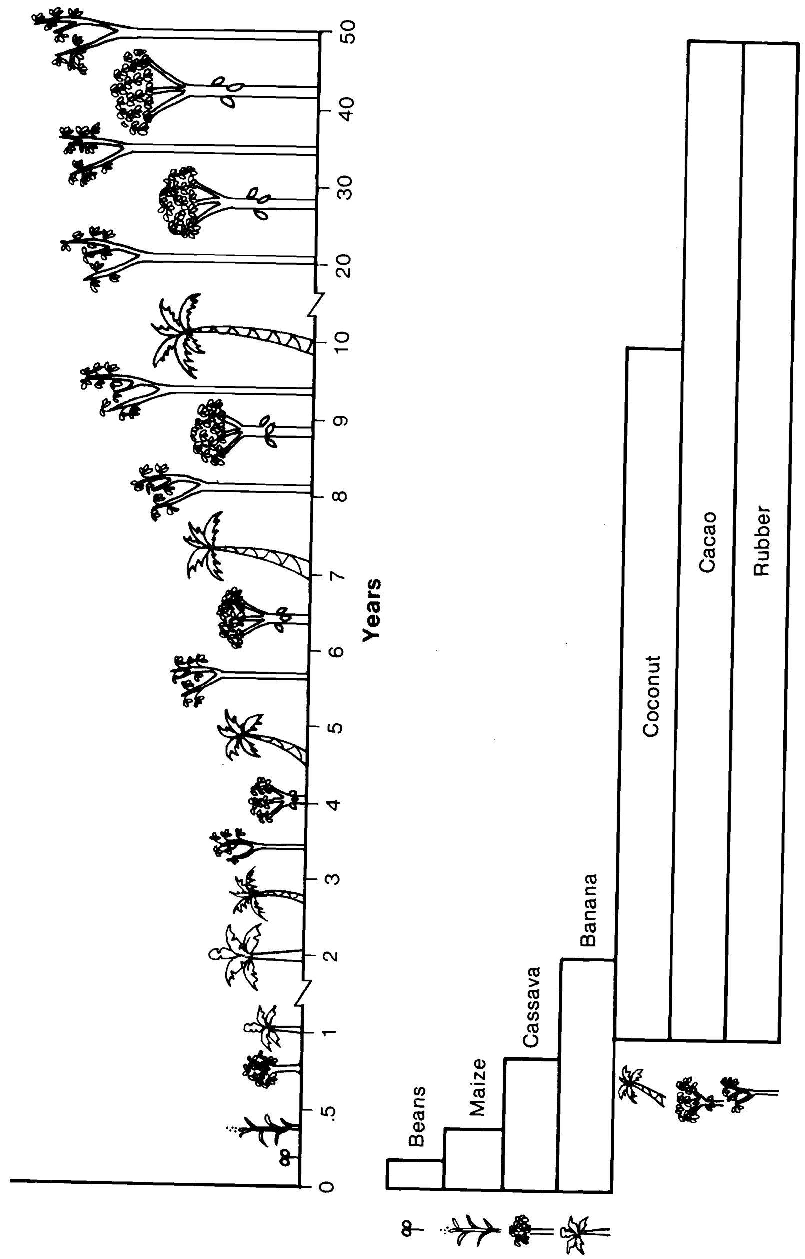
1. The crop (and livestock) species to be components of the system
2. The arrangement of the components in space and time
3. The quantity and nature of inputs and outputs

The design need not be static, because it can simulate natural succession where each successional stage provides the environmental conditions for a subsequent stage (Figure 15.1). For example, herbaceous annuals such as grasses and legumes can dominate in the initial successional stage. The horizontal arrangement of the initial stage is highly organized; vertical stratification is less important. As the succession progresses, annual species are replaced first by woody shrubs and then by trees, and vertical structure becomes as important as the horizontal structure. In the early stage there is rapid maturation of annual species, rapid crop turnover, and intense competition among crops close together in the single layer near the ground. During the later stages crop turnover is slower, the nutrient cycle is more closed (requiring less fertilizer input to replace nutrients that are lost to the system), and the planting density of each vertical layer is lower so light and other resources can be shared between the layers. Brown (1982) has tested this concept of agroecosystem design by comparing production patterns of an experimental natural-ecosystem mimic based on a succession of annual and perennial crops, a natural secondary forest succession, complex traditional agroecosystems, and agricultural monocultures.

