Toward Sustainable Agriculture in the Humid Tropics

Building on the TropSoils Experience in Indonesia

TropSoils Bulletin No. 91-02

Toward Sustainable Agriculture in the Humid Tropics

Building on the TropSoils Experience in Indonesia

Carol J. Pierce Colfer

The author is a consultant with the Food and Agriculture Organization's Forests, Trees, and People Program. Previously, Dr. Colfer was Associate Professor, Department of Agronomy and Soils, University of Hawaii. Her address is 14657 SW Teal, No. 226, Beaverton, Oregon 97219.

TropSoils Bulletin Number 91-02. Published August 1991 by the Soil Management Collaborative Research Support Program, Box 7113, North Carolina State University, Raleigh, NC 27695-7113. Neil Caudle, editor. Tim McBride, editorial assistant. Funded in part by Grant No. DAN-1311-G-SS-6018-00 from the U.S. Agency for International Development.

Cover photo by Richard Dudley

Foreword

The TropSoils/Indonesia project is part of the USAID-funded Soil Management Collaborative Research Support Program (CRSP). The project involved formal collaboration among the Center for Soils Research (CSR) in Bogor, Indonesia, the University of Hawaii in Honolulu (UH, lead institution), and North Carolina State University (NCSU, Raleigh). Additional cooperation was received from Andalas University (Padang), Gajah Mada University (Yogyakarta), Bogor Agricultural Institute, and University of Florida (Gainesville), as well as the local West Sumatra Extension and Transmigration offices, and the Small Ruminants CRSP. The work reported here was a team effort, and every attempt is made to give credit appropriately to all team members. The support of administrators and researchers from the above institutions is gratefully acknowledged. The greatest debt, however, is to the people of Sitiung—transmigrant or indigenous. Without their cooperation, this work could not have been written.


The author in Sitiung (photo by Richard Dudley).

The author, Carol J. Pierce Colfer, is an anthropologist who worked on the TropSoils Project in Sitiung between July 1983 and July 1986. She was formally affiliated with the University of Hawaii's TropSoils effort between 1982 and 1988. First employed as a "farming systems researcher," she later became team leader.

Contents

Introduction: Sustainable Agriculture, a Conceptual Framework

Sustainable agriculture, like motherhood and apple pie, is generally considered desirable. Indeed, it may well be the most fashionable phrase in agricultural and natural-resource-management circles at the present time. USAID (1990) defined sustainable agriculture, for use by its missions, in the following way:

> Sustainable agriculture is a management system for renewable natural resources that provides food, income and livelihood for present and future generations and that maintains or improves the economic productivity and ecosystem services of these resources.

It seems clear from this and other definitions that greater attention to environmental concerns is being called for in agricultural circles. The link between agriculture and the people who practice it is also clear. But there remains considerable confusion and disagreement about what the development of sustainable agriculture will mean in practice.

Three Sources of Guidance

There are three areas of knowledge on which we can beneficially draw—in addition to the conventional agricultural disciplines—in the endeavour to develop sustainable agricultural systems. These are farming systems research and development (FSR&D), indigenous knowledge, and agroecosystem analysis.

Farming among burned logs at the Sitiung V transmigration site (Unless otherwise noted, all photos in this publication are by Carol J. Pierce Colfer).

FSR&D

Farming systems research and development is not as popular now as it was only a few years ago. This dissatisfaction is attributable to several factors. Despite warnings by many, FSR&D was widely acclaimed as a panacea, raising unrealistic expectations.[1] It was carried out in areas categorized as agriculturally marginal, in contrast to the fertile areas where the Green Revolution was most successful. Wildly varying approaches were labelled FSR&D and applied in diverse contexts. The attempt to be interdisciplinary, holistic, iterative,[2] and family-based required skills that were in short supply, and in many cases, projects paid inadequate attention to ecological factors.

I think, however, that many of the lessons learned in farming systems projects can be applied as we develop strategies to make agriculture more sustainable. Indeed, this belief is the prime reason for writing this monograph.

Since FSR&D, like sustainable agriculture, covers such a wide range of approaches and activities, I introduce below some important features of the approach we took in the TropSoils project in Sitiung, West Sumatra. These features will be expanded in later sections.

Prior to our arrival in Sitiung, senior team members participated in a six-week exercise in Honolulu, which included team building and training in language and FSR&D. We began the project with unusually high spirits and excellent team rapport.[3] Our first activity was to undertake a *sondeo* (or rapid rural appraisal), during which we selected a site for our initial collaborative research activities—Sitiung V, Block C.

We had strong administrative support from the University of Hawaii and the Center for Soils Research to organize our activities within a farming systems framework. Our Indonesian collaborators were particularly keen to see significant rural development results from the project and felt the FSR&D approach represented a good possibility. We had been influenced by the works of Shaner, Philipp, and Schmehl (1982); Gilbert, Norman, and Winch (1980); and Hildebrand (1981); and we were all enthusiastic about using this approach.

I saw the FSR&D framework as an agriculturally acceptable means to integrate the desires, practices, and knowledge of local people—of both sexes—into agricultural experimentation. I was interested in those kinds of agricultural technology which would lead to an improved standard of living for rural people without adversely affecting their way of life. My own activities would include research on this process, as well as research on people and soils.

The other team members favored such integration as well. They wanted to increase the likelihood that what they developed would be acceptable and useful for farm families. Cooperative attitudes based on shared goals characterized our work during the period featured in this bulletin (1983-86).

As a means of accomplishing these goals, we accepted Shaner et al.'s (1982) characteristics of FSR&D: We wanted our project to be problem-solving, family-based, holistic, interdisciplinary, iterative/dynamic, complementary to other kinds of research, and responsible to society. Conspicuously absent from this list was any explicit concern with the environment or ecology, though we were not unaware of such issues.

Indigenous Knowledge[4]

When the TropSoils project started in Sitiung, "indigenous knowledge" was basically a technical term used in anthropology. Anthropologists have always devoted part of their research to documenting the knowledge held by local people in a variety of spheres, including, for example, agriculture, religion, technology, and the environment.

I was interested, as an anthropologist, in indige-

---

[1]Sustainable agriculture runs the same risk, noted also by Hart and Sands 1990.

[2]I refer to the process by which a research effort is tried, evaluated, corrected as necessary, and tried again—or abandoned. Our ability and willingness to approach our research in this way was a major factor in our successes.

[3]The senior level team in 1983 was composed of John Thompson (agronomist, Team Leader, UH), Djoko Santoso (soil scientist, Site Coordinator, CSR), Mike Wade (soil scientist, NCSU), and myself (anthropologist/farming systems researcher, UH). There were also four junior (bachelor's level) CSR soil scientists and two (high-school level) technicians, when the project began.

nous knowledge generally. But, a few years earlier, I also looked specifically at indigenous knowledge among Kenyah Dayaks in East Kalimantan. In the course of that research, I became convinced that local people approached agriculture and forest management in ways that were significantly different from, and in some ways superior to, those of conventional science (see e.g., Colfer 1983a; and Colfer et al. 1988).

Since that time, the literature on indigenous knowledge has burgeoned. Warren, one of the early proponents of indigenous knowledge, was instrumental in establishing CIKARD (Center for Indigenous Knowledge in Agriculture and Rural Development), which now puts out a regular newsletter. Clay (1989) has one of the most appropriately targeted expositions on the utility of indigenous knowledge in agriculture and natural resource management.

In my own view, the development of sustainable agriculture will require that we learn what local people know. Such knowledge must be evaluated and incorporated, as appropriate, into agricultural research. Indigenous knowledge includes the local people's conceptual approach to agriculture, along with more specific kinds of knowledge about their environment, their personal agricultural goals, and their values.

In considering indigenous knowledge, scientists often concentrate on—and are sometimes immobilized by—human and ecological diversity and the consequent economic and logistical complexities. My suggestion is that such diversity exists and cannot be ignored. It is better therefore to turn our attention, positively, to the under-used human creativity in rural areas. Chambers (1990) makes the same point:

> What has been missing is not the competence of rural people, but its perception, encouragement and support by outsiders. Indigenous knowledge is but one of the potentials (energy, intelligence, labor, coordinating capability, etc.) currently being ignored among the "rural masses."

Agroecosystem Analysis

Gordon Conway is the best known proponent of agroecosystem analysis (e.g., 1985; 1987; or Altieri 1987; Altieri and Hecht 1989). Conway is probably also responsible for the current emphasis on "sustainability." Gerber (1990) defines an agroecosystem as

> a complex of air, water, soil, plants, and animals in a defined area that people have modified for the purpose of agricultural production.

Conway suggested four system properties that could be used to understand the dynamics of particular agroecosystems: productivity, stability, sustainability, and equitability. **Productivity**—the quantity of an output per unit of input—is very familiar to agricultural scientists, though agroecosystems analysts may measure inputs and outputs in nonconventional terms. **Stability** refers to consistency of production. **Sustainability** is the ability to maintain a given, or desired, level of production over time. **Equitability** refers to the degree to which resources and products are distributed equally in the human population. Patterns of space (e.g, transects), **time** (e.g., crop calendar), **flow** (e.g., soil, water) and **decisions** (e.g., crop choices) are investigated.

Conway developed a short procedure for analyzing agroecosystems so as to develop a series of appropriate research questions. Two excellent examples of this approach in Indonesian agroecosystems are available in KEPAS (1985a, 1985b).

Agroecosystem analysis is similar to FSR&D in its holistic approach, which incorporates human beings into agricultural systems. It differs in its emphasis on problem definition and in its focus on environmental concerns and processes.

Sustainable agricultural development will, in my view, require that this type of agroecosystem analysis be incorporated effectively into agricultural projects, in an ongoing manner. Just as the TropSoils project discussed in this bulletin succeeded in incorporating human concerns into soil management, so must future projects incorporate, addition-

---

[4] There have been disagreements about the term "indigenous knowledge." Technically, for instance, indigenous knowledge should not include the knowledge of new settlers in an area. In my view and usage here, newcomers may have valuable knowledge about their new area (and particularly about their own interaction with this new environment).

ally, this ecological dimension.

Our collective experience with FSR&D has been, in my view, an essential prerequisite for the development of sustainable agriculture. A critical mass of skills in dealing with rural people and with other disciplines has been developed. We have learned that the ecological connection was one critical missing link. Another has been the significance of indigenous knowledge as a source of insights for "new" (scientific) approaches.

The purpose of this bulletin, besides providing specific results from an agricultural research project, is to show how human and agricultural sciences were effectively integrated. Such successful integration can serve as a basis for future improvements in our capacity to develop more sustainable agricultural systems.

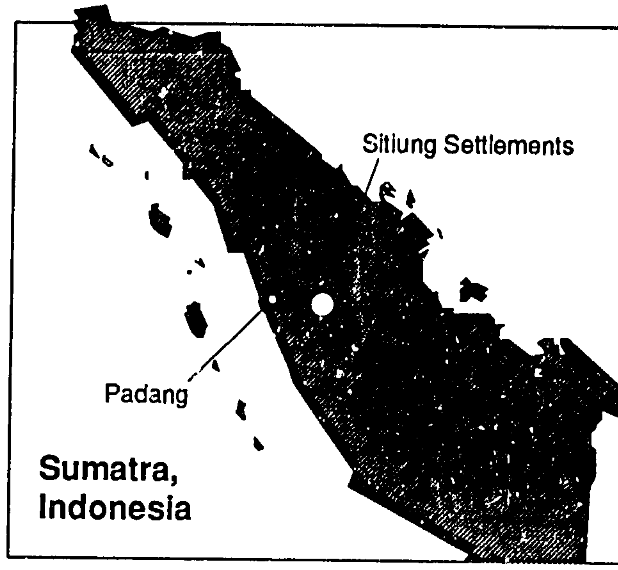


Figure 1. Location of the Sitiung transmigration settlements.

The Setting

Sitiung is a transmigration[5] site in the center of Sumatra, Indonesia, straddling Jambi and West Sumatra provinces (Figure 1). Until the late 1970s, the area was dominated by lush tropical rainforest, interspersed with small settlements of the indigenous Minangkabau. The Minangkabau (or Minang) had a sustainable system that included small, permanent, wet-rice plots and shifting cultivation of upland rice, rubber, and other assorted tree crops within the forest. These indigenous communities of Minangkabau now form a patchwork with new settlements of Javanese and Sundanese[6] transmigrants, marked by continually decreasing areas of natural forest. Between 1976 and 1986, the area absorbed some 6000 transmigrant families.

The dominant transmigrant farming system is based on two crops of rice, soybeans, and/or peanuts per year; on fixed, one-hectare plots of land per family; and on a productive, one-quarter hectare home and garden plot. This system is characterized by complex cropping integrating vegetables, field and tree crops, medicinal plants, and ornamentals.

The Sitiung transmigration area covers about 100,000 hectares. In 1983, when the TropSoils team first arrived, transmigration settlements were organized into Sitiung I through VI (later expanded to Sitiung VII and VIII), and each of these in turn was composed of "blocks" (villages). Sitiung I, for instance, was divided into four blocks (A-D), each of which had about 300 families. Our team of three American families settled in Sitiung I, Block A, to which "Sitiung IA" will refer. The Indonesian counterparts who joined in 1983 began to settle in Sitiung IV, Block B—a half-hour drive away. In time, a central office was developed on the road to Sitiung V, Block C, referred to hereafter as "Sitiung VC," the location of much of our work.

Sitiung might be characterized as having marginal lands. Its soils—Ultisols, Oxisols and Inceptisols—are extremely infertile and deficient in organic matter, comprising an inhospitable environment for much Western-style agriculture. The soils are highly acid, ranging from pH 3.4 to 5.7 (KCl), and aluminum toxicity is the foremost constraint to crop production. Phosphorus (P) and potassium (K) are the most significant limiting nutrients. In addition, annual crops frequently suffer water stress because the clay soils form aggregates and behave as

[5]Transmigration is a longstanding and controversial Indonesian government program to move hundreds of thousands of families from Java, Bali, and Madura to the less-populated Outer Islands of Indonesia.

[6]Sundanese are the dominant ethnic group in West Java. Their language, culture, and farming systems are somewhat different from Javanese.

sandy soils, allowing the ample rainfall (2500-3000mm/year, mainly September to May) to dissipate rapidly.

Erosion can be severe during heavy rainfall, especially on the steep hills where upland rice fields are often made. Flooding occurs regularly in the flatter, low-lying areas. Agricultural pests—wild pigs, monkeys, insects, and disease—are recurring threats, frequently wiping out entire crops.

The location was selected as representative of other transmigration sites in Indonesia's Outer Islands, many of which have had problems maintaining adequate subsistence and incomes for the newcomers. The early settlements in Sitiung had been cleared by bulldozer with unusual haste, and most of the topsoil had been removed. This provided an opportunity for the scientists to address problems of land reclamation, as well as other problems of agricultural development.

Organizational Framework

This bulletin provides a narrative of the progress of the TropSoils/Indonesia project, as project activities relate to the development of sustainable agriculture. We provide information about agricultural development in a particular humid tropical rainforest environment and describe an *approach* to development-related research—one which effectively incorporates local people.

In the above sections, I have introduced our version of farming systems, discussed its relevance to sustainable agriculture (a concept still undergoing definition), and briefly described the research site. Throughout the remainder of this bulletin, I indicate co-authors of most sections and sub-sections in order to give appropriate credit. I have made every effort to incorporate their suggestions into this document.

The second section outlines the three major iterations in our research activities. We focused initially on the farming system of the transmigrants from Java, specifically their upland rice fields. We did research *with* farmers and studies *of* farmers (Colfer et al. 1989a). I discuss our collaborative trials with farmers, as well as time-allocation studies, a farmer interview series, and a study of farmers' perceptions of agricultural constraints.

During the second iteration, we began collaborative work on home gardens, trying to work more with women and capitalize on a productive agricultural subsystem. We did studies of their home garden cropping system, their fishponds, and their animal husbandry. Concurrently we began looking

Sitiung, 1983.

at the differences between the transmigrants' and the indigenous Minangkabau farming systems—specifically, differences in their conceptions of agriculture and in agricultural decision-making.

Our third iteration focused on the indigenous Minangkabau farming system. We examined time and land use, income, and rice yields, as well as aspects of indigenous knowledge—indigenous soil taxonomy, plants used for food, and the overall conceptual approach to agriculture. I discuss the links between these activities and soil management in each subsection, to show the iterative nature of our decision-making about research priorities.

Section III proposes one way to utilize the vast quantities of site-specific information gathered in projects such as this: expert systems. Expert systems, or artificial intelligence in general, would seem to hold some promise for overcoming the recurrent problem of how to generalize from the specific case to a wider population.

The final section outlines an approach that builds on our TropSoils experience. I believe this approach can contribute to the development of sustainable agriculture.

Research in Indonesia: Three Major Thrusts

The three years of research covered by this bulletin can be divided into three major, overlapping, thrusts: (1) transmigrants' upland rice fields; (2) transmigrant home gardens, world views, and agricultural decisionmaking; and (3) the Minang agroforestry system. These different research themes represent our growing understanding of the opportunities that Sitiung presents to researchers.[1]

As we investigated topics and discovered new research directions, I was troubled by the lack of personnel with a significant ecological background. Particularly as we began to look seriously at home gardens, tree crops, and the varying stages of forest regrowth in the shifting cultivation system, we wanted input from, at the very least, an agroforester.

In the years intervening since I left Sitiung, I have become ever more convinced of the importance of incorporating not only the specific skills of ecologists but also the conceptual framework they represent. The following pages should make clear how an anthropologist—looking at soil, people, and crops from an alien perspective and communicating effectively—can bring new insights to a team of agricultural scientists.

Improving the sustainability of agriculture will mean paying informed attention to the environment, taking care to avoid practices that are profitable in the short run but environmentally damaging in the long run. But more important, ecologists, in concert with agricultural and social scientists, can point out opportunities for pursuing environmentally beneficial practices. A thorough understanding of the complex interactions under way in a home garden, or significant scientific knowledge about the variety of tropical fruits that grow in "abandoned" rice fields as they return to the forested state, would have been invaluable in Sitiung.

[1]Some of the material presented in this section is available, emphasizing women's agricultural roles, in Sigman et al. 1989.

Thrust 1: Transmigrants' Upland Rice Fields

Our first focus—transmigrants' upland rice fields—derived from our previous experience in Indonesia's Outer Islands, from governmental concern to help transmigrant farmers, and from our modified *sondeo* (Hildebrand 1979; 1981) in August 1983.

The *Sondeo*

with Djoko Santoso, John Thompson, and Mike Wade

Our three-day modified *sondeo* (rapid rural appraisal) was conducted by the new TropSoils team, including John Thompson (agronomist/team leader), Djoko Santoso, and Mike Wade (senior soil scientists); four junior Indonesian soil scientists, and three technicians (agricultural high school graduates). I was the only representative of the social sciences, health concerns, and a female perspective. Because of this, I served as a training consultant to the team, emphasizing the importance of noting non-agricultural aspects of the people's lives. I also gave pointers on how to interact respectfully with rural people so as to learn as much as possible.

After perusing secondary data from the Center for Soil Research, transmigration offices, and village headmen, we formed pairs, dispersed throughout a given settlement (in Sitiung I-V), and interviewed the men and women as we found them. Since we had only three disciplines represented, we assigned ourselves additional topics to investigate. These

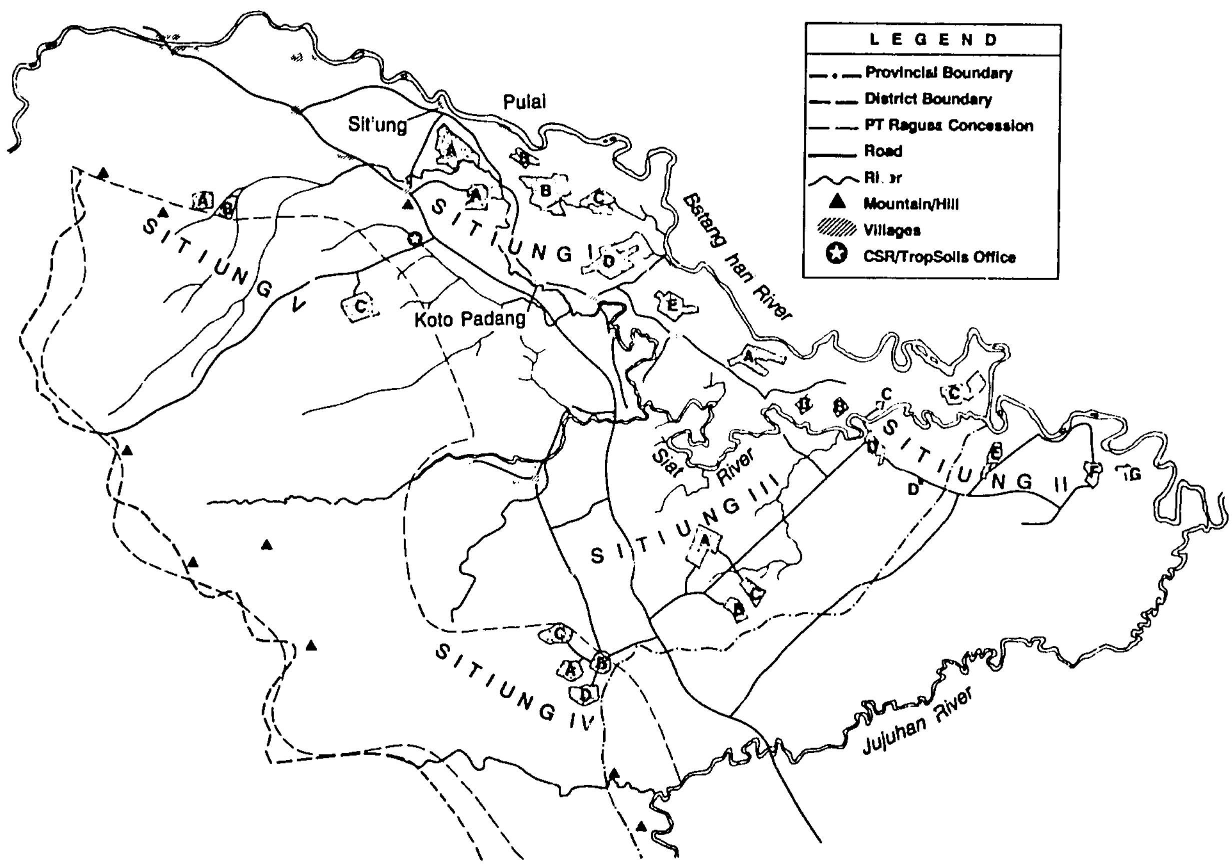


Figure 2. Map of the Sitiung area.

included health, division of labor, subsistence problems, nutrition, and off-farm employment. I reiterated the importance of talking with women as well as with men.

Based on our *sondeo* findings, we chose to begin our experimental collaborative work with the transmigrant farmers in Sitiung VC. This community was the most recently settled. Its population (1,466, Transmigration 1983) was composed of roughly two-fifths East Javanese from Ngawi and Madiun Districts (**Kabupaten**); two-fifths Sundanese from Garut District in West Java; and one-fifth indigenous Minangkabau.[2] Average family size ranged from 4.32 for the East Javanese to 5.94 for the local Minang.

The situation of the people in Sitiung VC was bad: Three hundred families arrived (240 from Java) between December 1982 and June 1983 and immediately confronted various problems. Their fields, promised "ready to plant," were littered with felled and rotting logs too wet to burn. Many of the wells that had been dug—one well for every four families—were dry. Their early efforts to grow crops met with dismal failure.

The transmigrants were disappointed and worried. The surrounding forests were alien and frightening for these people from Java, one of the most densely populated islands in the world. We reasoned that besides helping in a potentially desperate situation, we could also monitor the process of settlement, from the beginning.

Meanwhile we were in a race against time. We had to find and renovate our housing in Sitiung IA (Figure 2) and participate in a soil survey. We

[2]The Minangkabau represented 20% of the settlement at that time. They were recruited from supposedly "landless" local farmers (see "The Third Iteration"), as part of a new governmental policy designed to make the benefits of transmigration more equitably available to local people in need. Their home was nearby Koto Padang (Figure 2), a village from whose traditional forest lands in Sitiung V had been cut and cleared.

wanted to begin collaborative work with farmers on upland rice fields, and the August-September planting season was upon us.

As the foreign team (John, Mike, and I) found and organized housing for our families, we were confronted by the harsh inequities that existed between our resources and those of our Indonesian collaborators. Whereas we could each rent and furnish comfortable homes, six of the Indonesians (technicians and scientists alike) were crammed into one cinderblock building of about 430 sq. ft. with no windows or amenities of any kind, in Sitiung IVB. Whereas we each soon had new Toyota Landcruisers with funds for fuel, they had to share a very decrepit old Landrover on a miserly operating budget. None of us could overlook these inequities, and the struggle to ameliorate them—consistent with the CRSP mandate to collaborate and our own philosophical views—proved endless.

We assumed we would work on upland rice fields. Mike's Sulawesi experience and my Kalimantan experience suggested that this was the agricultural endeavor most dear to the people's hearts. The Sitiung Transmigration area had been defined by the government as "food crops"-based—which normally meant rice first, followed by other field crops (**Palawija**, like soybean, peanut, mungbean), so Djoko and the Indonesian staff also assumed we would start with rice.

Collaborative Work with Farmers[3]
with Mike Wade, Djoko Santoso, C. Evensen, I Putu Gedjer, Fahmuddin Agus, and D. Gill

We had hoped to have a month or two to select farmers carefully and rationally, since we expected to work with them for at least four years. We wanted particularly to ensure representation of female-headed households and poorer families among our cooperators. Time constraints made this impossible.

Instead, we reluctantly contacted leaders in four neighborhoods in Sitiung VC and asked each to find five farm families interested in working with us. We were able to get proportional representation by ethnic group (Javanese–8, Sundanese–7, and Minang–5). This approach also reinforced a common Indonesian practice of establishing "patron-client" relationships. We regretfully became the patrons of the leaders, and our cooperator-farmers in turn became their clients.

Team members Mike Wade and Ratno roll logs to help farmers cooperating in the research.

We called a series of meetings with farmers, in which we discussed our intention of trying to link farmers' knowledge and experience with that of scientists, in a self-sustaining manner. Our efforts to persuade women to attend the meetings failed. They pleaded shyness, trouble with Indonesian, child care, and other responsibilities.

In a final planning meeting, with the men from all 20 families, we suggested a possible experimental plan[4] that included four soil-amendment treatments, each occupying a plot 10m x 20m, and a proposed cropping pattern developed by the Indonesian Food Crops Institute in Sukarami, West Sumatra, and by Mike in Peru in the 1970s (Wade and Sanchez 1984).

Our proposed cropping plan included rice, subsequently intercropped with cassava. The second crop, an edible legume, would be planted between the growing cassava rows. The final crop, after the edible legume harvest, would be a leguminous

---

[3]These collaborative, on-farm activities have been reported in more detail in Colfer et al. 1984a, 1987a, 1989a; Wade et al. 1985a, 1985b; Gill et al. 1986.

[4]With the benefit of hindsight, and exposure to the many ideas discussed at a 1987 workshop (Chambers, Pacey and Thrupp 1989), I will, in the future, make even the initial plan with farmers, or at least brainstorm with them more, before developing the initial experimental design.

ground cover (*Calopogonium muconoides*) over half of each plot, with the other half planted to a mixture of vegetables. Three rambutan trees were also to be planted on each plot (12/farmer).

The farmers were forthcoming in their comments. One prompted a lively discussion by suggesting that we replace *Calopogonium* with mucuna beans (*Mucuna mocunoides*)—something the Javanese eat. The Sundanese thought mucuna beans were either intoxicating or nauseating. All agreed that the soil-enhancing qualities of mucuna bean were equivalent to *Calopogonium*, so we made the change. The condition of their log-littered rice fields, the importance of following through on commitments, their desire for a grove of rambutan trees, and related implications for plot locations on fields were all discussed.

At that meeting, we firmly established the collaborative nature of our experiment by altering aspects of our plan as desired by the farmers, when doing so would not incur significant additional expenses. We also went far in establishing rapport with these farmers by going out to their fields with them and helping them work.

During the rice-growing season, we worked regularly with the farmers, laying out plots, planting, fertilizing, and spraying. We noted the active involvement of women, particularly in planting. As the rainy season wore on, problems began to emerge which required changes in our plans.

The masses of nearly impenetrable roots we discovered just under the surface of their plots, and farmers' inability to hoe as planned, resulted in an early change in the experimental design—light hoeing instead of deep hoeing.

Later an old, weak Minang farmer simply refused to hoe his plots; a few others were also reticent. We took advantage of this and incorporated a till–no till treatment into the experiment. The effects of tillage—a major concern of the farmers from the beginning—turned out to be more significant than our fertility treatments (Table 1). The hoed plots gave uniform yields, which means they did not respond to the chemical amendments. Yields on the unhoed plots increased as amendments increased, with only the limed plots yielding as high as any of the hoed plots. This suggested—and subsequent

Table 1. Effects of tillage and fertility treatments on yield of white and red rice varieties.

	White rice		Red rice	
Treatment	No till	Till	No till	Till
	kg/200m² plot (no. of farmers)			
Control	3.6 (12)	5.7 (6)	5.7 (11)	9.6 (6)
Government	4.2 (9)	6.9 (10)	7.4 (8)	10.9 (9)
Rock phos.	5.6 (3)	6.1 (16)	4.4 (3)	9.4 (15)
Lime–NPK	4.8 (2)	7.1 (17)	8.4 (2)	9.4 (16)
Mean	4.6	6.3	6.5	9.8

From Wade, Colfer, and Santoso 1985b.

component research confirmed—that cultivation could, to some extent, substitute for inputs (Agus et al. 1986; Wade et al. 1985a).

In October several farmers suggested incorporating corn into the experiment by interplanting with the young rice seedlings. We agreed, and ran a meeting to discuss the planting arrangements, which were more complex than the simple spacing for rice. Again, only the men came to the meeting. The corn was planted too late and failed completely; but we also learned the folly of not discussing planting procedures with the women—the corn in almost every field was planted differently.

Over the years, the collaboration with these farmers continued, supplying both improvements in our on-farm trials and direction for our component research on-station. The things farmers failed to do

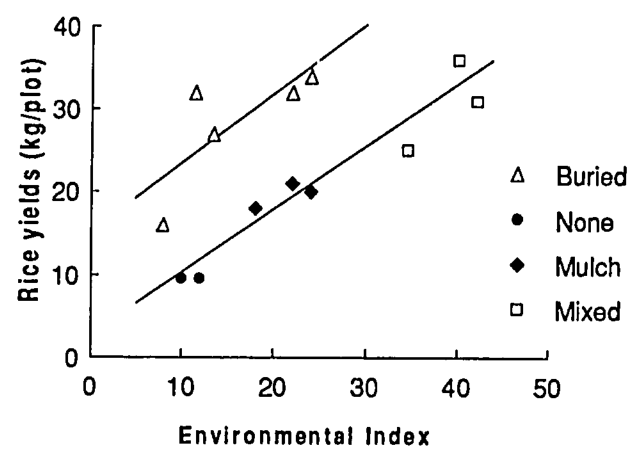


Figure 3. Rice-yield response to environmental index (Hildebrand 1985) for green manure buried in furrows, used as mulch, or mixed into the soil.

Table 2. Crop response to fertility treatments (mean of participating farmers, Sitiung VC, 1983-85).

Treatment	Rice Year 1 White	Rice Year 1 Red	Rice Year 2 Red	Peanut Year 1	Peanut Year 2	Rambutan Height	Rambutan Girth
	kg/plot ($200m^2$)					cm	
Control	4.2 a*	7.2	25	8.2 a	11.0 a	138	6.6
Government	5.5 b	8.5	20	9.8 b	15.5 bc	144	6.8
Rock phosphate	6.0 b	9.2	24	10.2 b	14.0 b	142	6.7
Lime–NPK	6.8 c	8.5	27	13.8 c	16.2 c	137	6.5
CV (%)	31	32	21	22	15	10	7

*Rows within a column followed by the same letter are not different at P.05 (DMRT).
From Wade, Colfer, and Santoso 1985b.

were often as instructive as those they chose to do. Farmers failed to plant a third crop during the first year. Though disappointed, we eventually learned the impracticality of a third crop when rainfall is so unpredictable. Our original idea of planting vegetables as an upland field crop—to enhance nutrition—proved impractical. We realized their home gardens were their usual source of vegetables and were in fact much more accessible for women than the more distant upland fields.

Farmers were unwilling to sustain the loss from low yields on their control plot for a second rice crop (1984 – 85), so we provided green leaf manure (GLM). Observation of their management of the GLM was instructive: Some did not use it; some mulched it; some mixed it into the soil; and some buried it in furrows. Burying the GLM was significantly more effective in increasing rice yields (Figure 3). Similarly, we observed their management of straw residue. This, like our observation of their GLM management, led to a range of experiments, both on and off the farm. Appendix II and Table 2 summarize specific things we learned from this collaboration.

Studies of Farmers

Besides the process-based approach of working with farmers, we needed to learn something about farmer characteristics. In the following sections we discuss a time-allocation study, a series of interviews with farmers, and a study of farmers' and scientists' views on constraints.

Time Allocation—Sitiung IA and VC[5]
with Russell Yost

I had planned from the start to conduct an observational time-allocation study (cf. Johnson 1975; Colfer 1981; Colfer et al. 1984b, 1987b; Tripp 1982); but differences between Sitiung IA and Sitiung VC made it clear that the study would have to include at least two locations.

Differences were obvious: Sitiung IA was a community that had been moved *en masse* in 1976 from Wonogiri in Central Java. In Sitiung IA, homes were larger than those in the newer blocks. The home gardens were complex and multistoreyed, and the families had cows, goats, and chickens. The farming system included paddy rice and other food crops, as well as some fishponds.

Sitiung VC farm families had no paddy rice or fishponds, and only a few chickens; they were busy clearing logs from their upland fields. Their home gardens, to which they applied most of the government fertilizer subsidy intended for their rice fields, were at that time largely devoted to field crops.

[5]This time allocation study is reported in more detail in Colfer et al. 1984b and Colfer and Yost 1987b.

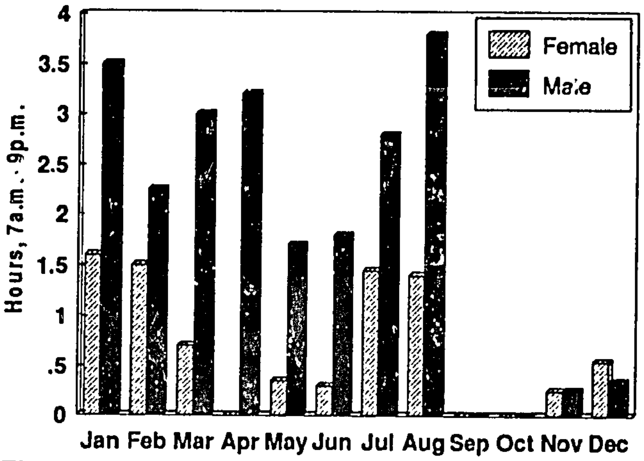


Figure 4. Seasonal variation in allocation of labor to upland fields, by sex, Sitiung IA, 1983-84.

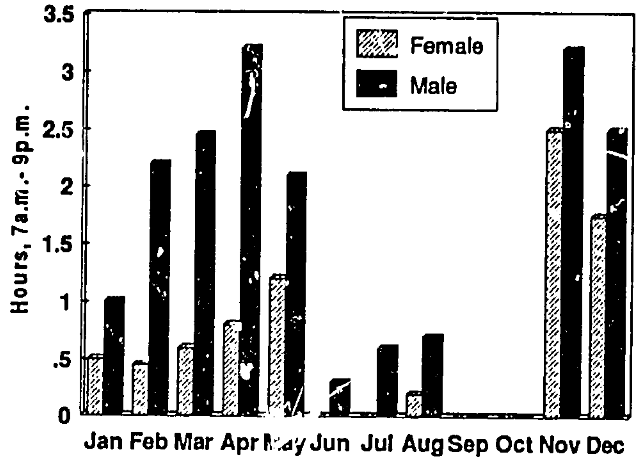


Figure 5. Seasonal variation in allocation of labor to paddy rice, by sex, Sitiung IA, 1983-84.

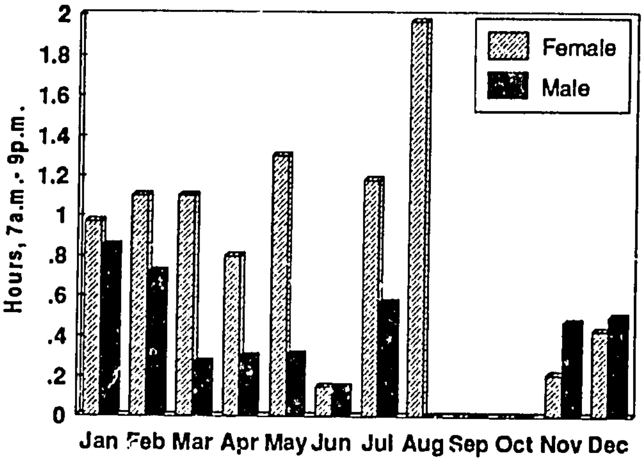


Figure 6. Seasonal variation in allocation of labor to home gardens, by sex, Sitiung IA, 1983-84.

Our study involved blocking two visits in each of two consecutive one-hour time slots (four visits every other day).[6] Households were scheduled in a rotating manner, to avoid duplicating visits with the same household within a short amount of time. Visits involved recording the sex, age, and activity or activities of each individual who resided in the household, by observation insofar as possible.

I began doing the interviews and gradually trained other team and paid community members to make the visits. In this way 5,635 observations of individuals were made over the course of a year. These data form a reasonable account of both the normal activities that occupy farmers and the division of labor by sex, location, and activity.

This study served as a rich source of insights for the team. The finding that in Sitiung IA 14% of people's time was devoted to caring for their livestock, which were fed mainly by cut-and-carry methods, reinforced our interest in pasture. We initiated a series of component trials on pasture grasses.

Figures 4 through 6 show the monthly division of labor by gender and field in Sitiung IA, 1983-84 (September–October missing). Work on upland fields and home gardens peaked in August for men and women, respectively. The active involvement of both sexes in farming is clear from these data, as is women's dominance in home gardening.

Figures 7 and 8 show 1983-84 data for Sitiung VC, which had no wet rice fields. Again, both sexes were involved in farming, though less so than in Sitiung IA. The comparatively greater involvement of men in home garden activities in Sitiung VC reflects family dependence—for subsistence—on that land which was most likely to be cleared of forest debris.

These quantitative findings alerted us to the integrated nature of agricultural activities other than those in upland fields—home gardening, livestock, and wet rice fields—and to off-farm labor as an

[6]Interviewers were given some flexibility to schedule their visits on either of the two days. We were careful, however, not to postpone a visit simply because it was raining—as rain was common and would likely affect people's behavior.

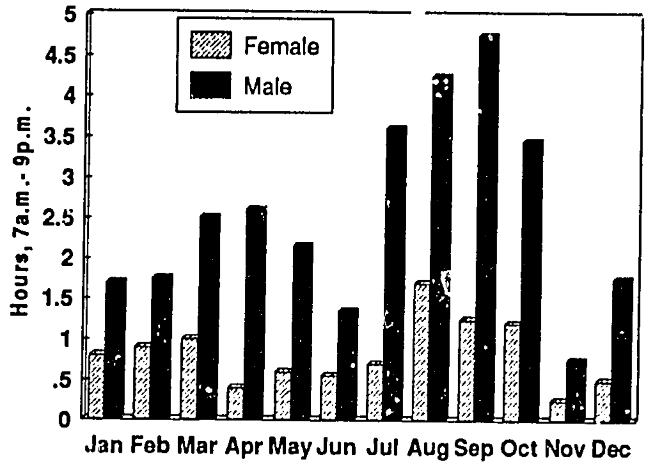


Figure 7. Seasonal variation in allocation of labor to upland fields, by sex, Sitiung VC, 1983-84.

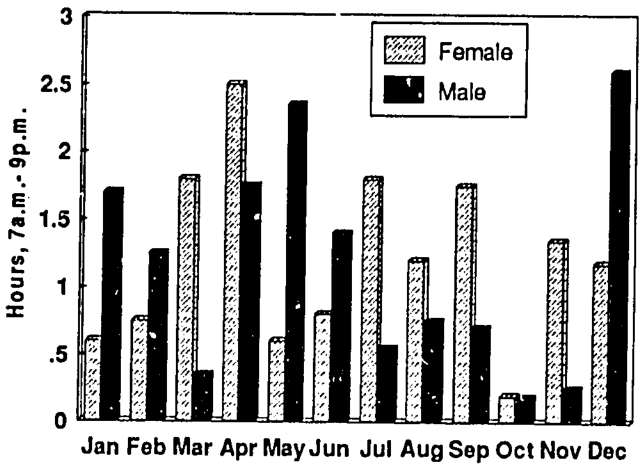


Figure 8. Seasonal variation in allocation of labor to home gardens, by sex, Sitiung VC, 1983-84.

integral part of the transmigrants' farming systems. The study also provided a data base to which we could return with specific questions about people's behavior.

Farmer Interview Series[7]

with Barbara Chapman, Bartholomeus Wied, Harry Apriadji, and Liek Irianti

We wanted to get a better sense of the nutritional, educational, health, and economic status of these people. We were also concerned about the representativeness of our cooperator farmers in Sitiung VC—because of our selection method. I chose 20 additional families randomly (stratified by ethnic group) and developed a series of interviews with all 40 families (cooperators and controls). A typical anthropologist, I was suspicious of surveys and reasoned that accuracy of response would improve if I could develop rapport, over time, with the sample families. Major topics in my first survey (11–12/83) included family composition, indicators of wealth, pre-transmigration experience, sources of income, and proportion of family farmland bulldozed.

The second interview series (1-2/84) focused on health and nutritional considerations, absences from Sitiung VC, animal ownership, current soil management practices, and interest in and ownership of tree crops.

The final series (planned by Chapman and me, and conducted in April 1984 by Bartholomeus Wied Harry Apriadji and Liek Irianti) was part of a larger survey conducted in Sitiung I, II, and VC (see Chapman 1984a, b, c; Colfer et al. 1985; 1987h). It included two-day dietary recall data including food source, and a section on sources and amounts of income.

Our findings may be divided into three main topics: income, labor availability, and existing knowledge (formal education and experience). We were interested in how poor the people were when they arrived, largely because we wanted to evaluate access to chemical fertilizers. Over half (23 farmers) brought no money with them, and none brought more than $100. Half of the 40 farmers had been completely landless, 15 more had less than 0.5 ha. The only farmers with more than a hectare were four local, reportedly landless, Minangkabau.[8]

Farmers' interest in soil conservation, which we had observed in their placement of logs on sloping lands, was also clear in their avoidance of bulldozing. Scientists who visited Sitiung I at the time of settlement characterized the location as a "moonscape." The remaining soils would not sustain a crop for the first couple of years.

Sitiung VC farmers, faced with the backbreaking task of clearing their fields of rotting logs, had

[7]These nutritional and income data are reported in more detail in Chapman 1984a, b, c, and Colfer et al. 1984a, 1985, 1987h.

[8]This is ironic since transmigration policy was to recruit local landless people in to the transmigration program.

Table 3. Average value of agricultural produce (in U.S. dollars) by village and by type of field per family per year (May 1983—April 1984) (Currency conversion—Rp. 1,000 = U.S. $1).

Location	N	Garden	Dry field	Paddy	Total value
		$ (%)	$ (%)	$ (%)	$ (%)
Sitiung I	20	36 (28)	6 (3)	88 (68)	130 (100)
Sitiung II	20	89 (33)	180 (67)	1 (—)	270 (99)§
Sitiung Va	20	53 (60)	35 (39)	– (—)	88 (99)§
Sitiung Vb	20	74 (44)	94 (56)	– (—)	167 (99)§
Mean		63	79	NA¶	164

a = A random sample from Sitiung V.
b = Our cooperator farmers from Sitiung V.
§ Rounding error.
¶ Only Sitiung I has paddy rice.
Revised from Colfer, C. Evensen, S. Evensen, Agus, Gill, A. Wade, and Chapman

access to free bulldozing. Only six of the 40 farmers took advantage of the offer; nine had partial bulldozing (in seven cases, less than one-quarter of the field); and 25 had no bulldozing at all.

The Sitiung VC Minangkabau had the lowest reported average annual income ($561, with a range from $371–$997). The East Javanese averaged $671 (range $545–$937), and the Sundanese were the wealthiest with an average of $779 (range: $267-$1,506). Included in these figures is an average government subsidy of $316, supplied during the first year of settlement only (Colfer et al. 1984a).

The source of income was also of interest (Tables 3 through 5; 1983-84 exchange rate: Rp. 1,000 = U.S. $1). Consistent with time-allocation study findings, off-farm labor provided a very significant, but varying percentage of people's incomes. The importance of home gardens compared to that of other agricultural endeavors, was noteworthy.

In the absence of cash, increased yields can sometimes be gained through more intensive management, requiring more labor. Most families had one male and one female agricultural worker. But frequent absence from Sitiung VC affected this labor availability.

Most Minangkabau farmers had returned to their home village by December 1984, abandoning their upland fields and leaving home gardens of sugarcane and tree seedlings (see "Thrust 3: Turning to the Indigenous Minangkabau"). The Javanese went home to visit or to persuade relatives to join them. Some Sundanese returned home to West Java for good, unwilling to accept that they might have to rely on cassava as a staple.

The reproductive status of women also affects labor availability. Thirty-five percent of the families surveyed included a nursing mother, and eight percent of the farm women knew they were pregnant. Family planning, though promised by the government, was not yet available.

People's health, and hence productivity, are adversely affected by low nutritional status. Recommended per capita caloric intake for the Indonesian population is 2,062 calories and 47 grams of protein daily. Chapman's research in Sitiung showed an average caloric intake of 1,840 calories, with 45 grams of protein per day (Table 6). Chapman concludes that

> Like Java, nutrition in Sitiung is poor. By conservative estimates, 50% of the families consume less than their nutritional needs of calories, protein, and vitamin A (1984b:2).

Only the Minangkabau had adequate levels of protein; none of the ethnic groups had sufficient caloric intake.

Illness can interfere significantly with agricultural labor. Although only a rough indicator, we

Table 4. Subsistence vs. sale of agricultural produce—per-family averages in dollars from garden, dry field, and paddy—as reported in three Sitiung locations (Rp. 1000 = U.S. $1; May 1983 through April 1984).

Location	N	Produce consumed	Produce sold	Total Agri. value
		$ (%)	$ (%)	$ (%)§
Sitiung I	20	112 (80)	28 (20)	140 (100)
Sitiung II	20	157 (58)	112 (42)	269 (100)
Sitiung Va	20	57 (61)	36 (39)	93 (100)
Sitiung Vb	20	78 (46)	91 (54)	169 (100)

a = Random Sample.
b = Cooperator Farmers.
§ Inconsistencies between Table 3 and 4 totals derive from rounding errors.
Revised from Colfer, C. Evensen, S. Evensen, Agus, Gill, A. Wade, and B. Chapman 1985.

found that over the two-month period between our first and second interviews, 19 families reported no health problems. But 16 children in 11 families, eight men, and ten women reported ailments, and one old woman died during that period.

Our third topic, existing knowledge (education and experience), was investigated because of the occasional practice of recruiting urban people without agricultural experience to agriculturally based transmigration projects. We found that almost half of our sample (45% of the women, and 44% of the men) had been farmers, and an additional third (26% of the women, and 38% of the men) had been agricultural laborers on Java. Of the women, 29% had no agricultural experience, with 18% of the men similarly lacking.

There was an ethnic difference in agricultural experience as well, with the Sundanese having the highest percentage without agricultural experience (31% for men and 38% for women). The Minang had the highest percentage of farm-owners (60%, both sexes).

Table 5. Sources of reported earned income per family (May 1983 through April 1984) in three Sitiung locations (Rp. 1,000 = U.S. $1).