FARMER-SCIENTIST COLLABORATION

Like the single-crop, improved-variety strategy that preceded it, a holistic farming systems approach places demands (albeit different ones) on agricultural scientists that could be difficult to meet. A program of agricultural research based on the functioning of an entire farm household can be overwhelmingly complex compared with conventional research aimed at improving the yield of a single crop under optimal growing conditions. The problem can be compounded if, as often happens, farmers' circumstances make it difficult to know what cropping improvements will really prove useful. Moreover, there are hundreds of different local, suboptimal conditions that require a corresponding number of different agricultural systems. Because it is beyond the means of a few centralized research units to develop so many new and different agricultural systems, a strategy of tailoring new agricultural systems to local conditions would work best if research and development were highly decentralized. The research must take place at the numerous places where the agricultural

Figure 15.1. The Chronological Arrangement of Interplanted Crop Components in a Successional Mixed Cropping System



Source: Hart 1980.

systems are to be used, and the burden of research must be carried by people dispersed over those areas. Improvements would have to be not only on existing agricultural systems but also on dissemination of particularly effective existing agricultural systems to areas where they are not yet known.

Because no nation has enough agricultural scientists to do this kind of job, one possibility is to structure agricultural development so farmers are themselves acting as "scientists" for the development of new and improved agricultural systems (Sheridan 1981, Whyte 1981). Agricultural research is not an alien concept to small-scale agriculturalists (Howes 1980), since many of them already experiment routinely with new crops and variations on existing practices. A decentralization of agricultural research would, however, have far-reaching implications for agricultural extension. Extension would continue to be a means by which outside technology is brought to local farmers, but it would no longer be based on the delivery of well-formed technical packages for local farmers to accept as they are. Extension would instead provide local farmers with the techniques to improve their effectiveness as "agricultural researchers."

This new kind of extension could have significant implications for agricultural scientists who are developing new technologies for extension to deliver. Agricultural scientists would have to add at least two kinds of research to their menu:

1. Research to establish the skills and information that small-scale farmers will need to be more effective "agricultural researchers" in a decentralized agricultural research strategy
2. Research to establish formats for agricultural extension in this strategy

This kind of research will be possible only if agricultural scientists collaborate closely with small-scale farmers and extension agents.

Another difficulty with designing new agricultural systems that are adapted to local conditions is the fact that those systems may have to be more complex than agricultural systems based on optimal conditions. The problem with this complexity is that the possibilities for research exceed what anyone can actually do. The conventional experimental design for agricultural research, based on field trials with various combinations of planting densities and levels of nitrogen, phosphorus, and potassium fertilizer, derives its strength from its ability to identify optimal cultivation practices with a finite number of experimental trials. This approach is no longer feasible for agricultural systems that may involve the adjustment of dozens of variables instead of three or four.

Fuller use of traditional agricultural knowledge and technology, drawing upon the collective experience of farmers in the area, could help to reduce this problem to manageable proportions. Traditional technologies can help to suggest which of many possibilities are most worth pursuing. In some cases it may be best to use existing traditional agriculture as a starting

point. To do so, agricultural scientists will have to understand how and why the traditional agriculture functions, and a close collaboration with traditional farmers would be necessary to acquire that understanding. In other cases, it may be necessary to design completely new systems while drawing on elements from both traditional and modern agricultural technologies.

A collaboration between scientist and farmer appears the most effective means since neither is expert in both technologies. For example, when farmer participation was enlisted for a pest research project in Nigeria, the scientists knew many details of grasshopper biology with which the average farmer was not familiar, but the farmers had a knowledge of the timing, location, and severity of pest outbreaks in the past that the scientists did not (Richards 1980). Moreover, the farmers realized that grasshopper outbreaks on a field were often associated with the proximity of a particular weed that provided a reservoir habitat for the grasshoppers (Barker et al. 1977), a fact that could have taken several years of systematic research for scientists to discover without the aid of the farmers.

To be effective, collaborative research between farmers and professional scientists will have to draw as much as possible on the intellectual resources of both parties. Achieving this degree of intellectual collaboration will be a challenge because, coming from different backgrounds, farmers and professional scientists are accustomed to codifying their technical information and organizing their "research" very differently. It is the joining of differences that offers so much reward from collaboration, but doing so will be above all a problem of communication between "farmer-scientist" and professional scientist. Such communication could be facilitated by the methodologies of human ecology and agroecosystem research, which can help both parties establish a conceptual framework on social system-agroecosystem interaction on which to build their communication.

There is a significant body of experience in communication between rural people and outside professionals in the context of adult rural education (Freire 1970) that may prove useful for collaborative agricultural research. The key is for professional scientists to assist farmers in looking critically at their world, developing an explicit awareness of their conditions and capabilities, and verbalizing them to one another and to the scientists. Many of the techniques are similar to those used in psychotherapy that emphasize mutual intimacy and openness of communication between therapist and client (Rogers 1961).