Location	N	Home industry	Wage labor	Agricultural production	Total income
		ave. $ (%)	ave. $ (%)	ave. $ (%)	ave. $ (%)
Sitiung I	20	87 (22)	163 (42)	140 (36)	390 (100)
Sitiung II	20	95 (11)	526 (59)	267 (30)	888 (100)
Sitiung Va	20	28 (3)	737 (86)	88 (10)	853 (99)§
Sitiung Vb	20	42 (11)	157 (43)	168 (46)	367 (100)
Mean		63	396	166	624

a = Random sample.
b = Cooperator farmers.
§ Rounding error.
Revised from Colfer, C. Evensen, S. Evensen, Agus, Gill, A. Wade, and Chapman 1985.

Many transmigrants earned wages from off-farm labor, including log-clearing in Sitiung VC.

Average educational attainments were low, ranging from 2.7 years for the East Javanese to 3.8 for the Sundanese. Fully 75% of the East Javanese had never attended school. However, the difference between men and women in average educational attainment was slight—only 0.2 years. Among the Minang, who have a comparatively strong cultural emphasis on formal education, the difference between men's and women's education averaged 1.7 years. Minang men had the highest average education—4.2 years.

Besides getting an overall picture of various factors we suspected to be important for agricultural development, we had our fears confirmed. Our cooperator farmers were indeed somewhat atypical. They were wealthier (both in land on Java and cash on arrival), better educated, better connected, and more involved in agricultural activities, and less involved in off-farm work, than were their control counterparts. They also had lower 1983-84 incomes than did those in the control groups (Table 5).

Table 6. Household nutrient intakes, by ethnic group. Sample of 80 families from Sitiung I, II and V, April 1984.

Ethnic group	Per capita calories		
	<1800	1800 – 2200	>2200
Java	58%	25%	16%
Sunda	75%	16%	8%
Minang	60%	30%	10%
	Per capita protein		
	<34 gr.	35 – 54 gr.	>55 gr.
Java	49%	38%	13%
Sunda	67%	17%	17%
Minang	10%	60%	30%
	Per capita Vitamin A		
	<3500 IU	3500 – 5500 IU	>5000 IU
Java	55%	16%	29%
Sunda	42%	42%	17%
Minang	40%	0%	60%

From Chapman 1984c.

Constraints[9]

with C. Evensen, Herman, M. Wade, and D. Gill

As time went on, we began to suspect that our views on constraints to production were somewhat different from farmers'. We developed a list of constraints we deemed scientifically important:

—low soil nutrient levels (particularly extractable bases Ca, Mg, K, and extractable P);

—soil acidity (Al + H levels of 2 to 3 cmol/kg common; soil CEC generally low, so acid saturation (Al+H/ECEC x 100) of unlimed soils often >60%);

—moisture stress (low availability of soil moisture related to high permeability of soils, shallow rooting—probably related to high Al saturation and/or low supply of bases in subsoil—and lack of water-management practices, such as mulching);

—soil variability (soil chemical and physical properties vary dramatically over distances as small as one meter (Trangmar et al. 1984));

—soil erosion (many fields provided for transmigrants on steep slopes);

—poor supply of agricultural inputs (cf. Perry 1985);

—quality of seeds (typically saved from the previous year or bought in local markets, perhaps exacerbating disease and pest problems);

—pests and diseases. For rice, these include rice blast (*Pyricularia oryzae*), seedling fly (*Atherion exiqua*), stem borer (*Chilo suppressalis?*), and brown planthopper (*Nilaparvata lugens*). For soybeans, they include seedling fly (*Agromyza* sp.) and a pod borer (*Etiella zinckenella*). For corn, peanuts, and cassava, the primary pest was wild pig.

We developed an instrument for determining farmers' views and selected 40 families, ten each in Sitiung I, II, V, and Koto Padang (an indigenous Minang village that had owned the forest which became Sitiung VC). Respondents were equally divided by gender. In each location, we selected residents of houses separated by at least ten other houses. A good cross-section of Sitiung, by gender and ethnicity, was obtained for in-depth interviewing.

We found farmers most concerned about the following constraints:

—poor soil and climatic conditions (the different ethnic groups perceived these problems and their solutions differently);

—labor scarcity (particularly for land preparation and harvest);

—shortage of cash for labor and agricultural inputs, and fears about ability to repay loans;

—marketing problems (closely related to transportation costs and other problems due to poor roads);

—agricultural risks due to pests and diseases (particularly the weed, *Imperata cylindrica*; birds and rats attacking rice; wild pigs decimating corn, peanuts, and cassava; and insects and diseases);

—governmental policy requiring emphasis on field crops in transmigrants' upland fields (until 1985), which precluded use of more appropriate perennials except on home gardens;

—lack of irrigation (except in Sitiung I).

This study confirmed our growing sense of the labor problem confronting transmigrant farmers. It was instructive, particularly to the agricultural scientists, to see the holistic view with which farmers perceived and elucidated their problems.

This study provided concrete evidence of commonalities in perception between scientists and farmers, as well. Both were struggling with environmentally determined agricultural problems with pests, water availability, and the vagaries of soil and weather. The ubiquitousness of such problems, combined with the low incomes earned from field-crop agriculture, pushed us to consider alternative agricultural approaches. We began to think about shifting some of our emphasis on food crops to high-value cash crops on home gardens, where intensive management might be more practical. We also began to consider more seriously a thorough investigation of the indigenous Minangkabau farming system.

[9] The data on constraints are reported in more detail in C. Evensen et al. (1985); Colfer et al. (1987c). In July 1984, several junior CSR scientists joined us, including most notably Ir. Fahmuddin Agus (now a Soil Science doctoral student, NCSU); Dr. Soleh Sukmana took over as the Indonesian Site Coordinator. Later that year, we were joined by Carl Evensen (Agronomy PhD student, UH) and Stacy Evensen (nutritionist, UH). In June 1985, Dan Gill (Soil Science PhD student, NCSU) brought his family to join us.

Thrust 2: Transmigrants' Home Gardens, World View, and Agricultural Decision-Making

Our concern with food crops on upland fields continued. But as we learned more about the conditions under which farmers were laboring, we realized that we were ignoring some good opportunities. Many factors influenced our decision to look more closely at home gardens.

We had been surprised by the amount of time devoted to, and income earned from, home gardens. We were also frustrated by our inability to involve women farmers—who dominated home garden production—more effectively in our collaborative work. Home gardens seemed also to provide an opportunity to experiment with crops requiring greater management than was possible on the more distant upland fields.

We wanted an opportunity to include crops with higher monetary and nutritional value in our experimental repertoire. From a strictly logistical point of view, home gardens were also considerably flatter than were many upland fields. So in January 1985, we conducted another *sondeo*.

Sondeo—Home garden[10]

with Carl Evensen, Stacy Evensen, Fahmuddin Agus, Dan Gill, and Ann Wade

We now had a more balanced team: an agronomist, a nutritionist, two soil scientists, a social worker, and an anthropologist, equally divided by sex. Our team of six split into three pairs, to maximize gender access, disciplinary diversity, and language capabilities. We observed and interviewed Central Javanese in Sitiung IA, and Minang, Sundanese, and East Javanese in Sitiung VC. Ann drew maps of three home gardens (Figures 9 through 11).

A house and garden in Sitiung VC.

We found a great diversity in Sitiung IA, despite all households having originally been given seeds and a planting map by transmigration officials for the one-quarter hectare home gardens. All gardens included trees such as rambutan, clove, coconut, stinkbean, papaya, jackfruit, and silk-cotton; pineapples and cassava; and annuals such as peanuts or soybeans, longbeans, chilies, eggplant, taro, cowpeas, rice, and corn. (Appendix III provides a list of crops.) Medicinal plants and spices were also common. All households had chickens. Stalls for goats and cows were almost universal, and fishponds not uncommon. Some home gardens included large areas of unused land.

Ethnically diverse Sitiung VC had still more variation. Minang home gardens (Figure 9) appeared to have only sugarcane; but closer inspection revealed bananas, taro, papaya, peanuts, eggplant, medicinal and magical plants, ginger, yambean, coffee, rambutan, jackfruit, and coconuts, scattered haphazardly amongst partially burned logs.

Some Sunda farmers were very involved in developing fishponds, intending to use the sludge to fertilize clove, rambutan, and orange trees. Chilies, cowpeas, mungbeans, and corn were favorite annuals. Bananas, jackfruit, papaya, and coconut were prominent tree crops. We found these farmers composting and managing crop residues on their home gardens.

[10] This *sondeo* is reported in more detail in Colfer et al. (1985). We made full use of available spouses in the project (e.g. Ann Wade, MSW; Stacy Evensen, MS, nutrition; Richard Dudley, Ph.D., fisheries biology/management), partly to make Sitiung more attractive to our team members. We used spouses, according to their skills, as technicians, English and computer teachers, temporary research assistants, consultants, and sometimes as regular employees. This practice had a positive impact on team morale—a common problem in remote field sites, and it provided valuable input we could not have afforded if we had brought people in from outside.

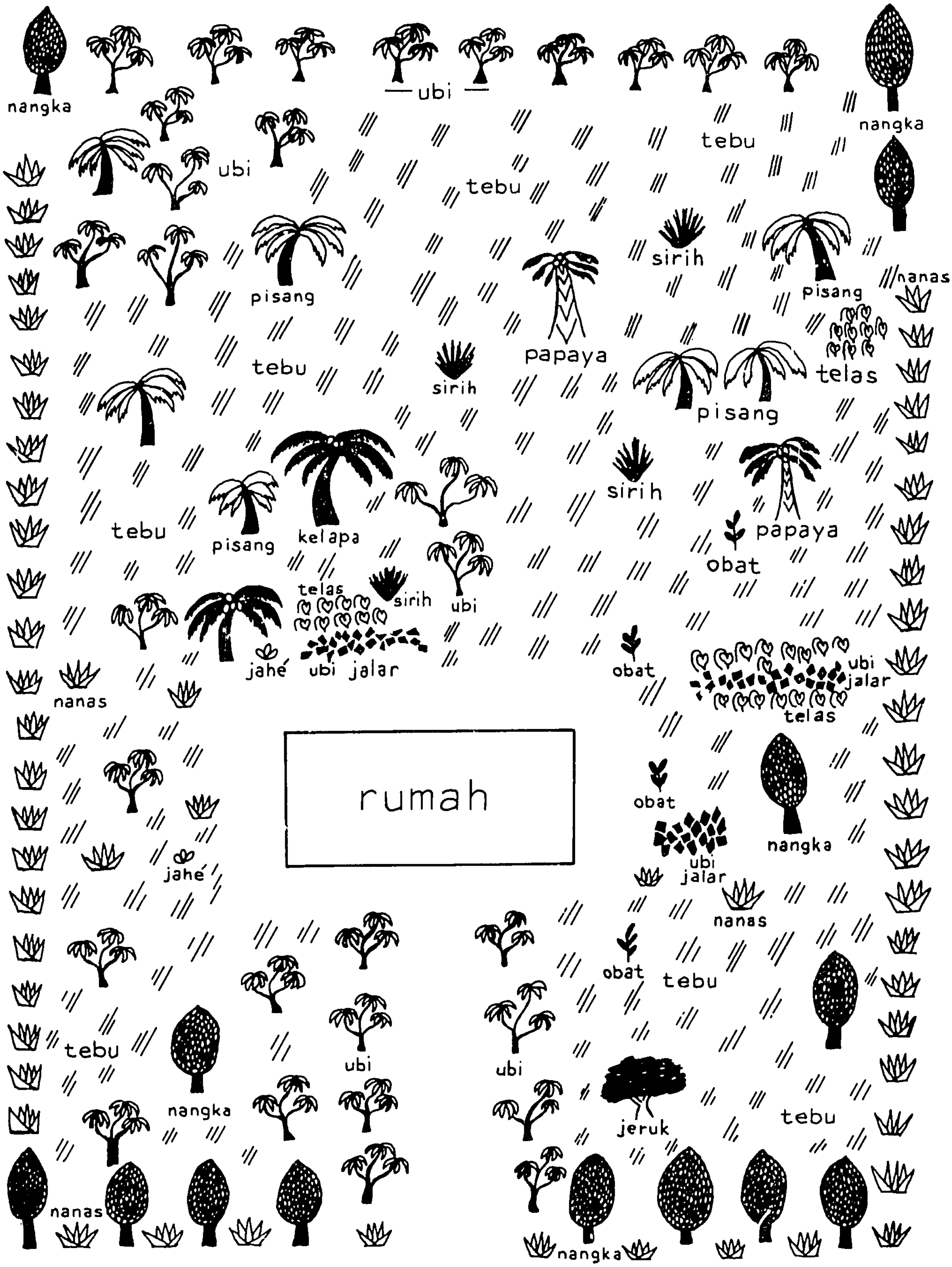


Figure 9. Sketch of a Minang home garden in Sitiung VC, 1985 (from original drawing by Ann Wade).

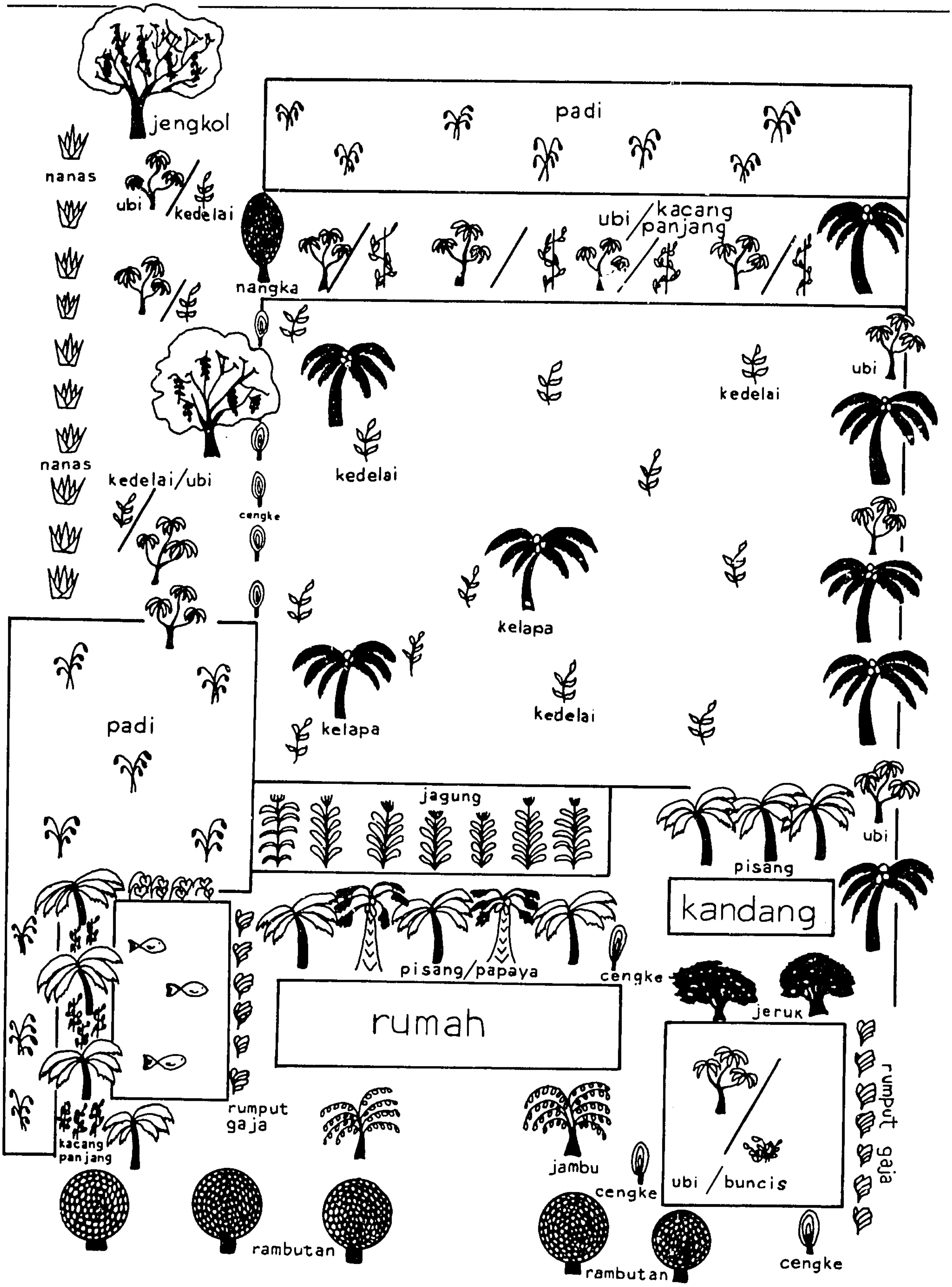


Figure 10. Central Javanese home garden in Sitiung IA, 1985 (from original drawing by Ann Wade).

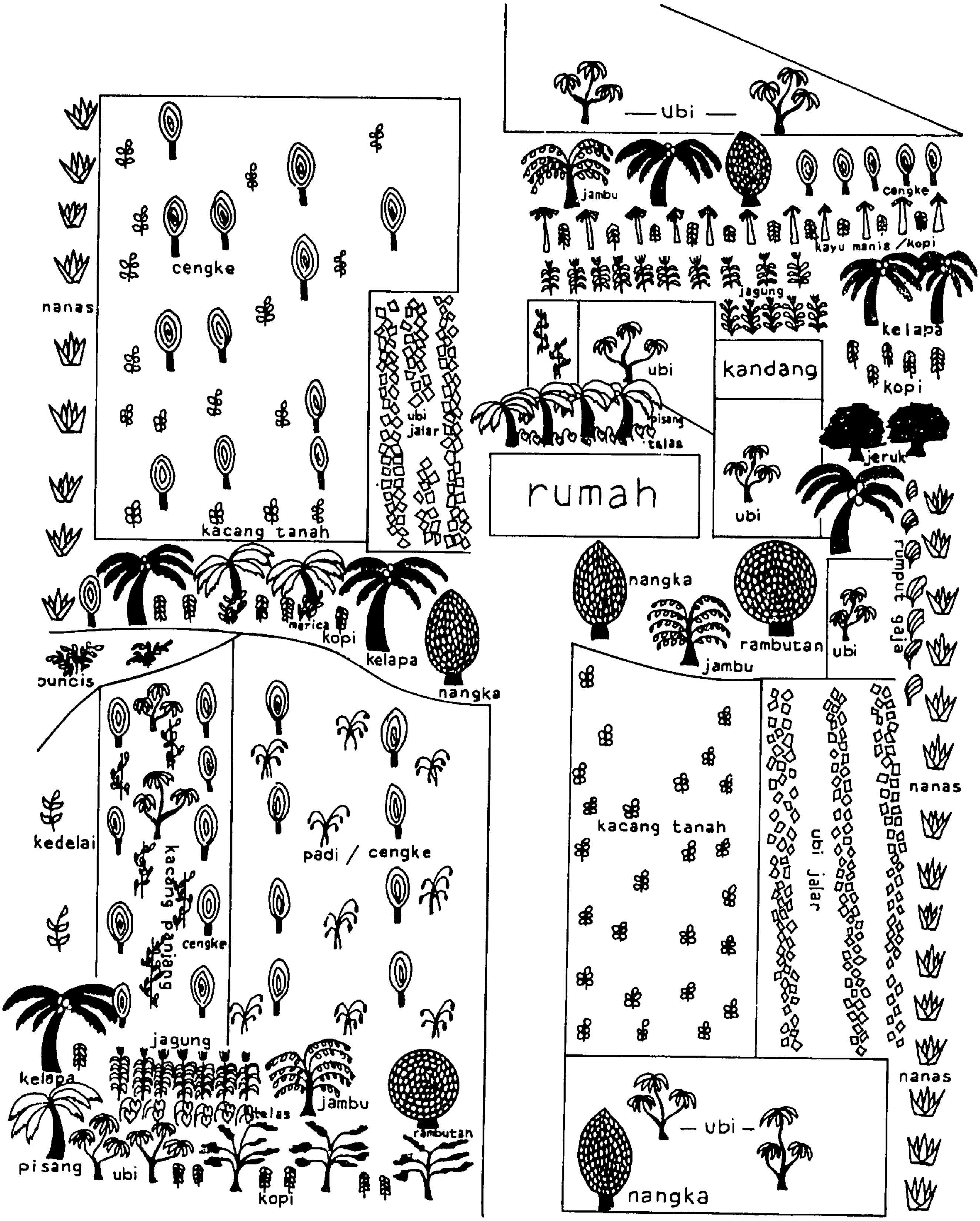


Figure 11. East Javanese home garden in Sitiung VC, 1985 (from original drawing by Ann Wade).

The East Javanese seemed particularly avid terrace builders, and were using their land very intensively. Tidy plots of peanuts, soybeans, and corn were ringed by jackfruit, rambutan, papaya, banana, or coconut borders. Cassava, chili, cowpeas, and pineapples graced smaller areas of the terraces or served as borders.

This second *sondeo* confirmed our sense that home gardens were characterized by crop rotations, fertilizer use, harvesting cycles, and land-preparation methods that differed significantly from methods on upland fields, and that TropSoils should be investigating appropriate soil-management strategies in this context.

Collaborative Work on Home Gardens[11]

with Fahmuddin Agus, Stacy Evensen, Sholeh and Richard Dudley

Fahmuddin spearheaded our first attempt at collaborative work on home gardens. We were concerned about our ignorance of home gardens as systems, but decided to initiate collaborative work while beginning descriptive studies (see next section).

We selected 13 cooperator farmers in Sitiung I and V, seven of whom had fishponds. Our interest in addressing nutritional concerns while looking at soil-management issues—along with farmer interest—led us to an experiment with chilies and bambara groundnuts.

Our 20 Sitiung VC cooperator farmers had already indicated their interest in chilies, though the chilies had failed to thrive because of soil infertility and pests. Farmers liked this crop for home gardens as well. It was high in vitamin A, which is frequently deficient in Indonesian diets, was widely used, and easily marketed. It sometimes brought a high price (in early 1984, $3.55/kg; in early 1986, $0.44/kg).

Bambara groundnuts were used by a few families and desired by more (seeds were hard to find) for subsistence purposes. There was no established market for them. Like the farmers, we were interested in these groundnuts because they were nutritious—rich in protein, carbohydrates, and iron—and because they were easy to harvest and prepare.

Table 7. Effects of different sources of nutrients on chili and bambara groundnut production, Sitiung I and V, 1985 through 1986.

Treatment	Average yield§ Chili	Average yield§ Bambara nuts
	kg/ha	kg/ha
Control	860 b*	2900 c
Compost	1677 a	3860 b
Manure	1883 a	3810 b
Fertilizer	1682 a	4189 a
Fishpond sediment	875 b	2960 c

§ Average of 13 replications, except for the fishpond sediment treatment which is the average of seven replications.

* Any two means having a common letter are not significantly different at the 5% level of significance using DMRT.

Revised from Agus, Colfer, S. Evensen, Sholeh, and Dudley 1989.

Tables 7 through 9 show yield and economic data relating to this trial. But we learned other things of use, as well. For example, we learned that the use of manure was ubiquitous and regular in Sitiung IA, where almost everyone had cattle, but was absent in Sitiung VC. We learned that time and effort were very important to these farmers in evaluating possible soil treatments such as composting and fishpond sludge. And we discovered that we needed to conduct a "species" trial to determine which vegetables were suited to the Sitiung context. This trial would be analogous to the pasture variety trials we conducted (see for instance, Thompson and C. Evensen 1985, C. Evensen et al. 1989).

As younger team members—who had not benefited from our team-building and training in FSR&D in Hawaii—became more involved in collaborative work, we realized the need for ongoing team training. Some young, unmarried men were reticent about trying to work with women. Also, conveying the importance of respecting farmers' views and experience took time and effort.

Meanwhile, our Indonesian collaborators had finally gotten somewhat more comfortable living

[11] This home-gardening collaborative work was reported in Agus et al. 1986, 1989.

conditions. An office (with some housing and lab space) was built between Sitiung IA and VC, near the Food Crops Institute's Sitiung research station. We tried to keep our laboratory needs to a minimum because of the difficulty maintaining equipment and keeping trained people in this remote site, and the likelihood that the government could not continue to support complex and expensive equipment. The new location significantly enhanced intra-team communication.

Table 8. Summary of partial budget calculation for chili§, Sitiung IA and VC, 1985 to 1986 (Rp. 1120 = U.S. $1).

Treatment	AY (KG/HA)	GB($)	NB($)	TCV($)	MRR(%)
Control	731	816	816	0	–
Pond sediment	744	830	777	54	d
Fertilizer	1430	1596	1542	54	1332
Manure	1601	1787	1683	104	288
Compost	1425	1590	1414	177	d

§ "d" in the MRR column means dominated. A treatment is dominated when its TCV is higher but its NB is lower than another treatment. The conversion rate used was Rp. 1,120 = U.S. $1. AY = Adjusted yield; GB = Gross benefit; NB = Net benefit; TCV = Total costs that vary; MRR = Marginal rate of return.

Revised from Agus, Colfer, S. Evensen, Sholeh, and Dudley 1989.

Descriptive Studies on Home Gardens

Although we began our collaborative work early in 1985, we had misgivings related to our ignorance. How should we deal with such complex systems? We determined that an early step must be a descriptive study of just what was in the home gardens and how they were being managed now.

Table 9. Summary of partial budget calculation for bambara nuts§, Sitiung IA and VC, 1985 to 1986 (Rp. 1120 = U.S. $1).

Treatment	AY (KG/HA)	GB($)	NB($)	TCV($)	MRR(%)
Control	2465	550	550	0	–
Pond sediment	3553	793	764	28	750
Fertilizer	2516	562	508	54	d
Manure	3293	735	631	104	d
Compost	3281	732	556	177	d

§ "d" in the MRR column means dominated. A treatment is dominated when its TCV is higher but its NB is lower than another treatment. The conversion rate used was Rp. 1,120 = U.S. $1. AY = Adjusted yield; GB = Gross benefit; NB = Net benefit; TCV = Total costs that vary; MRR = Marginal rate of return.

Revised from Agus, Colfer, S. Evensen, Sholeh, and Dudley 1989.

Home Garden Cropping Systems[12]

with Stacy Evensen

Stacy took the lead, planning a detailed study of eight home gardens, chosen by random sampling of the three ethnic groups in Sitiung VC, which by then had 255 families, 49% Sundanese, 49% Javanese, and 2% Minang. Direct observation, structured interviews, and drop-in visits were used to gather data, beginning in April 1986. An inventory of perennial and annual (food) crops was compiled for each home garden (Table 10); the garden areas specifically devoted to food crops were measured (Table 11).

The pattern initially observed—of home gardens dominated by traditional field crops—had changed by 1986. Perennials such as coffee, rambutan, citrus, and sugarcane were bearing or about to bear; and pineapple, papaya, banana, guava, jackfruit, and starfruit provided a continuous supply of food for home consumption and trade.

Still the diversity of Sitiung home gardens was considerably less than that reported for Java (also noted by Chapman 1984b). Of the 46 species encountered in our inventory, no one garden had more than 28.

The cattle and goat distribution programs planned by the government had not materialized, yet some farmers were planting leguminous trees (*calliandra*, *gliricidia*, and *sesbania*) for future forage and green manure.

When compared with upland fields, of course, the complexity of home gardens is rather daunting—particularly when scientists try to develop experimental designs on conventional soil-management

[12]The descriptive study of home gardening is reported in S. Evensen and Colfer 1989.

Table 10. Crop census of selected home gardens in Sitiung VC, 1986.

	Number of specific crops/trees planted per family									
	East Javanese				Sundanese			Minang		
Crop	A	B	C	D	E	F	G	H	No. of plants	Avg.
Avocado	-	-	-	-	-	-	-	1	1	-
Basil	-	-	-	-	-	1	-	1	-	
Banana	17	2	10	20	5	8	16	15	93	12
Calliandra	6	1	-	-	7	1				
Cassava	§	§	§	§	§	§	§	§	§	-
Chayote	1	-	-	-	-	-	-	-	1	-
Chili	-	3	3	-	-	-	-	10	19	2
Citrus	6	5	5	-	3	3	5	3	30	4
Clove	6	9	10	-	3	9	11	2	60	8
Coconut	11	6	8	6	6	12	13	8	70	9
Coffee	79	69	54	42	18	76	14	150	502	63
Corn	§	-	§	§	§	§	-	§	§	-
Crotolaria	-	-	-	-	§	-	-	-	§	-
Duku	-	-	-	-	-	-	-	3	3	-
Durian	-	-	-	-	1	-	4	-	5	-
Eggplant	-	5	-	-	-	-	-	8	13	2
Embacang	-	-	-	-	-	-	-	4	4	-
Ginger	1	-	-	1	-	-	1	2	5	-
Guava	3	2	13	-	3	7	7	2	37	5
Hyacinth bean	-	-	-	1	-	-	-	-	1	-
Jackfruit	16	16	25	20	17	28	28	32	182	23
Katuk	-	-	6	-	-	12	-	-	18	2
Kunyit	1	-	-	-	-	-	-	-	1	-
Laos	1	-	-	2	-	-	-	1	4	-
Lemongrass	1	-	-	1	-	1	-	1	4	-
Leucaena	-	1	15	21	5	9	-	-	51	6
Longbean	§	-	-	-	-	-	-	-	§	-
Mango	-	-	-	-	2	3	4	-	9	1
Mung bean	-	-	-	-	-	-	-	§	§	-
Papaya	16	2	16	7	6	17	7	6	77	10
Peanut	§	-	-	-	-	§	-	-	§	-
Pigeon pea	-	-	-	-	§	-	-	-	§	-
Pineapple	§	§	§	§	§	§	§	§	§	-
Rambutan	5	17	7	-	14	5	23	12	83	10
Sesbania	2	-	-	-	-	-	-	-	2	-
Silkcotton tree	2	3	2	4	1	-	4	-	162	
Soursop	4	2	5	2	-	4	-	-	17	2
Soybean	§	§	§	§	§	§	-	§	§	-
Spanish plum	-	-	-	-	-	1	-	-	1	-
Starfruit	-	-	-	-	1	-	4	-	5	-
Stinkbean	8	7	16	-	3	1	8	20	63	8
Sugarcane	15	-	-	4	3	1	1	>100	NA	-
Swamp cabbage	-	-	§	-	-	§	-	-	§	-
Sweet potato	§	§	§	-	-	-	-	§	§	-
Tamarind	1	-	-	-	-	-	-	-	1	-
Taro	3	-	-	-	-	-	-	-	3	-

§ An area planted; individual plants not counted.
- No data collected.
NA = Not applicable.
From S. Evensen and Colfer 1989.

Table 11. Home garden area planted to food crops, Sitiung VC, April 1986.

	Crop area (m²)						
Farmer	Soy	Peanut	Corn	Cassava	Mung	% Area unused§	Total area¶
A	2104	443	#	#	–	30	1783
B	1488	–	#	#	–	10	1339
C	945	–	#	260	–	20	965
D	1800	–	#	#	–	10	1620
E	1456	–	288	#	–	10	1570
F	157	–	1823	–	–	10	1782
G	No food crops grown						
H	250	–	70	–	630	5	910

§ Estimate of the area within the measured food crop plots unplanted due to the presence of stumps or trees.

¶ Estimation of the amount of home garden space planted to food crops. With the exception of Farmer A, who has 3200 m², all remaining farmers have 2500 m² available to them on their home garden lot. Of this total, an estimated 400 m² is taken up by the family house, bathing area and entrance or children's play area.

Crop was intercropped with soy or peanut; no individual measurements were taken of its area.

topics. Some significant positive differences include the option to manage more intensively (and guard where needed); the ready availability of composting materials and, where animals are present, manure; the multistoreyed nature of home gardens, providing various shade regimes, and a far greater variety of crops that can be harvested for sale at varying times as well as providing diversity in the diet.

Home gardens have been consistently undervalued in Indonesian research and development. Dove (1990) describes Penny and Ginting's (1984) study of home gardens in Sriharjo, Central Java, finding that an average holding of 0.23 ha of wet rice contributed only 35% of a household's income, while an average home garden holding of 0.1 ha contributed 49%.

For Sriharjo's smallest landowners, the home-garden contribution went up to an average of 92% of family income. Penny and Ginting also cited other studies of Javanese villages, with similar findings. These findings lend credence to our earlier results (Colfer et al. 1985; or Table 3) and justify continued efforts to improve soil management on home gardens.

Fishponds[13]

with Richard G. Dudley and Endang Hidayat

The numerous fishponds in Sitiung seemed suited to transmigrant farming systems. We foresaw three major benefits of improving management of fishponds and their sediment: increased yields of fish to be eaten or sold, improved recycling of waste products from the garden and household, and use of pond water and mud in the home garden.

We designed a study to determine (1) optimal uses of fishponds and pond sediments in improving soils and crop production in home gardens and (2) realistic techniques for enhancing the integration of fish raising and other pond activities into the overall management of the home garden.

In Sitiung IA and VC, 39 small ponds were sampled, including observations, interviews with farmers, and laboratory analysis of grab samples of the surface sediment (top layer of mud at the bottom of the pond). The grab samples were air dried and tested for K, Ca, Mg, P, and Al+H.

The most common fishes found in Sitiung ponds

[13]The study of fishponds is reported in detail in Dudley et al. 1989.

were *Oreochromis mossambicus* (**mujair**, Mozambique tilapia) and *Oreochromis niloticus* (**nila**, Nile tilapia—the species used in USAID's Pond Management CRSP, globally). These two very similar fishes, well suited to Sitiung's difficult conditions, were not highly valued by farmers. Rare, but preferred locally, was *Cyprinus carpio* (**ikan mas**, or common carp), which was more difficult to manage than the two tilapia. *Clarius batrachus* (**ikan lele**, or walking catfish) was uncommon but preferred, and it was suitable for Sitiung conditions.

The fishponds examined averaged 75 m² (ranging from 12 to 600 m²). Although large enough for tilapia and walking catfish, a reasonable maximum yield for a 10m x 10m pond would be about 30 kg or 6 kg per capita for a family of five per year. If sold, this amount of fish would have brought about $40.00 in 1986—a substantial supplement, given local incomes and the modest inputs to fishponds.

About two-thirds of the farmers fed their fish, commonly rice bran (**dedak**) and leftover human food. Reported harvests are shown in Figure 12.

In contrast to our collaborative home-garden trials, we discovered that 21 of 26 pond owners in

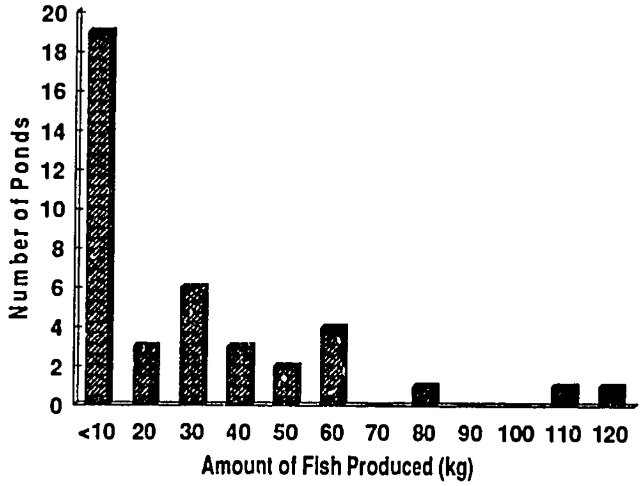


Figure 12. Pond harvest in kg of fish per 100 m² per year, and the number of ponds for each level of harvest. Estimation from farmers.

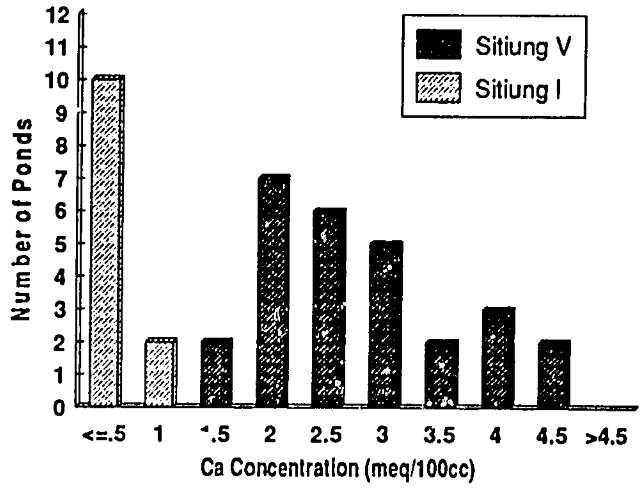


Figure 13. Concentration of Ca in pond mud. Each bar shows the number of ponds which had mud with the indicated concentration of Ca.

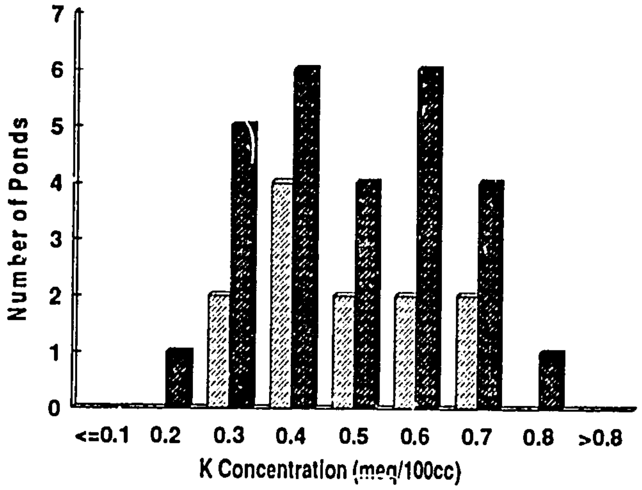


Figure 14. Concentration of K in pond mud. Each bar shows the number of ponds which had mud with the indicated concentration of K.

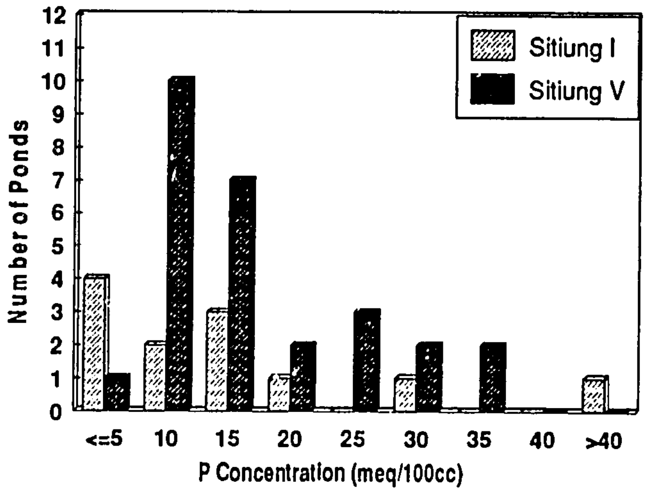


Figure 15. Concentration of P in pond mud. Each bar shows the number of ponds which had mud with the indicated concentration of P.

Sitiung VC used pond sediments as a soil additive—but pond owners used these on trees rather than on annuals. In Sitiung IA, only one of the four pond-owners used sediments in this way. The availability of manure in Sitiung IA, or the presence in Sitiung VC of Sundanese, who traditionally are fishpond enthusiasts, may account for the difference.

Figures 13 through 15 show the concentration of Ca, K, and P in the pond muds. Sediment nutrient levels are affected by age of pond, amount of fertilizer or food added, and growth and sedimentation of nitrogen-fixing algae. Sitiung VC ponds were less than 2.5 years old, and most Sitiung IA ponds were less than five years old.

It seemed probable that the utility of pond sediments and fish yields could be enhanced, over time, if pond management practices were intensified and additional food and fertilizers were added to the ponds (resulting in a potential conflict with agricultural uses of fertilizers).

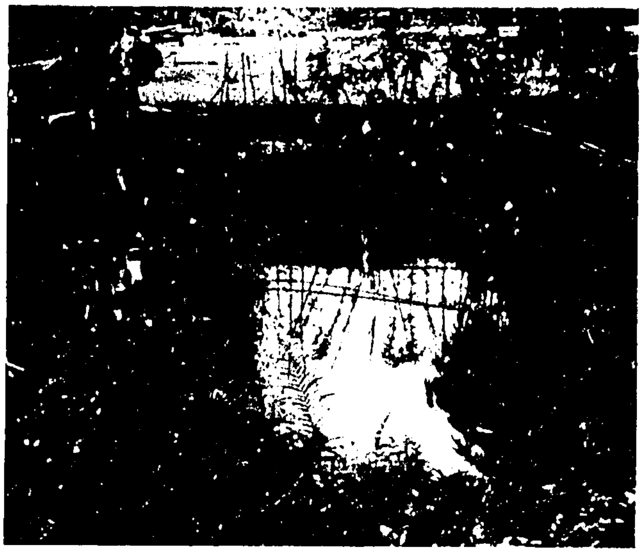
Small Ruminants[14]

with Ann Wade

Our study, conducted in September and October 1983 in collaboration with the Small Ruminants CRSP, suddenly gained additional relevance. We had been asked to administer a questionnaire and make observations of Sitiung farmers who had goats. We identified 41 farmers, by opportunity sample, mostly in our community of Sitiung IA. These farmers had a total of 138 goats, with an average herd size of 3.4.

We found that 90% of these farmers who owned goats also owned cattle; 65% of them had chickens as well. Thirty-two percent of the farmers fed their goats by the cut-and-carry methods, and 68% used a combination of cut-and-carry and grazing. All these farmers gave water to their goats, and 95% gave salt as well—sound management practices. No one dewormed animals or administered any form of medication, yet only 6% of the goats in the sample had died during the previous year (compared to 25% in Galang, a village in North Sumatra where a similar study was carried out the same year).

[14]This study of small ruminants is reported in Pulungan et al. 1985.



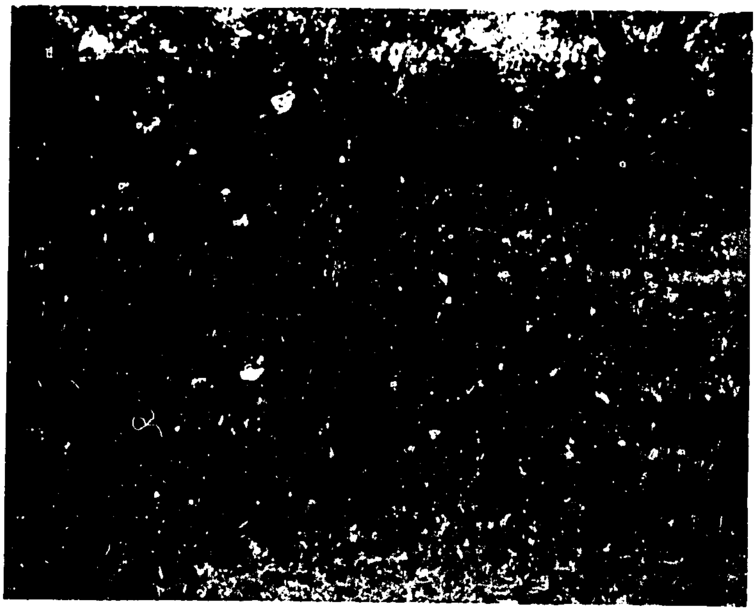
Richard Dudley inspecting a pond in Sitiung IA.

Men, women, and children were reported as participating almost equally in cut-and-carry activities. Seventeen farmers reported that their children did the herding, six the wife, and three the husband. Grazing took place in home gardens (50%), on roadside or fields (46%), or in woods (4%).

Many goat owners (83%) selected young grass for cutting, with 51% expressing a preference for elephant grass. The leaves of jackfruit and cassava were given to goats by 49% and 41% of the farmers respectively. Such leaves are protein-rich and provide an excellent complement to their grass diet. Also important human foods, these crops are typically available in the home garden. The bran from rice was also fed to goats (41% of the respondents) and cattle, and the animal wastes were used for fertilizer.

Cattle, we had gradually come to realize, were seen principally as a source of emergency cash. If a major financial need arose, people would sell a cow. This was also true, to a lesser degree, with goats—which were only eaten during parties (common in Javanese villages). Cattle were also used as draft animals and were seen as a source of prestige.

During the course of these studies, the more we learned about home gardens, the more important we found them to people's subsistence, nutrition, and economic well-being. A variety of annuals and perennials gave a continuing supply of food, medicine, and fodder for subsistence and market uses;



Goats grazing in Sitiung IA.

chickens and fish ponds provided a rare source of animal protein; goats and cattle were walking bank accounts; and the garden setting provided shade, flowers, and places to sit and visit or watch one's children in comfort and beauty.

We were also struck by the integrated nature of the transmigrant farming system. Products from one segment fed neatly into other segments of the system, offering many opportunities for informed and careful manipulation. Production of any one item in the system could be enhanced, but care would have to be taken not to disrupt some other dependent component.

Awareness of this integration produced dilemmas—enhancing fish production by increased use of manure as fish feed would reduce the manure available for use in rice fields. Enhancing production of vegetables on the home garden might well interfere with tree crop production on the same land. Such tradeoffs would require evaluation.

This awareness also made us confront genuine problems—increasing production of particular crops could well reduce the nutritional status of the people, who were less likely to eat a crop they could sell for a reasonable price. When they had money to spend, people were likely to buy foods such as cookies, candy, and noodles, which were less nutritious than the amaranth, swamp cabbage, and longbeans they produced for subsistence.

But this awareness also gave us the opportunity to build on these interdependencies. We realized that with the transmigrants' cut-and-carry system of feeding their animals, some would be interested in planting fodders that could also increase soil fertility and reduce erosion. The use by some farmers of rice residues prompted us to experiment with various application techniques to determine the method that would most benefit the subsequent legume crop. It might be possible to increase fish production by using chicken manure (which was not currently used).

We were beginning to understand the importance of having a diversity of income sources, in an environment as characterized by risks as Sitiung. Rarely was one source of income sufficient to support a family. Few endeavors were (or were likely to become in the near future) profitable, reliable, or long lasting enough to trust exclusively for family subsistence.

World View and Agricultural Decision-Making

To this point, our research efforts had been directed toward what people were doing—we were either working with them or asking them about their behavior. Yet it seemed to us that people's percep-

Table 12. Measure of values relating to selected soil-management concepts, Sitiung, 1985.

Good and	Minang	Javanese	Sundanese
Soil	js 60	m 31	m 23
Garden	js 60	m 27	m 19
Unirrigated field	js 59	m 27	m 25
Wet rice field	js 58	m 30	m 23
Home garden	js 56	m 28	m 20
Rubber	js 64	ms 41	mj 26
Fruits	js 56	m 29	m 20
Rice	js 55	m 25	m 24
Other field crop	js 62	ms 30	mj 19
Vegetables	js 62	m 24	m 23
Water	js 46	m 25	m 24
Fertilizer	s 34	s 28	mj 16
Pests	js 68	ms 52	mj 26
Yield	js 61	m 26	m 27
Cultivation	js 66	m 23	m 24

Note: The smaller the number, the more highly valued the concept. If there is a letter before the number, there is a significant difference between ethnic groups. In the Minang column, the distance between "good" and "soil" (60) is significantly greater than that perceived by Javanese (j) and by Sundanese (s).
From Colfer, Newton, and Herman 1989.

Table 13. Measure of behavior relating to selected soil-management concepts, Sitiung, 1985.

Me and	Minang	Javanese	Sundanese
Soil	16	24	14
Garden	27	23	19
Unirrigated field	20	24	23
Wet rice field	16	24	25
Home garden	20	19	20
Rubber	j26	ms 53	j 30
Fruits	32	21	21
Rice	11	22	15
Other field crop	31	23	21
Vegetables	29	18	24
Water	29	22	17
Fertilizer	29	30	22
Pests	s 54	s 54	mj 29
Yield	js 53	m 24	m 23
Cultivation	28	21	24

Note: The smaller the number, the closer the concepts. If there is a letter before the number, there is a significant difference between ethnic groups. In the Javanese column, the distance between "me" and "rubber" (53) is significantly greater than that perceived by the Minang (m) and the Sundanese (s).
From Colfer, Newton, and Herman 1989.

tions were also important. We were particularly interested in documenting how the different ethnic groups saw (1) the general agricultural realm and (2) the appropriate spheres of decision-making for men and women.