Richards (1980) and Chambers (1983) have reviewed some methods for communication between scientists and peasant farmers. To initiate the process a scientist can stimulate a farmer to explain his conceptual frameworks using open-ended approaches such as interpretation of photographs (e.g., explaining what is happening in a photo of an agricultural landscape), drawing maps (e.g., to explain the suitability of different kinds of land for different kinds of agriculture), and conversations along the lines of semi-structured interviewing illustrated in the appendix of Chapter 13. Given the opportunity, farmers will express systems of classification quite different from those of scientists. For example, crop classifications may be utilitarian (Table 15.1) rather than based on biological taxonomy.

Scientists can deepen their insights into a farmer's work by engaging in that work themselves (Hatch 1976). Insights into farmer decision processes also can be sharpened through joint play-acting simulations of farm management scenarios by farmers and scientists (Oxenham 1982). When a scientist communicates with a farmer about a technology, he must do so in terms meaningful to the farmer. This requires not only an appreciation of the way farmers perceive their agriculture and the functioning of their agroecosystem but also a readiness to build upon their intellectual capacities (Barker 1980).

Farmer-scientist collaboration aimed at blending modern and traditional technology is a process that extends far beyond the agricultural sector. Southeast Asia is currently being flooded with Western culture and technology under the aegis of development, and a major issue in virtually all sectors of human activity is how to deal with this. Should the introduced culture and technology be allowed, or even encouraged, simply to replace indigenous culture and technology, or should there be a conscious effort to draw upon the best and most appropriate of both? As this is a fundamental question that scientists and other agents of change are beginning to confront in a variety of sectors, establishing meaningful collaboration between modern agricultural scientists and "farmer-scientists" could be of considerable significance beyond the confines of agriculture.

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APPENDIX:
EXAMPLES OF AGRICULTURAL POLICY OPTIONS

A. Role of agriculture in national development
   1. Meet national food needs
   2. Increase material welfare of the rural population
   3. Use agriculture to help finance urbanization and industrialization

B. Agricultural development goals
   1. Increase production
   2. Improve the stability, self-sufficiency, resilience, and/or sustainability of production
   3. Equity

Table 15.1. Traditional Basis for Classifying Crops in Sierra Leone

		Rice Varieties[a]					
		Kobei	*Gibengbei*	*Kenemi*	*Monyoe*	*Boguti*	*Ngiemayakei*
Men[b]	High/low yield	2	1	1	1	1	1
	Brownish/lighter	2	1	2	1	2	2
	Low/high soil moisture required	1	1	2	1	1	2
Women[b]	Short/long growing season	1	1	2	1	1	2
	Swamp/upland varieties	2	2	1	2	2	2
	Hardens after cooking/keeps soft	2	2	1	2	2	2
	Less sweet/sweet	2	2	1	2	2	1
	High yield/low yield	2	2	1	2	2	1

	Legume Crops[c]				
	Abrus	*Mucuna*	*Phaseolus*	*Vigna*	*Delonix*
Food/nonfood	2	2	1	1	2
Income/no income	2	2	1	1	2
Weed/not weed	1	1	2	2	2
Shade/no shade	2	2	1	1	1
Utility for children/no utility for children	1	2	1	1	1
Utility for farmer/no utility for farmer	2	2	1	1	1
Games/no games	1	2	1	1	1

Source: Richards (1980).

Note: 1 designates the first quality listed; 2 designates the second quality.

[a] Local names.

[b] Men and women have different classifications of rice varieties because of different roles in the production and preparation process.

[c] Generic names.

C. Priority crops
   1. Grains
   2. Legumes
   3. Starchy root crops
   4. Vegetables
   5. Animal products
   6. Other crops with a high cash value
D. Strategies of increasing production
   1. Increase the land area under cultivation
   2. Increase the number of crop cycles in a year
   3. Increase the yield per crop cycle
      a. Increase the yield per unit area
      b. Increase the yield per unit of labor input
      c. Increase the yield per unit of material or energy input
E. Priorities for providing inputs to production
   1. Improved varieties
   2. Technical information (extension)
   3. Chemical inputs (fertilizers, pesticides)
   4. Irrigation
   5. Mechanization
   6. Credit
   7. Transport
F. Market structure
   1. Subsistence
   2. National integration to meet urban needs
   3. Export crops
G. Agricultural research
   1. Research (centralized vs. decentralized)
   2. Standard "optimal conditions" package vs. adaptation to local social and ecological conditions
   3. Single-crop vs. "farming systems" approach
   4. Scale of production
   5. Blending of foreign and indigenous technology
H. Agricultural extension
   1. Dissemination of improved technology
   2. Dissemination of research and management skills
   3. Facilitation of local infrastructure development

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