Agricultural World Views[15]
with Barbara Newton and Herman

The significant differences among the ethnic groups became progressively clearer as we worked with them on a daily basis. In order to quantify the obvious conceptual differences, we used a multidimensional scaling technique called the Galileo (Woelfel and Fink 1981; Colfer 1982b). The Galileo was designed to portray quantitatively, world views or cognitive maps of particular conceptual domains.

We first selected ten farmers, evenly divided by sex, from each of the three ethnic groups (Minang, Javanese, and Sundanese). We conducted and taped in-depth, nondirected interviews in the respective languages, in which we only asked, "What is the relationship between soil and people?"

The taped interviews were analyzed and substantive concepts were counted. The 21 most common concepts formed the core of an instrument that paired each concept with every other concept. We then selected 100 farmers, evenly divided by sex, from each ethnic group, and asked them to measure the distance, in their own minds, between the concepts. The farmers were to use the distance between black and white (arbitrarily set at 100 units) as a measuring stick. The richest data are in the form of a means matrix for each ethnic group, much like figures showing the distance between cities, published in Colfer et al. 1989c.

[15]This study is reported in detail in Colfer et al. 1987g, 1989b, 1989c.

Table 14. A measure of perceptions of men and soil management concepts, Sitiung, 1985.

Men and	Minang	Javanese	Sundanese
Garden	14	22	19
Unirrigated field	17	22	26
Wet rice field	13	23	26
Home garden	26	24	22
Rubber	js 14	ms 50	mj 32
Fruits	29	24	23
Rice	j 10	m 24	16
Other field crop	33	24	23
Vegetables	s 34	s 28	mj 16
Water	s 52	s 56	mj 21
Fertilizer	js 47	m 27	m 25
Pests	s 50	s 55	mj 28
Yield	js 44	m 26	m 25
Cultivation	23	16	18

Note: The smaller the number, the closer the concepts. If there is a letter before the number, there is a significant difference between ethnic groups. In the Minang column, the distance between "men" and "rubber" (14) is significantly greater than that perceived by the Javanese (j) and the Sundanese (s).
From Colfer, Newton, and Herman 1989.

Table 15. A measure of perceptions of women and soil management concepts, Sitiung, 1985.

Women and	Minang	Javanese	Sundanese
Garden	30	21	20
Unirrigated field	21	24	25
Wet rice field	19	22	17
Home garden	17	20	16
Rubber	38	52	34
Fruits	26	24	24
Rice	14	20	18
Other field crop	26	21	23
Vegetables	20	19	17
Water	js 48	m 24	m 21
Fertilizer	js 76	ms 63	mj 32
Pests	s 46	s 56	mj 30
Yield	js 46	m 26	m 24
Cultivation	30	19	20

Note: The smaller the number, the closer the concepts. If there is a letter before the number, there is a significant difference between ethnic groups. In the Sundanese column, the distance between "women" and "fertilizer" (32) is significantly less than that perceived by the Javanese (j) and the Minang (m).
From Colfer, Newton and Herman 1989.

An interesting feature of this method is the apparent reflection of people's values in the distances they give from "good" (Table 12), and the reflection of their behavior in the distances from "me" (Table 13). People who regularly farm, for instance, tend to put agricultural concepts closer to "me" than would nonfarmers; and if they value farming, they would typically put those concepts close to "good" as well. In this data set, it is clear that though the Minang recognize their farming behavior, they value farming far less than the other two ethnic groups. The greater distances generally used by the Minang (Tables 12 through 15) are striking and consistent with the extensive nature of their farming system (see A Year in Pulai, below). In all ethnic groups, the active agricultural roles of both sexes is clear (Tables 14, 15). The study also reflects the Sundanese emphasis on home gardens, the Minang involvement with rubber, and the central role of rice for all ethnic groups.

This study, like the time-allocation study, served as a rich source of data as we considered working on various fields, with particular crops, or on differing activities related to soil management. The results could also be used effectively in developing extension messages, though our research mandate and time constraints regretfully precluded our doing so.

Women's Decision-Making[16]

with Evi Martha and Vickie Sigman

That we were concerned to incorporate women into the project effectively is clear. In some places, such as the Middle East, women do much of the agricultural labor, yet have little influence on decision-making, little choice in matters related to adoption of new technology or conservation practices. Al-

[16]The women's decision-making studies are reported in Evi Martha 1985, 1986; Colfer et al. 1987e, 1987f, 1989d; and Sigman et al. 1989.

Table 16. Division of labor in paddy rice fields as reported by women farmers, Koto Padang, Sitiung IA and Sitiung ID (in percent of subsample).

	Koto Padang N = 30			Sitiung IA N = 41			Sitiung ID N = 69		
Steps	Wife	Husb.	Fam mem.	Wife	Husb.	Fam mem.	Wife	Husb.	Fam mem.
Hoeing	57	40	27	36	98	37	61	81	38
Flattening	na	na	na	0	98	37	13	90	38
Choosing crop	na	na	na	20	66	0	9	67	1
Planting	43	43	27	98	22	39	91	52	42
Fertilizing	0	0	0	37	98	41	51	77	41
Replanting	63	20	23	95	10	44	90	30	39
Weeding	60	23	20	95	59	49	91	36	48
Controlling H_2O	na	na	na	0	98	0	0	88	36
Spraying	20	40	10	5	98	37	0	88	38
Harvesting	53	43	23	90	95	39	68	84	45
Threshing	53	36	30	95	95	41	86	81	45
Winnowing	na	na	na	88	10	39	87	20	43
Carrying home	30	36	27	78	95	41	62	78	42
Drying	na	na	na	98	0	49	93	20	49
Carrying/huller	na	na	na	90	90	44	74	71	41
Deciding/sell	na	na	na	80	41	0	45	25	0
Controlling $	na	na	na	83	15	0	52	12	0

na = Not asked.
Revised from Martha 1985, 1986. Respondents were asked to identify who participates in each stage in the production of paddy rice. For instance, 57% of the Koto Padang sample reported participating in hoeing. 40% reported their husbands' participating, and 27% reported other family members participating.

though this seemed unlikely to be the case in Sitiung, I felt some compunction to confirm my understanding.

At the same time that I was considering this issue, I was contacted about a collaborative effort being planned by the Farming Systems Support Program and the Population Council—to compile cases of agricultural research that incorporated gender issues (recently published, Feldstein and Poats 1989). They were particularly interested, early on, in intra-household decision-making.

This seemed an excellent means of continuing our collaborative relationship with Andalas University. For very minimal expense and effort, we gained the services of Evi Martha—a Minangkabau sociology student—in two studies of decision-making. She, in turn, received training and supervision in social science methods and in farmer-based and interdisciplinary research.

Evi moved to Koto Padang, a Minang village of 1507 people, for July and August 1985. Our study combined participant observation and a structured questionnaire on division of labor and decision-making in a variety of contexts. We chose a stratified random sample of 30 married Koto Padang women, ten from each three neighborhoods. We interviewed 18 men in the same community.

In early 1986, we conducted a comparison study of Central Javanese women in Sitiung IA and ID. We chose a random sample of 15% of the households in each community, resulting in 41 respondents in Sitiung IA and 69 in Sitiung ID.

Tables 16 through 19 show some of our results from Koto Padang and Sitiung IA and ID. All three communities had wet rice as integral parts of their farming system, and Koto Padang inhabitants relied on tree crops extensively (cf. Naim and Herman 1984). These studies provided us with additional information about other local farming systems. They also confirmed information we had collected by other means about the division of labor by sex in the area.

Our sense that women considered themselves farmers was emphatically confirmed, as was their significant involvement in agricultural decision-making. These studies gave us more specific information about people's allocation of labor to various agricultural tasks than we had been able to get from our time-allocation studies.

The firm hold that women have on family purse

Table 17. Division of labor in home gardens as reported by women farmers, Koto Padang, Sitiung IA and Sitiung ID (in percent of subsample).

	Koto Padang N = 30			Sitiung IA N = 41			Sitiung ID N = 69		
Steps	Wife	Husb.	Fam mem.	Wife	Husb.	Fam mem.	Wife	Husb.	Fam mem.
Choosing crop	na	na	na	41	98	7	16	88	3
Planting	80	20	7	98	95	63	94	71	65
Weeding	87	20	20	98	78	63	96	62	65
Fencing	na	na	na	0	100	63	0	97	65
Harvesting	87	73	53	100	98	63	96	84	64
Selling	na	na	na	15	7	2	10	3	0
Controlling $	na	na	na	17	0	2	10	1	0
Look for grass for livestock	na	na	na	80	85	61	58	78	58

na = Not asked.
Revised from Martha 1985, 1986.

Table 18. Division of labor in upland fields as reported by women farmers, Koto Padang, Sitiung I A and Sitiung ID (in percents of subsamples).

	Koto Padang N = 30			Sitiung IA N = 41			Sitiung ID N = 69		
Steps	Wife	Husb.	Fam mem.	Wife	Husb.	Fam mem.	Wife	Husb.	Fam mem.
Land clearing	7	13	7	7	29	12	4	9	3
Hoeing	n/d	n/d	n/d	24	29	15	22	9	12
Making holes	10	13	7	20	29	12	17	9	12
Choosing crop§	n/a	n/a	n/a	5	29	0	0	9	0
Planting	13	7	7	29	29	17	25	25	13
Fertilizing	n/d	n/d	n/d	17	29	15	22	9	13
Weeding	17	13	7	29	17	17	25	22	16
Harvesting	17	13	13	29	27	17	25	9	16
Carrying home	10	13	13	27	29	17	23	9	16
Deciding/sell	n/a	n/a	n/a	20	12	0	9	13	1
Controlling $	n/a	n/a	n/a	22	2	0	17	1	1

n/d = Not done.
n/a = Not asked.
Revised from Martha 1985; 1986.

strings was something of a surprise to us; and we identified a number of ways that women group—something that can be valuable in efforts to extend new technologies or conservation strategies in the future. We learned that women in all these settings—like the women in our collaborator farm families—rarely attend formal meetings that include men.

In Sum

As these studies progressed and we gained a more complete understanding of the local context, my sense that indigenous systems could offer us valuable guidance and insights grew. The Minang seemed to have a farming system that required less effort than the transmigrants' system yet provided them with a better income. Their nutritional and education status appeared to be better than the transmigrants'. And their land appeared to be in better shape.

The fact that they had dealt with the Sitiung environment for decades (at least) suggested that they should have developed some significant knowledge about subsisting and, to some extent, prospering. We resolved to address Minangkabau farming concerns directly.

Table 19. Division of labor in orchards as reported by women farmers, Koto Padang, 1985.

Steps	Wife	Husband	Family member
Forest clearing	2	4	2
Hole digging	3	4	2
Planting	4	2	2
Weeding	5	4	2
Harvesting	5	4	4
Carrying home	3	4	4

From Martha 1985.

Distinctive Minang house in Koto Padang.

Thrust 3: Turning to the Indigenous Minangkabau

In early 1985, we planned a collaborative project that would incorporate coconuts with green manures and field crops in six locations, including a Minang community, as a first step toward building on the Minang experience with tree crops. However, as our team shrank, that plan had to be set aside.[17]

I remained convinced that the indigenous Minangkabau system could provide us with pointers for structuring our research program. We had observed the differences between transmigrant and Minang farming systems. Some of these differences had been clarified in a 1984 study (Naim and Herman 1984) on tree crops in Koto Padang.

Tree Crops in Koto Padang[18]

with Herman and Mochtar Naim

Herman, a Minangkabau and student of agricultural economics and rural studies at Andalas University,

[17]In the fall of 1985, our team was cut back considerably. The Indonesian governmental budget was cut by a third; the Wades and the Thompsons left. We were joined by Stephenie Kan (Agricultural Economics MS student), and Dr. I. Putu Gedjer took over as Site Coordinator. I became team leader.

[18]The data on Koto Padang tree farming were compiled and analyzed by Herman, with supervision from Mochtar Naim and me. Their report (Naim and Herman 1984) was translated into English by Fahmuddin Agus and me. See also Naim et al. 1987.

lived in Koto Padang in August and September 1984. With a combination of short-term participant observation, secondary data, a formal survey of 31 families, and in-depth interviews with local leaders, we began our study of the Minang farming system, with special reference to tree crops.

Koto Padang had a population of 1,507 (with 62% under 20 years old) in 1984, divided into three distinct neighborhoods. From an anthropological perspective, the Minangkabau had a significantly different cultural tradition from the Javanese and Sundanese, as was clear in our Galileo results.

Consistent with Minang tradition, but unlike Javanese or Sundanese traditions, land is generally owned by and passed through the female line—matrilineal inheritance. Although women's status tends to be comparatively high in matrilineal groups, men continue to wield most political power. A woman's older brother represents the clan in political and resource disputes, rather than her husband or father.

In Koto Padang we found that husbands had greater influence than brothers in decision-making and ownership in the Sitiung area, whereas the reverse was more common in the Minangkabau heartland. Two clans were believed to have settled earlier in the Sitiung area, and thus had greater access to land resources. In contrast to Minang tradition and reputation (Naim 1971; Kato 1982; Schwede 1989), there was very little circular migration—only 3% of the population was absent.

Koto Padang, as well as a number of other indigenous communities, was involved in the Abai Siat Smallholder Rubber Project. This quasi-governmental project was designed to work with local clans to designate one three-hectare plot per family to be replanted to rubber, using "modern" approaches. Seedlings and guidance in spacing, weeding, fertilizers, and pesticides were provided, as was guidance in marketing and employment.

The economic base of the community included both rubber and paddy rice. Naim and Herman's study focused on all tree crops. Table 20 shows the land-use pattern of Koto Padang's 5,200 ha. Table 21 shows the number and kinds of trees in home gardens and in upland fields, with rankings based on contribution to family income.

Table 22 shows the sources of income reported by Koto Padang inhabitants for one month. These data should be interpreted with caution, as accurate accounting is virtually impossible in a short-term study. About 41% of the reported incomes derived, in one way or another, from tree crops—in addition

Table 20. Land use in Koto Padang, 1984.

Land use	Area (ha)	Percent
Forest	838	16.1
Paddy	435	8.4
Rubber smallholding	1827	35.1
Home garden	1125	21.6
Upland field	128	2.5
Swamp	175	3.4
Government-owned land	250	4.8
Other	422	8.1
Total	5200	100%

From Naim and Hermann 1984.

Table 21. Number of tree crops in Koto Padang home gardens and upland fields, 1984.

	Home gardens		Upland fields	
Crop	No. trees	Rank§	No. trees	Rank§
Coffee	941	3	879	1
Coconut	418	1	53	4
Jackfruit	280	8	97	5
Duku	255	2	10	
Rambutan	250		410	
Jengkol	148	6	1028	2
Durien	128	4	43	3
Rubber	95		0	
Cinnamon	95		1	
Badaro	52	5	0	
Jambak	40		0	
Orange	35		230	
Ambacang	30	7	1	
Mangosteen	19		8	
Clove	16		0	
Jambu	16		0	
Komang	6		9	
Manggo	5		0	
Kwini (mango)	4		0	

§ Rank based on contribution to income.
Revised from Naim and Herman 1984.

to subsistence uses. The Minang reported much higher incomes than did transmigrants in Sitiung I—$960/year compared to $390/year (Chapman 1984b). The higher incomes, along with the minimal work involved in managing trees, attracted our interest, as did Naim and Herman's conclusion that 1.5 ha of rubber was sufficient for the subsistence needs of a family of five.

By the fall of 1985, we had decided it was time to look seriously at the Minangkabau system, with the intention of doing collaborative work as soon as we were able to rebuild our team. I hoped that, besides righting an ethnic imbalance, we would discover agricultural approaches that were more compatible with the local environment. Our efforts with field crops just seemed too prone to failure.

A Year in Pulai[19]

For the studies of the Minang, I selected Pulai, a community of 432 people, situated on the southern bank of the Batang Hari River, a ten-minute ride from my home in Sitiung IA. Proximity was a major concern, since I planned to rely heavily on participant observation as a research tool. This would mean spending a lot of time in the community.

After obtaining permission to work there, I designed a third, year-long observational time-allocation study which began in October. Throughout the year I interacted with community members as often as possible, accompanying them to their fields and to community events, visiting them in their homes, and receiving them in my home. Between March and June 1986, Pak Syarif, my village assistant, and I designed and conducted two surveys. One survey on land ownership and use was administered to all 83 households in the community; another on sources and amounts of income reached 78 households, or 94% of the community.

Table 22. Farmers' mean income per month, by source, Koto Padang, 1984 (Rp. 1,000 = U.S. $1).

Source	Income ($)	Total (%)
Rubber	15.23	19
Coconut	2.26	3
Coffee	0.52	1
Duku	0.9	1
Jackfruit	0.21	0
Banana	0.62	1
Sugarcane	0.44	1
Pineapple	0.5	1
Rubber tapping	10.66	13
Project labor	1.54	2
Contracting	11.67	15
Civil service	1.16	1
Transport	17.74	22
Rubber trade	2.95	4
Shop (small)	1.3	2
Animal husbandry	0.42	1
Rice	11.38	14
Total average income	79.5	100

Revised from Naim and Hermann 1985.

Time Allocation—Pulai[20]

with Russell Yost and Stephenie Kan

We used the same method for this study as we had used in the Sitiung IA and VB time-allocation studies (above), and made comparable analyses.

Figure 16 provides an overview of time allocation, by sex, among the most important productive activities—paddy, upland field, home-garden, orchard, cattle, off-farm labor, and forest-related.

Figures 17 through 26 provide more detailed, seasonal information about labor allocation to six of the above activities. Again, female involvement in agriculture was clear. Minang women were even more involved in paddy rice cultivation, compared to men, than were transmigrant women. Figure 20, showing male and female involvement in harvesting tree crops outside the home garden, reflects Minang reliance on the surrounding successional stages of forest regrowth.

---

[19]The Minang farming system encountered in Sitiung is different from that of the Minang heartland. Sitiung is defined as part of the "rantau" (or pioneer areas). Agriculture in the Minang heartland is more focused on wet rice and is more commercial (see, e.g., Schwede 1989).

[20]I planned and coordinated most of the data collection. However, with my departure in July 1986, Stephenie Kan continued supervision of Pak Syarif, the Pulai community member and my field assistant, who had been conducting the interviews. Russ Yost took responsibility for doing the computer analyses of the data.

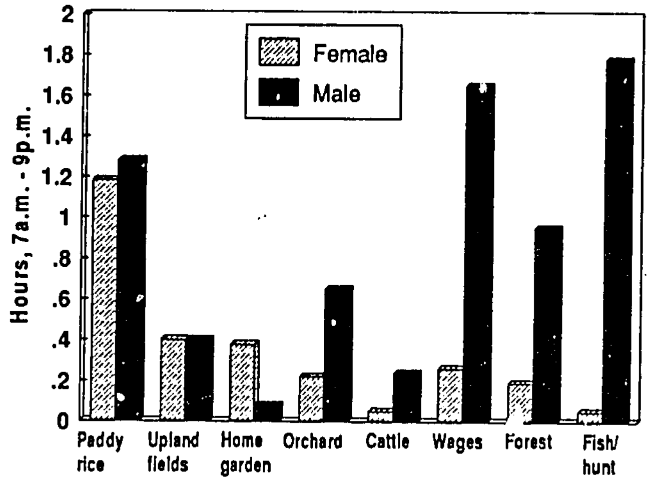


Figure 16. Time allocation to six productive activities, by sex, Pulai, 1985-86.

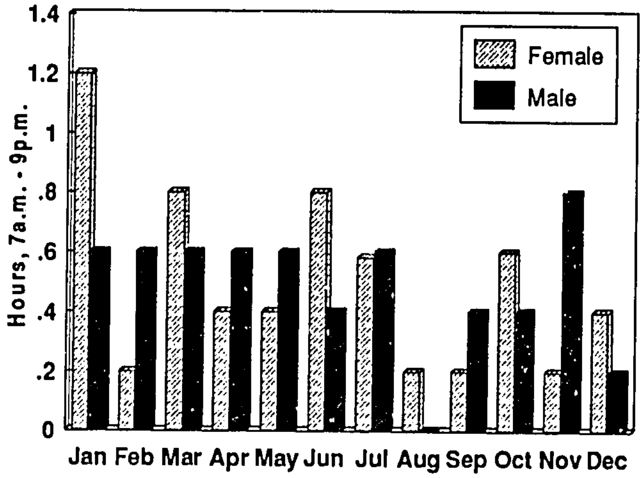


Figure 17. Seasonal variation in the allocation of labor to upland fields, by sex, Pulai, 1985-86.

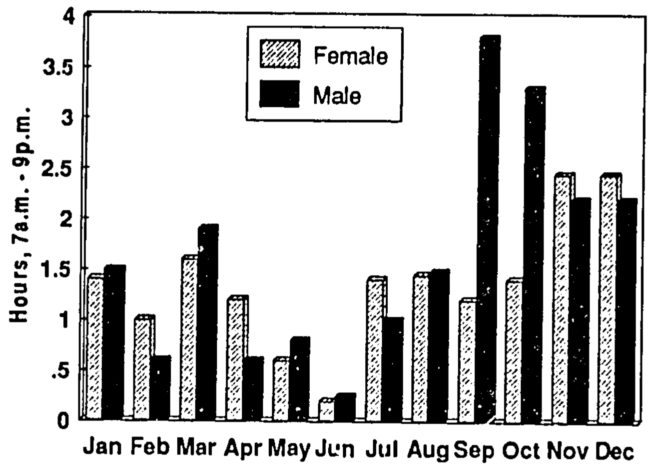


Figure 18. Seasonal variation in the allocation of labor to paddy fields, by sex, Pulai, 1985-86.

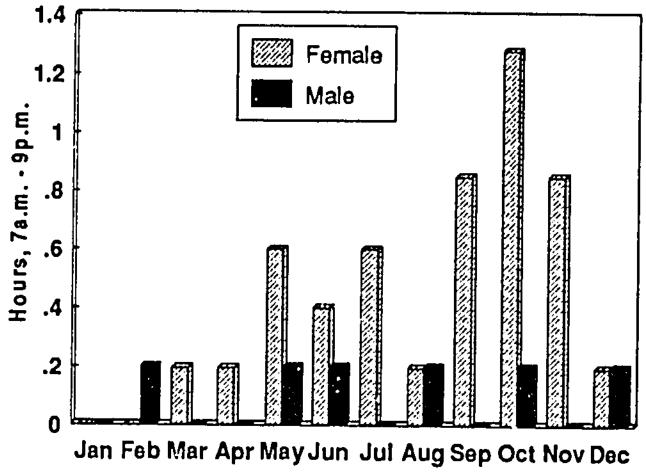


Figure 19. Seasonal variation in the allocation of labor to home gardens, by sex, Pulai, 1985-86.

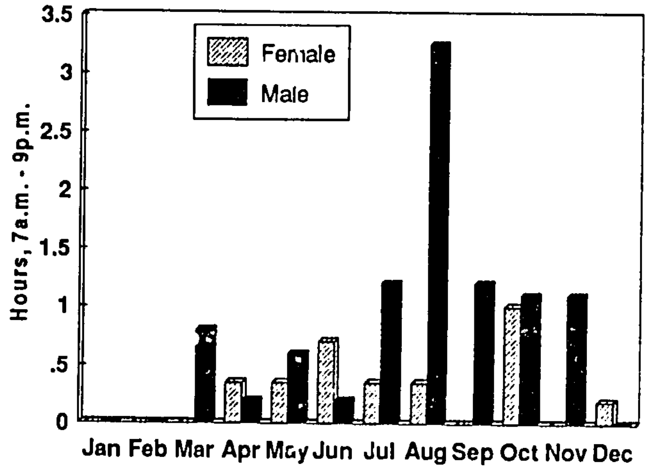


Figure 20. Seasonal variation in the allocation of labor to orchards, by sex, Pulai, 1985-86.

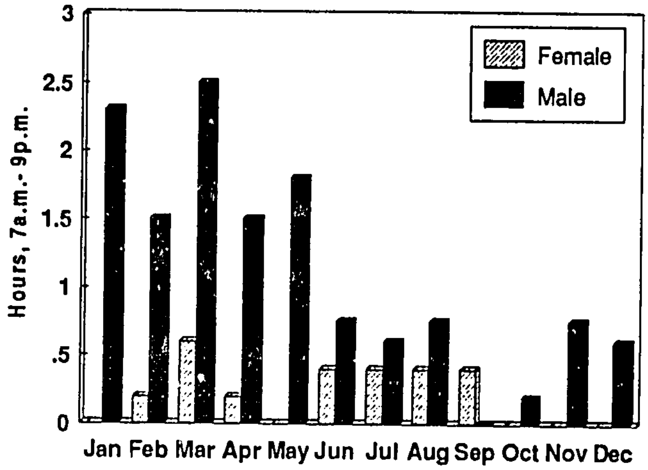


Figure 21. Seasonal variation in the allocation of labor to forest harvesting, by sex, Pulai, 1985-86.

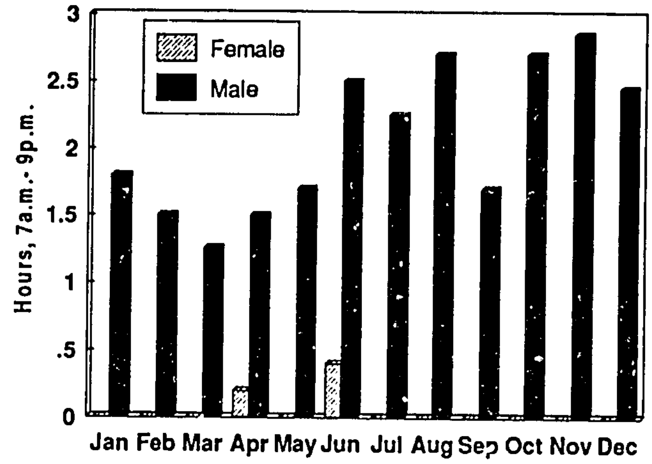


Figure 22. Seasonal variation in the allocation of labor to fishing and hunting, by sex, Pulai, 1985-86.

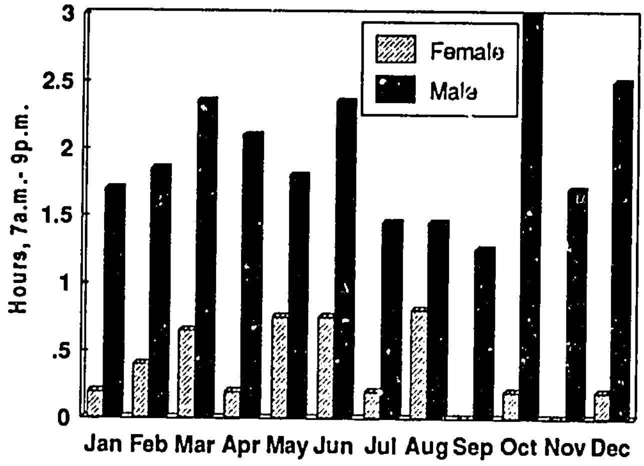


Figure 23. Seasonal variation in the allocation of labor to wage labor, by sex, Pulai, 1985-86.

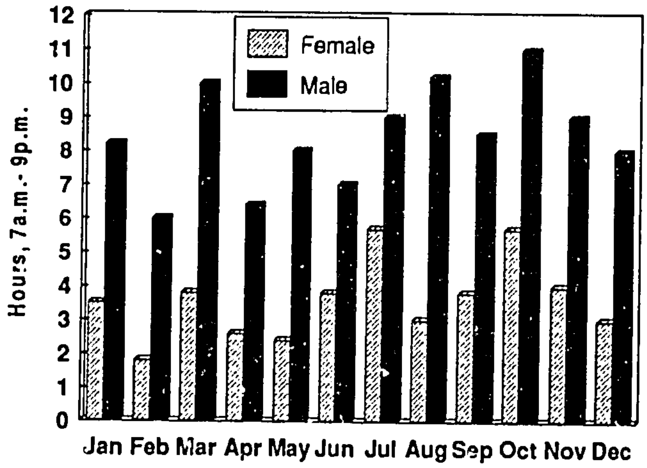


Figure 24. Seasonal variation in the allocation of labor to productive activity, by sex, Pulai, 1985-86.

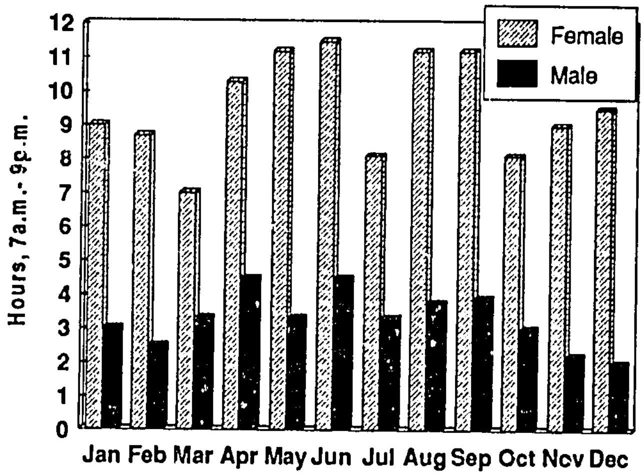


Figure 25. Seasonal variation in the allocation of labor to reproductive activity, by sex, Pulai, 1985-86.

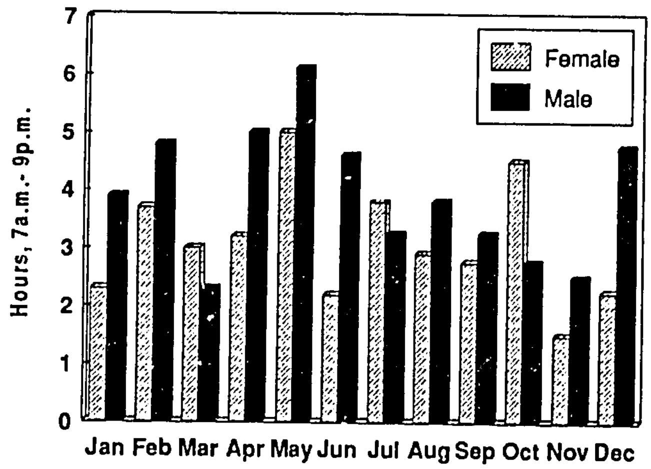


Figure 26. Seasonal variation in the allocation of labor to leisure activity, by sex, Pulai, 1985-86.

Minang man processing coffee in his home garden.

The frequency tables are of particular interest. Table 23 shows the activity frequencies by sex, for all three data sets. Pulai's allocation of labor to tree-crop orchards (687), fishing (502), gold panning (1310), and care of water buffalo (1407), for instance, clearly differ from labor allocation in the transmigrants' farming systems.

Collecting rocks (1309) is an example of the opportunistic approach characterizing the Minang farming system (see Vayda et al. 1980, for a similar approach in Kalimantan). The people were collecting rocks for sale and use as gravel. During my nine months of participant observation, I saw no one collecting rocks for this purpose. However, after I left, a buyer appeared, and there was immediately a flurry of rock collecting. Many Minang express a pride in their ethnic group's flexible and entrepreneurial nature.

Pulai men are more than twice as involved in productive[21] activity (with 502 observations) than are women (with 206 observations). Roughly a fifth of men's productive activity is devoted to fishing—mainly a subsistence activity. Care of water buffalo (many of which are owned by others) and off-farm labor are other significant uses of male labor. Women's productive labor is principally agricultural.

Pulai women (with 566 observations) are more active than men (192 observations) in the reproductive sphere—maintenance and reproduction of the species. More than 30% of women's time is devoted to child care and another fifth to cooking. Interestingly, men do almost three-fourths of the shopping—their most common reproductive activity.

We have postulated elsewhere (Colfer et al. 1984b) that the amount of leisure activity, by sex, might be one index of gender equality within a given culture. In Pulai, this ratio (186 observations of females at leisure to 237 of males at leisure) computes to .78. The comparable ratio for transmigrants was .89; and for a very egalitarian group in Kalimantan, .98 (Colfer 1981).

Land Use and Income

Land ownership among the Minang is a fuzzy concept. Local people variously maintain that all the approximately 1,000 ha of Pulai land belongs to the leader of the Tigoninik clan, to the five clans, to the women of each clan, to a particular family, or to a particular person in the family.

In our survey we interviewed people by household and asked who in that household had or owned (**punya**) what fields or orchards. Ownership in this case was interpreted by Pulai residents as established use rights. A total of 93.2 ha, or just over one ha per family, was reported under use for the entire village. Table 24 shows numbers and sizes of the various kinds of fields that Pulai's people recognize as being used or controlled by women, by men, and jointly. Because of the traditional abundance of land, gaining rights to use land has not been difficult for Pulai inhabitants.

---

[21]In our analyses we have divided all the activities observed into three major categories: productive, reproductive, and leisure (shown in Table 23). Our findings counter the common stereotype that men do productive work and women do reproductive, or maintenance, work. The data indicate that women are also involved in significant productive activities, as men perform many important reproductive functions.

Table 23. Summary of time allocation by sex in three locations—Sitiung IA (1983 through 1984), Sitiung VC (1983 through 1984), and Pulai (1985 through 1986).

		Sitiung I		Sitiung V		Pulai	
	Act 1	F	M	F	M	F	M
		% of total					
Reproduction							
Eat	101	4.94	3.76	3.56	3.61	2.93	2.79
Drink	104	0.00	0.00	0.55	0.00	0.10	0.32
General food preparation	200	0.00	0.00	0.27	0.00	1.36	0.00
Cook	201	7.68	0.70	14.23	0.45	11.49	1.18
Hand mill rice	202	0.00	0.00	0.14	0.00	0.00	0.00
Get water	203	0.55	0.00	0.41	0.15	0.84	0.00
Shop	204	2.96	0.94	1.92	0.75	1.46	4.08
Cut/peel food	206	3.51	0.00	1.09	0.45	0.21	0.00
Getting stored/milled rice	207	0.2[illegible]	0.23	0.00	0.00	0.00	0.00
Wrap food	208	1.65	0.12	0.00	0.00	0.00	0.00
Clean food	209	0.22	0.00	1.50	0.15	0.21	0.00
Pound food	210	0.55	0.12	1.50	0.00	1.04	0.00
Get firewood	211	2.41	1.64	0.14	0.30	1.36	0.00
Wash food	212	0.00	0.00	0.00	0.45	0.00	0.00
Smoosh food	213	0.00	0.00	0.14	0.30	0.00	0.00
General childcare	300	0.33	0.23	1.23	0.45	13.06	2.36
Hold a baby	301	0.11	0.23	2.05	0.75	0.94	0.00
Feed/nurse baby	302	0.99	0.00	1.78	0.00	4.91	0.11
Watch/teach children	303	1.21	0.23	0.68	0.30	0.21	0.00
Carry on back/hip	304	1.65	0.12	3.15	0.45	3.87	0.00
Care for sick/old or mass	305	0.22	0.12	0.68	0.15	0.10	0.00
Maintain machines	412	0.00	0.47	0.14	0.75	0.00	0.43
Mending	414	0.00	0.00	0.00	0.00	0.00	0.32
Sharpen knives/tools	416	0.00	0.00	0.00	0.45	0.00	0.00
Bathe	801	2.52	2.46	1.50	1.66	2.40	2.04
Wash dishes	802	0.55	0.12	0.96	0.00	1.67	0.00
Wash/dry/fold clothes	804	1.98	0.59	2.19	0.15	2.19	0.11
Elimination	805	0.00	0.00	0.00	0.30	0.21	0.00
Sweep floors	806	0.88	0.23	0.68	0.15	0.00	0.00
Wash house	807	0.11	0.00	0.00	0.00	0.10	0.00
Clean village	808	0.00	0.12	0.00	0.00	0.42	0.75
Get dressed	809	0.55	0.23	0.41	0.60	0.31	0.11
Tidy house	810	0.00	0.00	6.43	1.51	0.31	0.11
Seek fleas	811	0.00	0.00	0.00	0.30	0.00	0.21
Clean yard	812	5.82	0.94	0.14	0.00	4.08	0.00
Burn trash	813	0.00	0.12	0.00	0.00	0.00	0.00
Iron	814	0.11	0.00	0.00	0.00	0.00	0.00
Wash a baby	815	0.00	0.00	0.14	0.00	0.94	0.00
Attend a funeral	907	0.00	0.12	0.00	0.00	0.10	0.11
Unspecified education	1000	0.00	0.00	0.00	0.00	0.00	0.11
School in a village	1001	3.40	4.81	0.27	0.60	0.31	0.54
School away	1002	0.00	0.00	0.55	0.45	1.36	3.33
Study	1003	0.55	0.35	0.00	0.15	0.00	0.21
Watch television	1006	0.77	0.47	0.00	0.00	0.52	1.40

Table 23. Continued.

	Act 1	Sitiung I F	Sitiung I M	Sitiung V F	Sitiung V M	Pulai F	Pulai M
		% of total					
Production							
Build structure/fences	402	0.00	0.70	0.00	1.66	0.21	0.32
Make roof shingles	404	0.00	0.00	0.00	0.15	0.00	0.00
Woodcutting	406	0.00	0.00	0.00	0.60	0.00	0.00
Make knife/hoe	410	0.00	0.12	0.00	0.15	0.00	0.00
Sew	411	0.22	0.00	0.55	0.00	0.31	0.00
Making a boat	413	0.00	0.00	0.00	0.00	0.00	0.43
Making a net	415	0.00	0.00	0.00	0.00	0.00	1.29
Making/weaving taing	421	0.00	0.00	0.00	0.00	0.10	0.00
Fix animal house	423	0.00	0.12	0.00	0.15	0.10	0.00
Make toys	426	0.00	0.12	0.00	0.15	0.00	0.00
Make basket for grass	427	0.00	0.00	0.00	0.60	0.00	0.00
Hunting	501	0.00	0.00	0.00	0.00	0.00	0.11
Fish	502	0.00	0.23	0.00	0.75	0.52	11.0
Unspecified agriculture	600	0.33	0.35	0.27	0.45	0.21	0.75
Weed ladang	601	0.44	0.00	0.41	1.36	0.31	0.32
Scare away pests	602	0.00	0.23	0.00	0.00	0.00	0.11
Check ladang	603	0.33	1.06	0.41	0.90	0.52	1.07
Harvest ladang	604	2.20	2.82	1.78	1.66	0.21	0.32
Travel to ladang	605	0.99	2.58	0.96	1.36	0.10	0.11
Staying overnight in ladang	606	0.00	0.00	0.00	0.00	0.00	0.11
Gardenmaking	607	0.00	0.00	0.00	0.00	0.10	0.43
Bring rice from ladang	608	1.54	1.53	0.00	0.00	0.00	0.00
Clear forest/ladang	609	0.00	0.00	0.14	0.45	0.00	0.00
Fell large trees/ladang	610	0.00	0.00	0.00	0.30	0.00	0.00
Dry rice/ladang	611	0.11	0.12	0.00	0.00	0.10	0.11
Debranch felled trees in lad.	612	0.00	0.00	0.00	0.45	0.00	0.00
Thresh ladang	613	0.00	0.00	0.00	0.30	0.00	0.00
Shell crops/get seeds	614	0.00	0.00	2.19	1.05	0.00	0.00
Shell crops/get seeds	615	0.00	0.00	0.00	0.30	0.00	0.00
Agricultural planning	616	0.00	0.00	0.82	0.45	0.00	0.00
Plant ladang	618	0.33	0.12	1.09	2.86	0.00	0.00
Hoe ladang	619	0.55	7.86	1.23	8.89	0.00	0.00
Burn in ladang	620	0.00	0.00	0.27	1.51	0.00	0.00
Fertilize ladang	621	0.00	0.00	0.14	0.15	0.00	0.00
Spray ladang	622	0.00	0.23	0.14	0.15	0.00	0.11
Choose land for ladang	623	0.00	0.00	0.00	0.00	0.00	0.11
Exchange labor	624	0.00	0.00	0.00	0.00	1.67	0.00
Ag labor in chili field	625	0.00	0.00	0.00	0.00	0.84	2.36
Weed sawah	650	1.43	0.47	0.00	0.15	2.19	1.18
Hoe sawah	651	0.44	7.86	0.00	0.00	0.84	1.07
Plough sawah	652	0.00	2.11	0.00	0.00	0.00	0.21
Plant sawah	653	2.74	0.23	0.00	0.00	0.42	0.43
Travel to sawah	654	0.33	1.06	0.00	0.00	0.00	0.00
Spray sawah	655	0.00	0.23	0.00	0.00	0.10	0.11

Table 23. Continued.

	Act 1	Sitiung I F	Sitiung I M	Sitiung V F	Sitiung V M	Pulai F	Pulai M
		% of total					
Harvest sawah	656	0.11	0.23	0.00	0.00	0.94	0.86
Transplant	657	0.00	0.12	0.00	0.00	0.10	0.00
Check/guard sawah	658	0.11	0.23	0.00	0.00	0.94	1.50
Carry rice from sawah	659	0.00	0.35	0.00	0.00	0.00	0.11
Unspecified labour in sawah	660	0.11	0.00	0.00	0.00	2.82	1.72
Transport padi sawah home	661	0.00	0.00	0.00	0.00	0.10	0.00
Hoe home garden (HG)	675	0.44	1.53	0.82	3.16	0.00	0.00
Plant home garden	676	0.99	0.59	1.50	1.36	0.10	0.00
Burn home garden	677	0.00	0.12	0.27	0.30	0.00	0.00
Scare pests/HG	678	0.00	0.00	0.55	0.00	0.00	0.00
Watch crops/HG	679	0.11	0.00	0.27	0.30	0.00	0.11
Harvest home garden	680	2.85	0.12	3.28	1.05	0.63	0.21
Dry in home garden	681	2.20	0.47	0.96	0.90	0.63	0.00
Spray home garden	682	0.00	0.00	0.00	0.15	0.00	0.00
Fertilize home garden	683	0.00	0.00	0.14	0.15	0.00	0.00
Weed home garden	684	0.33	0.00	0.96	0.45	1.36	0.32
Unspec. average labor/HG	685	0.00	0.12	0.00	0.00	0.00	0.00
Carry rice/HG	686	0.11	0.00	0.00	0.00	0.00	0.00
Harvest planted tree crops	687	0.00	0.00	0.00	0.00	0.94	2.26
Process crops after drying	690	0.00	0.00	0.00	0.00	0.42	0.21
Unspecified wage labor	1200	0.11	5.16	0.00	0.45	0.00	0.21
Work for company	1201	0.00	0.59	0.00	0.00	0.00	0.21
Sell at home	1202	0.00	0.35	0.68	0.30	0.94	2.15
Carpenter	1205	0.00	0.47	0.00	0.00	0.00	0.75
Buy to resell	1206	0.00	0.00	0.14	0.30	0.00	0.11
Resettle or transmig. worker	1207	1.65	0.00	0.00	0.15	0.00	0.32
Average wage labor	1209	0.00	3.17	0.14	0.75	0.10	0.11
Office work	1212	0.00	0.47	0.00	0.15	0.21	0.86
Plywood or sawmill	1214	0.00	0.12	0.00	0.15	0.00	0.21
Transport for sale	1215	0.00	0.12	0.00	0.00	0.00	1.18
Get wood with truck	1216	0.00	0.00	0.00	0.90	0.00	0.64
Teacher	1217	0.33	0.00	0.27	0.30	0.52	0.97
Get transmigration subsidy	1218	0.00	0.00	0.41	0.30	0.00	0.00
Maid/waiter	1219	3.51	0.82	0.27	0.15	0.10	0.32
Sell wood from forest	1220	0.00	0.12	0.00	2.86	0.00	0.00
Seek work	1221	0.00	0.00	0.00	0.30	0.00	0.97
Tree crops factory or plant.	1222	0.00	0.70	0.00	0.75	0.21	0.43
Construction	1223	0.11	3.52	0.00	0.00	0.00	0.00
Sell at market	1224	2.09	0.35	0.00	0.00	0.10	0.97
Tailor	1225	0.00	0.82	0.00	0.00	0.00	0.11
Waiting for work	1226	0.00	0.00	0.00	0.00	0.00	1.50
Collecting rattan	1301	0.00	0.00	0.00	0.00	0.00	0.32
Make lumber/forest	1305	0.00	0.00	0.00	0.15	0.00	6.66
Glean food/leaves	1307	0.44	0.12	0.00	0.15	0.00	0.00
Collect rocks for gravel	1309	0.00	0.00	0.00	0.00	0.00	2.79

Table 23. Continued.

	Act 1	Sitiung I		Sitiung V		Pulai	
		F	M	F	M	F	M
		% of total					
Gold panning	1310	0.00	0.00	0.00	0.00	1.15	0.64
Chicken care	1401	0.00	0.00	0.41	0.15	0.10	0.00
Make fish pond	1402	0.00	0.00	0.00	0.30	0.00	0.00
Get grass	1403	7.46	7.28	0.00	0.00	0.00	0.32
Cattle care	1404	0.33	0.23	0.00	0.00	0.10	0.11
Herd	1405	0.66	0.47	0.00	0.00	0.00	0.21
Water buffalo care	1407	0.00	0.00	0.00	0.00	0.10	1.29
Leisure							
Unspecified leisure	700	0.00	0.00	2.74	1.36	0.63	0.21
Rest	701	0.11	0.12	2.05	3.31	6.48	3.97
Sleep	702	1.87	1.76	2.87	4.22	1.15	1.07
Sick	703	0.44	0.12	0.55	0.75	0.10	0.32
Play	705	1.32	3.87	9.85	9.49	0.73	3.11
Playing around	706	0.00	0.00	0.27	0.60	0.73	0.64
Sitting/standing	708	9.44	7.16	1.50	6.33	0.00	0.00
Informal visit	901	1.32	0.94	1.50	3.46	1.15	0.75
Attend meeting/get letter	902	0.00	0.70	0.00	0.45	0.10	0.11
Visiting away from village	904	0.77	0.47	0.55	0.15	0.63	3.44
Visit Koto Padang	905	0.00	0.00	3.56	3.31	0.00	0.00
Unstable residence	906	0.00	0.47	0.27	0.15	1.04	0.97
Attend party	909	0.33	1.06	0.68	0.60	0.10	0.64
Visit Java	910	0.22	0.35	3.28	4.22	0.00	0.00
Read Koran	911	0.00	0.12	0.14	0.30	0.10	0.00
Pray	912	0.11	0.00	0.14	1.36	3.13	6.02
Go to mosque	913	0.66	2.23	0.00	0.15	1.25	1.61
Get prayer water	914	0.00	0.00	0.00	0.00	1.36	1.61
Extension course	1004	0.00	0.12	0.00	0.45	0.00	0.11
Dance	1101	0.00	0.00	0.00	0.00	0.10	0.00
Sports	1103	0.88	2.11	0.14	0.00	0.63	0.86
Write a letter	1104	0.11	0.00	0.00	0.00	0.00	0.00

Table 24. Ownership and hectarage of Pulai fields, using local field categories, June 1986.

	Total		Women's		Men's		Joint	
	No. of fields	Tot. ha	No. of fields	Tot. ha	No. of fields	Tot. ha	No. of fields	Tot. ha
Paddy rice field (**sawah**)	63	18.9	11	3.2	2	0.5	50	15.1
Upland rice field (**ladang & soso'**)	28	22	0	0	2	1.5	26	20.5
Rubber orchard (**kebun karet**)	52	34.9	32	18.7	9	7.4	11	8.8
Other orchard (**kebun**)	8	2.3	8	2.3	0	0	0	0
Home garden (**pakarangan**)	82	15.1	17	3.2	4	0.4	61	11.4
Totals	233	93.2	68	27.4	17	9.8	148	55.8

From Colfer, Gill, and Agus 1988.

Table 25. Ownership of rice fields and rights to income, by sex, Pulai, 1985-86.

	Means of production			Rights to income§	
Owner/ beneficiary	No. of fields	Hectares owned	% Total hectares	U.S. $	Rice income %
Women	11	3.21	7.8	1908	17.4
Men	4	2.07	5	356	3.2
Joint	76	35.64	87.1	8712	79.4
Total	91	131.92	99.9	10976	100

§Income was derived by multiplying the local measure, "gantang," by 1.6 kg., and then multiplying the resulting figure by Rp. 150, the going price of field dried paddy in nearby markets. The totals were then converted to U.S. dollars (U.S. $ 1 = Rp. 1127, 6/86). Pulai residents, however, do not sell their rice.
From Colfer, Gill, and Agus 1988.

Table 26. Ownership and control of income from the 52 rubber orchards reported in Pulai, June 1985 through May 1986.

	Ownership		Control	
Owner/ beneficiary	Rubber trees	Hectares	Income in U.S.$§	% total income¶
Women (32 fields)	7800	18.7	1492	2.8%
Men (9 fields)	3100	7.4	4450	8.6%
Joint (11 fields)	3650	8.8	1422	2.7%
Total	14550	34.9	7364	13.8%#

37 families (43% of all Pulai families) owned these fields.
§ U.S. $1 = Rp. 1127, 6/86.
¶Percent of total village cash income, deriving from rubber, controlled by each category (women, men, and pairs).
Rounding error.
From Colfer, Gill, and Agus 1988.

Rice and rubber, as in Koto Padang, are the most important crops. Tables 25 and 26 provide gender-disaggregated data on land use and rights to income from these two crops. The Minang, unlike transmigrants, are very reluctant to sell rice, considering such sale a source of shame. Since rice is fundamentally a subsistence crop, converting it to money is something of a misrepresentation. However, if added to Pulai's cash income sources (Table 27), rice income would comprise just over 17% of the total income.

Rubber is viewed as a ready source of cash by the Minang. Once the trees are established, rubber requires almost no management. Indeed, to the casual observer, a Minang rubber orchard appears to be a natural forest. When labor is abundant or cash needs are pressing, Minang tap rubber.

The dominance of women in rubber-tree ownership complements men's dominance in income from rubber. The figures in Table 26 are consistent with the predominance of men in rubber tapping, and the tradition of a tapper receiving two-thirds of the harvest and an owner receiving one-third.

Table 27 shows very clearly the significance of trees, including forests, in family incomes. It also shows how the Minang have chosen to diversify

A Pulai man makes a fishnet as his wife runs their *warung*, or "store."

their farming system. The remaining 50% of Pulai's income is just as diverse, derived from animals, contracting, fishing, transportation, official salaries, and gold panning. Th's diversity makes eminent sense in such a risky environment.

The diversity also distributes labor requirements throughout the year: In October and November, people are weeding their rice; December and January is rambutan time; Coffee, bearing throughout much of the year, produces most between March and May. Rubber, collected in half-coconut shells which fill with rain, not latex, on rainy days, is most available during the driest months when rice is not cultivated. Coconut bears all year long.

Table 27. Percentages of total cash income deriving from important tree-related sources, Pulai, May 1985 through June 1986.

Income source	Total	Controlled by Women	Men	Both
Orchard				
Rubber	14.4	2.8	8.6	3.0
Coffee	0.7	0.2	0.0	0.5
Banana	0.2	0.1	0.0	0.1
Guava	§	§	0.0	0.0
Home garden				
Coffee	5.8 #	4.3	0.4	0.8
Banana	0.1 #	0.0	§	0.2
Stinkbean	0.4	0.3	0.1	0.0
Rambutan	0.2	0.1	0.0	§
Duku	2.6	1.7	0.3	0.6
Durian	§	§	0.0	0.0
Coconut	0.9 #	0.7	0.0	0.3
Logging	20.2	0.0	20.2	0.0
Tapping	5.3	0.2	5.1	0.0
Totals (%)	50.8 #	10.4	34.7	5.5

§ Amount between 0 and .001.
# Rounding error.
From Colfer, Gill, and Agus 1988.

Diet

Although we had some information that Minang diets were preferable to transmigrants' (Chapman 1984a,b,c), we wanted more specific information about where people were getting their food and which foods they were eating. This could help us choose appropriate crops to incorporate into our experiments. We were also curious about Minang

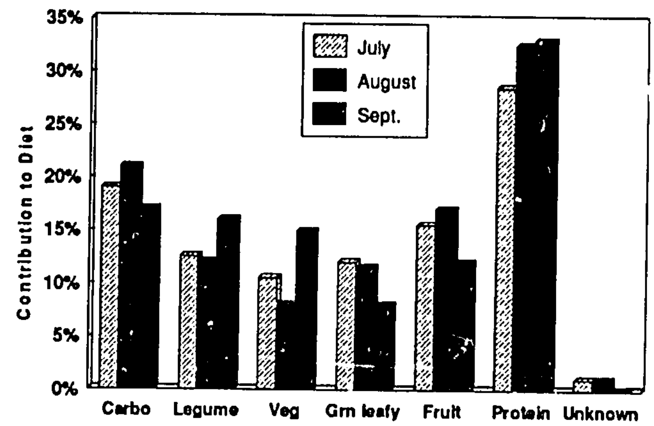


Figure 27. Nutritional category by month, excluding main rice dish, Pulai, 1987.

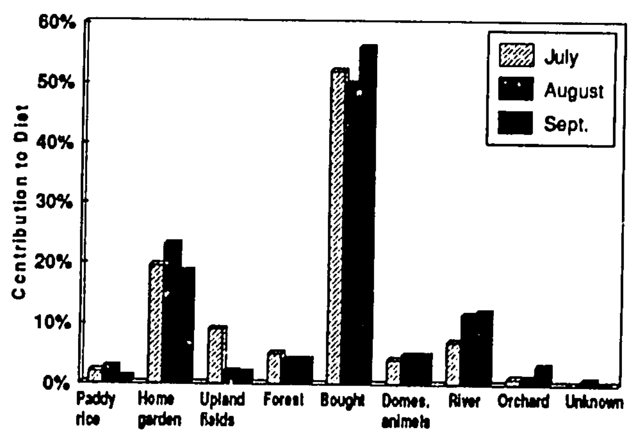


Figure 28. Sources of food by month, excluding main rice dish, Pulai, 1987.

dependence on the market for food.

I designed a study that was implemented between July and September 1987, after my departure. We asked three families I knew well to record what they ate at each meal for these three months. Over this period, 749 meals were recorded.

Among the Minang any meal includes 60% to 90% rice. The study suggests that this dependence on rice and consequent neglect of better sources of protein and vitamins may be the most detrimental aspect of their diet. The following figures include only non-rice foods.

Table 28 shows the range of crops eaten during these three months, as well as my nutritional categorization. Figure 27 shows the distribution, by month, of approximate nutritional categories, and Figure 28 shows the sources of foods, by month. The most striking element in these data is the significant amount of animal protein eaten by these people. Their integration into the market economy is also clear from the high percentage of purchased foods. As with the Javanese and Sundanese, home gardens provide dietary diversity.

Minang Soil Classification

with Fahmuddin Agus and Dan Gill

Information about time allocation, land use, income, and diet is important and useful for project planning. However, trying to understand how local people look at their agricultural system has a greater potential impact in developing sustainable agriculture in the tropics. The discussion in this section draws on nine months of regular involvement with the Minangkabau people and a slowly unfolding understanding of how they looked at their agricultural system. Investigating indigenous conceptual approaches to agriculture has the potential

Table 28. Crops encountered in Pulai's diet record-keeping study July through September 1987.

English	Indonesian	Latin
Carbohydrates		
Cassava root	ubi kayu	*Manihot esculenta*
Potato	kentang	*Solanum tuberosum*
Rice	nasi	*Oryza sativa*
Sweet potato	ubi jalar	*Ipomoea batatas*
Legumes		
green bean	buncis	*Phaseolus vulgaris*
Longbean	kacang panjang	*Vigna sesquipedalis*
Locust bean	petai	*Parkia speciosa*
Mungbean	kacang hijau	*Phaseolus radiatus*
Peanut	kacang tanah	*Arachis hypogaea*
Soybean	kacang kedele	*Glycine max*
Stinkbean	jengkol	*Pithecellobium jiringa*
Vegetables		
bamboo shoot	rebung	[various]
Bittergourd	pare	*Momordica charantia*
Cabbage	kol	*Brassica oleracea*
Chillie	cabe	*Capsicum annuum*
Corn	jagung	*Zea mays*
Cucumber	ketimun	*Cucumis sativus*
Eggplant	terong	*Solanum melongena*
Shallot	bawang merah	*Allium cepa var.*
Squash	labu kuning	*Cucurbita moschata*
Tomato	tomat	*Lycopersicon esculentum*
White raddish	lobak	*Raphanus sativus*
Green leafy vegetables		
amaranth	bayam	*Amaranthus hybridis*
Cassava leaf	daun ubi kayu	*Manihot esculenta*
Ferns	pakis	[various]
Spring onion	daun bawang	*Allium fistulosum*
Swamp cabbage	kangkung	*Ipomoea aquatica*
Fruits		
banana	pisang	*Musa spp.*
Coconut	kelapa	*Cocos nucifera*
Durien	durien	*Durio zibethinus*
Jackfruit	nangka	*Artocarpus heterophyllus*
Papaya	papaya	*Carica papaya*
Pineapple	nanas	*Ananas comosus*
Salak	salak	*Salacca edulis*
Starfruit	belimbing	*Averrhoa carambola*

From Colfer n.d.

A Pulai woman collecting latex in her rubber orchard.

to provide us with simple, but perhaps revolutionary shifts in our own perceptions—which in turn can lead us to creative and more sustainable forms of agriculture.

I began by using ethnoscientific methods to study the indigenous soil classification system (discussed in the next section), and in the process learned the Minang words used to describe soil. Some of the adjectival distinctions are consistent with soil science descriptors of soil: **alui - kasau** (fine - coarse), **baderai - bageta** (crumbly - sticky), **luna' - kore** (soft - hard), **gocau** (muddy), **bapasiu** (sandy), as well as color terms (**hitem** (black), **merah** (red), **kunieng** (yellow), **putieh** (white).

Others are not as easily translated. Indonesian soil scientists normally use **masem** to refer to acidity, and expect aluminum toxicity in such soils. The Minang, however, say that fertilizers make a soil **masem**. After digging a hole to plant a fruit tree in newly cleared old growth forest (**imbo**), one must wait three months to allow the soil to become **masem** (and **dingin**, cold, see below). When the weeds begin to grow in the hole, one knows the soil is **masem**.

Before planting paddy rice, one must wait three or four days after the water buffalo have trampled the soil in land preparation, so that the soil will become **masem**. **Ona**, or alluvial soil, is good because it becomes **masem** after receiving fertilizer from the river water. In general, the Minang maintain that only rubber does not need **masem** soil. It is clear that misunderstandings between local people and soil scientists or extension workers are likely on this topic.

Pane and **dingin** literally mean hot and cold, respectively, and are not normally used by soil scientists to describe soil qualities. The Minang maintain that soil in the forest is cold. When the forest is cut and burned, the soil becomes temporarily hot, but cools down in a relatively short time. However, if cultivated continuously and exposed to the sun, after several years the soil becomes hot and cannot grow crops until it is left to rest. The red color of the soils the Minang consider least desirable is said to come from too much heat—from exposure to the sun—and from loss of ash. Borrowing from Caudle (1988) I suggest an appropriate definition for Minang **dingin** might be "acid soils sufficiently buffered by organic matter to support a crop."

Baminyak literally means oily. It, like **putieh** (white) and **gocau** (muddy), is most likely to be used in connection with paddy rice. I was unable to understand exactly what it meant in Pulai, but it was a positive attribute, and looked wet, but was not. **Baminyak** may be comparable to **gemuk** (fat), a concept reported in Sherman (1981) from North Sumatra. There it was considered most important for plant growth, but it differed significantly from scientists' views of "fertility."

Finally, I elicited terms (nouns) which might be called aspects of soil: **lulua'** (mud), **liye'** (clay), **kabuik** (dust), **pasiu** (sand), **krekel** (gravel), **batu** (rock), and **tanogan** (perhaps iron-laden soil?). All but the final term are comparable to English usage.

Tanogan, like **lulua'**, is used to describe soils in paddy-rice fields, sometimes paired with **baminyak**. **Tanogan** is not considered desirable because its mud will not break up into the fine aggregates desired for paddy-rice cultivation. **Tanogan** can only be identified during the hot season; and, if there is water nearby, it has an oily yellowish-reddish film on it. Our soil scientists suggested that such soils might be iron-laden.

This study convinced us that there was considerable overlap in soil scientists' and farmers' soil classification systems. The differences were intriguing, and we would have investigated them by analyzing the kinds of soil we were unable to understand fully (**baminyak**, **tanogan**, **dingin** and **pane**) had we remained in Sitiung. Minang use of the term **masem** has important extension implications.

A Pulai woman planting paddy rice.

A Minang Agricultural World View

with Dan Gill and Fahmuddin Agus

There is a tendency for Western scientists—and Javanese and Western farmers—to view agricultural systems as fixed plots of specified size to be cultivated repeatedly and therefore intensively with field crops such as rice or soybeans. Soil management, in such a system, involves the utilization of various methods of tillage, amounts and kinds of fertilizers and pesticides, and irrigation water.

The Minang, however, who farm in an area where land availability has not been a constraint, see land and agriculture in more fluid terms. There are a few small and highly prized lowland areas that can be used for paddy rice, and use of these may be somewhat compatible with the views of scientists and Javanese farmers. But most land is forested and, for the most part, freely available to Pulai inhabitants. This broad expanse of forest is viewed as a potpourri of agricultural potential from which a given field will be selected for a specific crop.

There are three ways in which land is categorized in Pulai: by topography and water availability, by stage of forest regeneration, and by kind of agricultural fields.

1. Topography and water availability. The most general set of categories relate to water and topography (Figure 29). Swampy areas (**awang**) are highly valued, and efforts are consistently made to convert these poorly drained soils to **sawah** (paddy-rice fields). Alluvial, usually seasonally flooded areas near rivers are called **ona** (or **rena**). They are said to be reserved for annual crops; however inspection reveals numerous fruit trees (though no rubber), bananas, pandanus, bamboo, and the sago palm. The

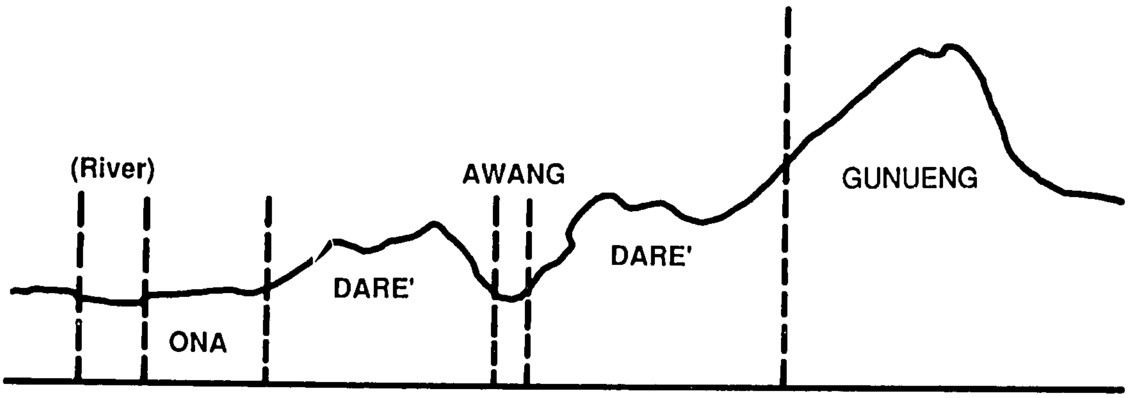


Figure 29. Minang topographical categories, Pulai 1986.

rolling hills and sloping soils which dominate the area are called **dare'**. Mountains are called **gunu-eng**. Our emphasis was on **dare'** since most of Pulai falls into this category—as does most of the land on the Outer Islands.

Our small number of soil samples only allowed us to make tentative conclusions, but the trends were not surprising. The few **ona** samples taken showed 10-40 times the Ca levels of the **dare'** samples, while P levels were similarly elevated in **ona**. Exchangeable Al, a major problem for annual crops, was relatively low in the **ona**, while Al saturation of the **dare'** samples ranged from 51-92%.

These analyses are consistent with indigenous appraisal of **ona** soils and reflect the benefits of periodic sediment deposition of relatively basic materials from upstream. They also reflect the general desirability of these soils for agriculture, compared to others in the area.

2. *Kinds of agricultural fields.* The second set of indigenous categories of land relates to agricultural use: There are home gardens (**pakarangan**), paddy ricefields (**sawah**), upland rice fields (**ladang**), and orchards (**kabun**). Pulai's home gardens were on **dare'**. Crops included coffee, coconut, rambutan, duku, mango, and guava, as well as the more exotic **kwini, ambacang, kedondong, jambak,** and others we could not identify. **Kabun,** orchards, can be subdivided by crop: citrus, coffee, rubber, rambutan, duku, and one annual crop, chili. Upland rice fields and orchards also tend to be found on **dare'**.

3. *Stages of forest regeneration.* The final indigenous method of land classification relates to forest regeneration. **Dare'**, or upland, is subdivided according to stage of forest regeneration—or fallow—in this long-cycled, shifting-cultivation system. The impossibility of separating upland agriculture from forest regeneration in this classification system is the key to this Minang agricultural model (Figure 30). Each of the stages is described below, as it fits in with the Minang agricultural system.

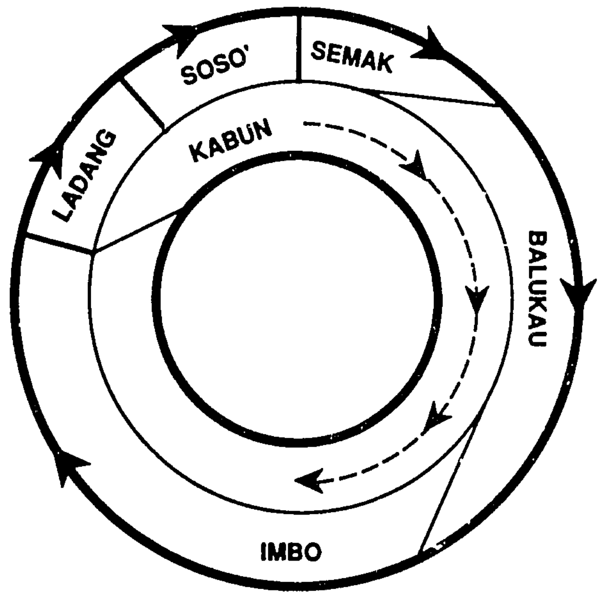


Figure 30. Indigenous agroforestry cycle, Pulai 1986.

Ladang (newly cleared land, planted to rice).

To clear a forest, women first slash the underbrush and small trees, and then men fell the large trees. This debris is left to dry for a month or two and then burned. **Ladangs** are cleared originally to plant upland rice, which holds a very special place in that it is viewed as absolutely essential for human sustenance. Men and women work together to plant the rice, with men dibbling and women putting seed in the holes.

There are many indigenous varieties of rice. Some farmers mix varieties and plant them together; others keep them separate. Some plant several varieties on different portions of their field, while others plant only one variety. In a few unstructured interviews on the subject, farmers named 14 varieties of regular upland rice, six of glutinous rice, and two of paddy rice. In a more thorough investigation in East Kalimantan, over 22 varieties of upland rice and nine of glutinous rice were used by Dayak swidden farmers (Colfer 1991b). Such diversity is part of a risk-management strategy among both peoples.

At some point during the rice-growing season (approximately September - March), tree crops are planted among the growing rice. The most common tree crop is rubber, but fields usually have a few jackfruit and stinkbean. Fruit trees, planted here and there, include **kedondong, ambacang,** guava, **petai,** and **jambak,** as well as other unidentified species.

Annuals, planted in small areas, include chili, sorghum, cucumber, corn, eggplant, longbeans,

Table 29. Nineteen weeds from an upland field, Sitiung.

Vernacular (Minang)	Scientific name	Family name
Sawi nggeng (male)	*Erechtites hieracifolia* (L.) Rafin ex dc.	Asteraceae
Sawi nggeng	*Blumea lacera* (Burm. f.) Dc	Asteraceae
Name not elicited	*Diodia ocymifolia* (Willd. ex R.&S.) Bremek	Rubiaceae
Tinjan belukar	*Clerodendrum serratum* (L.) Moon	Verbenaceae
Sawi nggeng	*Crassocephallum crepidioides* (Benth.) S. Moore	Asteraceae
Saleguri	*Porophyllum ruderale* (Jaq.) Cass.	Asteraceae
Siani' talang	*Scleria ilicifolia*	Cyperaceae
Indarung	*Trema orientalis* (L.) Bl.	Ulmaceae
Batang sago	*Adenanthera pavonina* L.	Fabaceae
Rasam dudue'	*Selaginella plana* Hieron	Selaginellaceae
Paku	*Pteris ensiformis* Burm.	Polypodiaceae
Paku segal	*Lycopodium cernuum* L.	Lycopodiaceae
Paku ban	*Nephrolepis exaltata*	Polypodiaceae
Salabun	*Paspalum conjugatum* Berg.	Poaceae
Balimbing tanah	*Torenia violacea* Pennell	Scrophulaceae
Siani'	*Scleria sp.*	Cyperaceae
Talate nggang	*Oplismenus burmanni* (Retz.) Beauv.	Poaceae
Nibu rusa	*Laportea interrupta* (L.) Gaud.	Urticaceae
Kandueng	*Symplocos javanica* Kurz.	Symplocaceae

Identified by Herwasono Soedjito, Herbarium Bogoriense, 1986.
From Colfer, Gill, and Agus 1988.

mungbeans, bittermelon, and angled loofah. Because of distances to market and the small quantities grown, these are subsistence crops.

Weeding uses considerable amounts of women's time. In a few brief conversations, we elicited 35 names for different species of weeds. The women assured us there were "one thousand and one" kinds of weeds. Extensive lexicons normally indicate areas of indigenous knowledge, sometimes having great potential for use. Table 29 provides the names of 19 weeds collected in a grab sample from one of these fields, and identified by Herwasono Soedjito at the Bogor Herbarium. Weeds may make an important contribution to production of a second crop, since they help cover the soil and increase its organic-matter content. They are also, of course, the first stage of forest regeneration.

In March or April women harvest the upland rice, normally using a pannicle or finger knife (**anuai**). The rice stalk is left in the field and is trampled during harvest. Men transport the rice to the field hut and back to the village. We sampled and measured the yields of six upland fields in Pulai, getting an average yield of 807 kg/ha (March 1986), with a range from 480 to 1250 kg/ha. Once harvest is completed, the field becomes **soso'**.

Soso' (field in its second year after clearing).

The decision to plant the same field a second year depends primarily on the rice harvest the first year, though labor availability and alternate sources of income also have an influence. If the harvest was relatively abundant, a decision to plant again is more likely. The increase in weeding the second year is also a consideration, as is the difficulty of clearing a new field. Other field crops are normally not planted, except in **ona**, the alluvial plain, where chilis are a favorite crop.

Whether the field is planted to rice again or not, useful products continue to be collected from **soso'**. Bananas and pineapples, frequently planted the first year, are bearing. Chilis often continue to produce. The occasional need to check on the rubber and other tree crops means that these fields continue to be harvested periodically, on a small scale.

We measured the eight Pulai second-year fields already planted to rubber (May 1986) as an estimate of the average size of rubber orchards. The overall average field size was about 0.64 ha, ranging from 0.16 ha to 1.60 ha. On most fields, trees were not planted in rows. We calculated an average of 417 trees per ha, with spacing averaging 4.9 m (range: 2.8 to 7.8 m) between trees. In the process, we also measured slope with an inclinometer, getting what seemed to be an unskewed range from 0 to 47%.

Semak (brush stage of forest regrowth).

As the bushes begin to take over, the area loses the appearance of an agricultural field. Jackfruit and stinkbean planted during the **ladang** phase begin to bear fruit, while bananas and pineapple continue to produce. Near the village there are areas of **semak** planted to coffee, rambutan, duku, citrus, and there are many areas farther away where rubber is growing to maturity surrounded by **semak**.

Balukau (secondary forest, probably less than 30 years).

By the time the regrowth has become secondary forest (**balukau**), the rubber and other tree crops are bearing. Local rubber trees produce after about eight years. Jackfruit and stinkbean continue to bear. **Durian**, a highly valued crop, and **cebodak hutan** (forest jackfruit) provide wild produce. Durian is not planted, reportedly because it is considered to be freely available to other clan members, no matter who planted it. Even outsiders are allowed to take a few of the fruits. Another disincentive to planting durian is the ten to twelve years the tree requires to mature. Pulai people therefore express no interest in trying to grow it commercially.

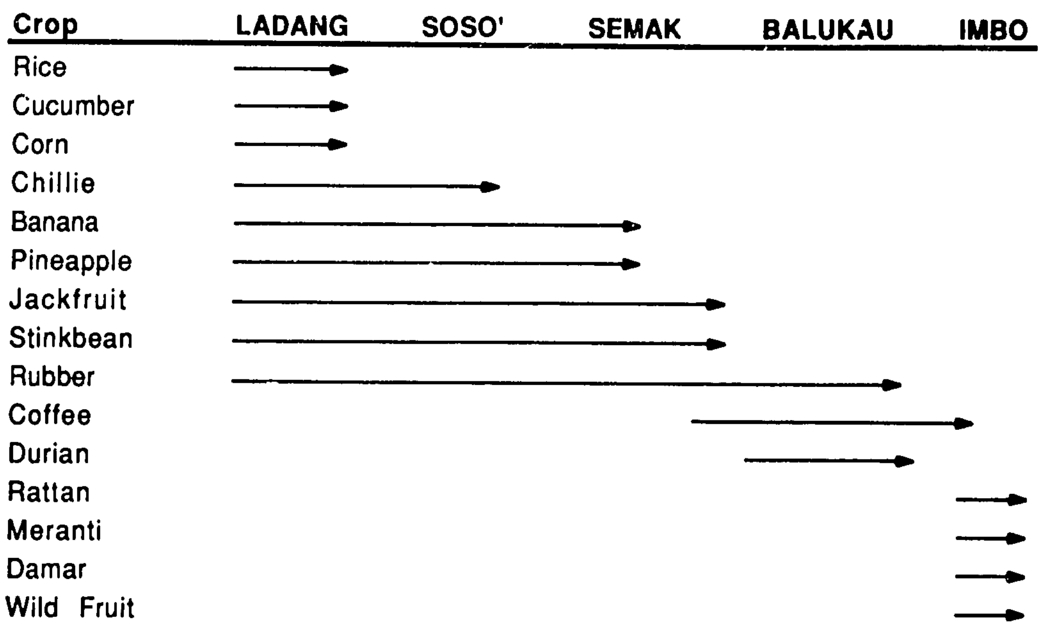


Figure 31. Representative "crops" by stage of forest regeneration, Sitiung 1986.

Coffee trees, requiring shade, are also frequently planted in **balukau**. Sometimes a special **kabun** (or orchard) is set aside for coffee; or it can be planted among the rubber trees. **Balukau** may also be cut down, left for a time, and then planted directly to fruit trees, like rambutan, duku, or citrus.

***Imbo** (old growth forest).*

Since this area appears to have been settled for a long time, it seems probable that very little true "primary forest" remains. However, the people differentiate between **imbo** and **balukau**, the former being considered older and providing different kinds of products. Table 30 shows **imbo** products, including some we were unable to identify.

It is apparent that there are many more **imbo** products, since the forest is taken for granted by Pulai residents, and its utility has not been emphasized in rural development efforts. Figure 31 shows representative "crops" by stage of forest regeneration (see Colfer 1983, for an East Kalimantan version; and TAD 1981, for a partial inventory from East Kalimantan forests).

From the farmers in Pulai, we can learn several lessons useful in the development of sustainable agricultural systems:

1. Tree crops can be effectively integrated into a system that maintains its subsistence margin. Trees can maintain the ground cover that protects the soil from erosion in these sloping areas; they can supply leaf litter, important for soil regeneration; they are more tolerant of aluminum; their deeper rooting systems can access water, avoiding the moisture stress that beleaguers annual crops; their nutrient uptake requirements are often lower than those of many annual crops; they require comparatively little human labor; and they provide a salable or edible product.

The Pulai practice of matching land and crops is environmentally desirable. An improved agroforestry system that utilizes the forest rather than

Table 30. A sample of products from Pulai old-growth forests with known use or commercial value.

Saps	
joneng	red dye from rattan fruit. Sap is shaken from fruit, collected, flattened like a pancake, and sold. 1985 price: U.S. $9/kg.
julutueng	also called 'geta putieh,' a white sap tapped like rubber, exported. Said to be used in bubble gum.
damau	damar (Indonesian) is used for caulking canoes, maybe for making glass. Was once a common source of lighting. Usually from family Dipterocarpaceae (Scholtz, 1983, 219).
geta merah	or 'red sap,' gathered by others for unknown use. Tree is cut down.
Fiber	
rumbai	obtained in swampy areas, from sago tree (*Metroxylon rumphii*). Used for weaving seed bags.
rotan	rattan. Three kinds (*aotabo, umbai, manau*) used commercially. 1985: U.S. $.35/stick to collector.
liapi	*rumbia* (Indonesia). Fan shaped palm used for roofing. Grows on special hilly areas (Licuala).
Wood products	
logs	*meranti* (favored export dipterocarp), *kulin* (ironwood), *kapur* (another dipterocarp)
balok	beams, frequently made from *meranti,* with chainsaw, in the forest, dragged out with water buffalo to road. 1986: U.S. $25/m³ at roadside.
tonam	*marsawa* (Indonesia). Buttresses of trees used in making gold-panning 'plate.' Tree itself used for building.
garu	found inside the *kare* tree, it ranges in size from a pebble to water glass. If soft, price is U.S. $100/kg (1986). Probably aloe wood, in Kalimantan found in genus *Aquilaria*, family Thymelaeaceae). Tree must be destroyed to discover *garu's* presence or absence.
fruit trees	local names for *rambutan*-like *(Nephelium lappaceum)* fruits include *kuduk biawa', kudung tunjuk,* and *buah soni. Duku*-like *(Lanseum domesticum)* fruits include *tampui', dondon (Spondius dulcis), langsat, rambai (Baccaurea motleana). Manggosteen*-like *(Garcinia mangostana)* fruits are *manggis* and *sontu.* Others include *tampuai, gera'an, lasau, barangan, tungao tungao,* and *petai (Parkia speciosa).*

transforming it into agricultural land is a sensible goal for those marginal lands of the humid tropics which must be converted for human use. Any system in such areas should probably include both a cash and a subsistence component.

2. A diversified system in high-risk environments such as humid tropical rainforest areas has important advantages. Risks from crop disease, insect and animal depredations, uncertain water availability, and price fluctuations can be reduced by depending on a variety of crops, as Pulai farmers do. Additional risk protection is derived by maintaining fields in several places. If bananas are flooded in one field, the rubber orchard and the upland ricefield are probably unaffected. If the upland field suffers a drought or insect attack at a critical time in the rice's development, the home garden will still provide its coffee, coconuts and rambutan income, along with jackfruit and cassava leaf for subsistence.

3. Both sexes actively participate in forest agriculture like that in Pulai. The Minang women have rights to land and traditionally recognized agricultural roles. They are dominant in rice production and in the home garden. Our global concern to protect the subsistence base requires general recognition of women's contribution to subsistence. Further, research and extension efforts will be most effective if they build on the existing roles and knowledge of both sexes.

The findings from the Pulai study led me to believe that there is potential value in broadening our definition of worthwhile research. A shift in the scientific world view is called for. Much agricultural research involves manipulating the management of a single field crop to maximize yields within a tightly controlled experimental environment. Such research continues to be important. However, for systems such as the one described here—not atypical in humid tropical rainforests—we need to look at interactions among crops. Also, crops must be

A rice-planting party on an upland field.

selected to fit both the type of land and the human systems in the area.

I concluded that greater attention should be devoted to the feasibility of growing and selling indigenous nontimber forest products such as rattan, bamboo, or dyes (cf. TAD 1979, 1981; Peluso 1983); or to the potential of small-scale planting of dipterocarps (including Philippine mahogany, or **meranti**) by farmers to assure a supply of timber for market (cf. Hartshorn's work in Peru); or to the selection and breeding of forest fruit trees to lengthen the harvest season, increase production, or improve marketability (Erick Fernandez, personal communication 1986; or Peluso 1990). Efforts should be made to develop research designs that consider successional stages of forest regrowth as "plots" for experimentation.

Some of these important research topics are amenable to traditional agronomic research designs. Others are not. To build on indigenous knowledge[22] we need to look to disciplines that study "wild" populations, including ecology, fisheries, and wildlife, and some branches of forestry. The necessity of borrowing or creating new methods of investigation must be taken as a scientific challenge, if we genuinely want to develop sustainable agricultural systems.

---

[22]Thrupp (1989) warns the scientific community against approaching indigenous knowledge in an "extractive" manner. She urges instead that we work to legitimize it. Indigenous knowledge, like other knowledge, can be an effective mechanism for empowering rural people.

Synthesis

The previous chapter has presented a summary of the most important studies undertaken in the Sitiung area linking farmers and soil management. It should be clear that by mid-1986, our team had a good understanding of transmigrants and their upland fields, home gardens, and the Minang approach to farming. We were conducting experiments continually, and huge quantities of information were accumulating.

I was convinced of the utility of what we were doing, and felt that this kind of research was badly needed. We all wanted our work to be as useful as possible, and we were concerned about the common criticism of such field-based research—that it has only local significance and that the results cannot be generalized on a broad enough scale.

Naturally, studying individual farming systems contributes to anthropological knowledge, and it is clear that by working with farmers in an interdisciplinary mode, we were contributing to greater understanding of the process of such collaborative work. But I was convinced that this kind of research had broader real-world implications, that effective agricultural development would, in the long run, have to tap the creativity and commitment of local people. The best way to do that, in my view, was to build on existing systems, just as we were trying to do.

The common argument that the only economically viable way to develop is to standardize simply does not fly. The development world has been operating from that perspective for decades. Yet any meeting of scientists finds them complaining bitterly—or sadly—about people's unwillingness to accept new technologies. Close inspection typically reveals excellent reasons why people do not want to accept this or that new technology given their circumstances.

East Javanese girls dancing on a rice-drying floor in Sitiung VC.

Coffee processing in Pulai.

Assuming then, for the sake of argument, that standardized, global, agricultural solutions are not viable, and that we cannot economically field an interdisciplinary team of Ph.D.s in every village of the Third World, what are our options?

Although TropSoils team members all gave talks at various meetings, prepared research briefs for distribution to interested parties, and wrote scholarly articles, we were not satisfied that these were adequate ways to make our findings known to others. There needed to be a better way to share the multitudinous field-based data that were being collected in various farming systems and in other research projects around the world.

If the burgeoning body of data could be shared, there seemed two possible ways to express the dilemma outlined above—that standardization is cheaper but does not work, that site-specific solutions work but are too expensive.

It may be, as ecologists are wont to argue, that general principles will emerge as we gain a fuller understanding of various individual systems. Indeed, in many cases, we already know general principles about human behavior and ecology that are not adequately integrated into development projects.

If such principles prove elusive, we may be able to develop mechanisms for storing, in a more accessible form, the vast amounts of information being generated. If decision-makers, whether scientists, policy makers, extension personnel, or farmers, could easily access information on other people's experience, they could build on what has been discovered in other places. This chapter will discuss our preliminary efforts to put our people-oriented research findings into an "expert system."

Expert Systems: A Possible Aid in Agricultural Decision-Making[1]

with Russell Yost, Fahmuddin Agus, and Stacy Evensen

Expert systems are computer programs designed to use human knowledge to solve problems. Knowledge and experience from human experts are manipulated within the program using symbolic logic and heuristics (rules of thumb). Thus, in a relatively quick, consistent, and inexpensive manner, the knowledge gathered through years of research can be accessed and applied to specific problems. This artificial expertise is easy to transfer and document and allows expert knowledge to be made more available to researchers, policy makers, educators, and others.

In our work on developing FARMSYS, the early stages of an expert system, we used EXSYS

[1]The material discussed in this section is available in more detail in Colfer et al. 1989e.

v.3.2 (a "shell"); more sophisticated versions are now available. FARMSYS runs on an IBM-compatible computer with 256K. Creating an expert system, using "editxs," requires 640K. Throughout the discussion in this section, the term "expert system" refers to the EXSYS software.

The purpose of an expert system is to provide access to knowledge that would otherwise only be available from an expert. With an EXSYS program disk and a FARMSYS disk, a user can receive a recommendation related to agricultural research and development in Indonesia. Similarly, with ACID4[2] a user receives a recommendation on lime required for a particular location and crop; FISH provides the best kind of fish to stock in a fishpond in Sitiung.

Generally, EXSYS operates by chaining backwards from each "choice," or recommendation, through a series of rules constructed in an "if-then" format. As the user answers a series of questions, the computer determines appropriate choices and attaches probabilities to those choices.

Using an expert system is simple, though the information needed to answer the questions it asks may not be available. Creating an expert system is not quite so easy.

An expert system such as FARMSYS consists of three major building blocks: qualifiers, variables, and choices. **Qualifiers** are the most commonly used component in FARMSYS. Appendix IV contains several rules from FARMSYS. Rules 7 and 9 are composed only of qualifiers.

Qualifiers can be clear-cut (religion is **Muslim**) or fuzzy (most crops planted probably require **minimal management**). They can deal with easily quantifiable matters (domestic animals may include **chickens and pigs**) or qualitative attributes (ethnicity is symbolized by **female rice cultivation and male expedition making**). The boldface parts of each sentence indicate the appropriate value, selected from several (see Qualifier 76 in Appendix IV).

Variables initially were created to deal with quantitative material but have now been improved to allow for the inclusion of "string variables"—letters. Variables allow for rules requiring formulae.

Rule 220 contains variables. Number 1 in the "if" clause should read, "If the proportion of bought food is greater than the sum of the proportion of food from orchards, food from dry fields, and food from home gardens." The second component of the "if" clause is a qualifier.

The "then" clause introduces the third component, the **choice** or recommendation. These choices, with a probability of appropriateness or accuracy, are the end product provided to a user. A choice in FARMSYS is a development-related recommendation.

In sum, then, site-specific information collected in Indonesian villages is formed into "if-then rules" composed of qualifiers, variables, and choices about people and agricultural research and development. These rules lead to development-oriented recommendations for scientists and policymakers, taking peoples behavior and beliefs into account. In this TropSoils activity, we made rules relating to nine specific Indonesian communities.[3] Ideally, we could abstract additional general principles about people and soil management after we have successfully described these specific situations.

FARMSYS: Its Current State

In the following subsections, we provide an overview of the structures used for the rules and choices. The procedure used by the EXSYS program requires that the "if-then" rules be organized in a hierarchical fashion, with more important items occurring earlier in the program.

---

[2]ACID4 and FISH are two other expert systems developed under TropSoils auspices, spearheaded by Russell Yost and Richard Dudley, respectively. Yost remains involved in a TropSoils sub-project on "decision support systems" which has continued to develop expert systems dealing with soil fertility issues.

[3]FARMSYS includes data from two villages in East Kalimantan—studied in 1979-80—as well as the data discussed in this monograph. Long Segar is a resettlement village two days and a night's riverboat ride from the provincial capital of East Kalimantan; Long Ampung is a remote community in the interior of Borneo, accessible in 1980 only by foot. Both communities were inhabited by Kenyah Dayak shifting cultivators. The research, conducted in 1979-80, was supported by the UN Man and Biosphere Programme, in collaboration with the East-West Center (Honolulu), Mulawarman University (Samarinda), and Lembaga Biologi Nasional (Bogor).

The Structure of the Rules

Two facts emerged immediately as critical for differentiating among the farmers we had worked with. One was ethnicity and the other location. Each of these appeared to have very significant and interacting impacts on their cropping patterns and approaches to agriculture in general. Early in the FARMSYS program are a series of rules identifying relevant factors about ethnicity and our locations of study. Such rules are in the form "IF (e.g.) ethnicity is Minangkabau, THEN (1) Religion is Muslim, and (2) . . . and (n) . . ." (Appendix IV provides a number of partial rules for illustration).

In order to indicate to the user how information might be relevant or irrelevant in other areas, we made some of FARMSYS' first rules provide probabilities for the choice expressed as "Results of this system should be applicable" (see Rule 1, 5). Ethnic differences also had to appear early in the program (Rule 11).

Given these locational and ethnic differences, we proceed to a series of topics that vary along these dimensions and relate to agricultural research and development. The topics we have so far identified as relevant are discussed below, roughly in the order they are addressed in FARMSYS; examples of rules dealing with each topic are provided (after the dash). The interconnections among these factors preclude strict ordering.

1. **Crops grown**—Rule 22
2. **Land use**—Rule 34
3. **Division of labor**—Rule 101
4. **Risks**—Rule 119
5. **Animals**—Rule 143
6. **Land preparation**—Rule 138
7. **Fertilizer/inputs**—Rule 154
8. **Income**—Rule 146
9. **Production**—Rule 172
10. **Nutrition**—Rule 168

Collecting latex in Pulai, where the tasks of women and men are often interchangeable.

The Structure of the Choices

Just as the rules are organized into a hierarchical structure, so are the choices. The EXSYS program begins with the first choice and tries, by going through the rules, to provide the user with that recommendation. It repeats this procedure with each choice. Our choices were designed for scientists. We tried to organize them into a logical order, given the decision needs of agricultural scientists. We assumed that the scientists may be working with farmers, and that they are trying to design their experiments so that their results will have the maximum probability of being usable by farmers. Users can specify their research goals: increased production only, equity only, both of these, improved nutrition, and/or increased financial security for all family members or for heads of household only.

The first series of choices, or recommendations, relates to which farmers the scientist should be working with. These choices specify women farmers, men farmers, both sexes, a fair mix of ethnic groups, and a fair mix of clans resident in the area. This process should widen the perspective of users, since the usual practice is to work with men farmers from Indonesia's dominant ethnic group.

The second series of choices helps the scientist choose a type of field. The choices at this stage are upland fields, paddy fields, and home gardens. Again this process may widen the realm of agricultural endeavor, since very little research is done on home gardens.

Our third series of choices recommends crops to be used in experiments. As with type of field, the variety of potential crops suggested—tree, fodder, vegetables, minor forest product, as well as field crops—may be an eye-opener for some users.

The last series in the list of choices relates to specific kinds of experiments appropriate under differing conditions. Some examples follow.

Given the lack of interest and experience of the Minang and Dayaks with hoeing upland field crops, experiments requiring incorporation of fertilizers or lime before planting are unlikely to lead to popular technologies. With the transmigrants, however, such experiments could yield a high rate of adoption, if funds were available for the purchase of inputs. Research on minimum tillage would at least initially be suspect among transmigrants; Outer Island farmers, on the other hand, could be expected to take to it immediately.

Experiments and technologies requiring manure use among the Dayaks would probably be of little value, since Dayaks express revulsion at the thought of handling manure; Javanese cattle owners do so regularly, and would benefit from such experiments.

Experiments on spacing of food crops or use of herbicides might best include women farmers, since they are often in charge of planting and weeding. Those who do the work often have the most motivation to succeed. Conversely, experiments on land preparation or techniques for felling large trees in land clearing are, as a rule, most appropriate for male collaborators.

All of these choices must, of course, be evaluated by the scientists themselves, taking into account other more agroecological factors, as well as their own areas of expertise. The recommendations are designed to mirror what an anthropologist with some familiarity with things agricultural might suggest, based on intimate knowledge of these farming systems.

In Sum

Our use of expert systems is at a very early stage. Indeed, we still are unsure if we can effectively and justly depict the relevant aspects of local farming systems within the "if-then" framework of the FARMSYS software. We have tried to incorporate

A Sundanese woman at harvest in Sitiung VC.

information on various locations and ethnic groups in our search for principles applicable in other quite divergent areas.

The most fundamental problems we have encountered to date include the following.

1. EXSYS uses the qualifiers and variables provided in the if-then rules to determine what information it needs from a user. It then asks the user for that information. In FARMSYS as well as ACID4, the answers to many of the questions are unlikely to be readily available.

In FARMSYS we have quantitative information on time allocation and on dietary patterns of different ethnic groups. As the system now stands, it asks users questions such as, "What percentage of total food consumed is green leafy vegetables?" Very few people could answer this question. One possible solution is to delete such specific, quantified data, and rephrase the information in more qualitative terms ("Do people eat a little, an average amount, or a lot of green leafy vegetables?").

2. The probabilities assigned to choices (recommendations) are currently determined largely by my own judgment. A more systematic method incorporating other judgments is important in the long run. Ideally, anthropologists and human ecologists with experience in various parts of Indonesia would work together to improve FARMSYS.

3. The system works best when rules occur in a hierarchical manner, with the most important factors appearing early in the program. Many features of FARMSYS are on the same level. The four ethnic groups, for instance, are equally important; yet throughout the system, arbitrary selections were made simply because the system operates **in order**. No real solution seems probable, and it may not be important.

We remain enthusiastic about the potential of expert systems for the following reasons:

—They can handle large quantities of complex data (qualitative as well as quantitative), and incorporate them quickly into a chain of reasonable links leading to a recommendation.

—They can enable someone from another discipline to get an "expert opinion"—an answer—without having to learn a whole new repertoire of jargon and methods. Users can prod the system for more information about how answers are derived by asking that the rules used be displayed.

—They seem to offer an avenue for supplying village-based information to policy and decision-making centers of government.

From the standpoint of sustainable agriculture, expert systems offer a hope for making in-depth, local analyses available on a broader scale. There is no question that vast quantities of local data can be stored in a comparatively accessible form.

Further, the process of developing expert systems will help analysts like me identify those principles which can and should be addressed more broadly. For people who think and work from a holistic perspective, the process of rule-making is difficult and a bit alien. But it forced me to identify **critical** cultural factors—from all the interesting ones—and to state them succinctly—something it is not easy to get anthropologists to do.

Conclusions

The preceding sections have included an introduction to our approach and our location; a summary of our research findings related to people and soils, over a three-year period; and a potential, partial solution to the problem of site specificity. In this final section, I would like first to return to the discussion of our research approach and its strengths. The purpose is to make as clear as possible those elements of our approach that may be of use in the effort to develop sustainable agricultural systems. I will conclude with some suggestions for improvements that I see as necessary for such development.

Minang farmer in Pulai.

The Strengths of TropSoils

Early in this bulletin, I mentioned our attempt to adhere to the farming systems research and development guidelines put forth in Shaner et al. 1982. In most cases, our efforts succeeded insofar as they conformed to the guidelines, which outlined an approach that was holistic, farmer-based, problem-solving, iterative/dynamic, interdisciplinary, complementary, and responsible to society. The pages that follow describe how we applied this approach to our work in Sitiung.

Holistic

From the anthropological point of view, a holistic approach makes eminent sense. Looking at human behavior in a systemic manner is a sine qua non of our discipline—much as the experimental method is fundamental to soil science. A primary goal of any anthropological research must include identifying the important elements in people's behavior and beliefs, as well as understanding the interconnections among these elements.

Despite the importance of a holistic understanding, it is impossible to look at everything. In order to restrict our investigations to areas directly related to soil management, I used what Vayda (1983) has called "progressive contextualization" (see also Vayda et al. 1980). Contextual analysis involves identifying a particular problematic human action, such as growing crops, and tracing the causes and effects of this action outward. The approach helps focus research efforts. For example, in our case, we did not devote significant attention to areas with

Mike and Suwandi explain research results to collaborating farmers in Sitiung VC.

little or no impact on agriculture.

Some of the areas to which contextual analysis led us include division of labor (who ploughs, plants, fertilizes?), alternative sources of income (are there significant off-farm work opportunities?), decision-making (who chooses crops, decides on fertilizer use?), religion and food taboos (can people eat or handle pigs?).

Developing agricultural technologies without knowing such parameters is risky, to say the least. On the TropSoils project, one determinant of research priorities was the holistic understanding of the factors affecting people's practice of agriculture. Besides conducting our own studies, we got help from visitors and short-term consultants in areas where we lacked expertise—including nutrition, psychology, economics, and botany—always trying to address soil management with the "whole picture" in mind.

Farmer-based

Again, this concept is very comfortable for anthropologists. We are, by definition, focused on people. "Farmer-based," as the TropSoils team interpreted the term, includes an element of collaboration that much anthropological research has not traditionally included. We perceived the farm families as partners in an egalitarian sense. We were trying to bring together our scientific knowledge with their experiential knowledge of their needs, skills, and environment. We anticipated, and got, a synergistic effect.

Besides working with farmers directly in collaborative trials, we tried to gain an understanding of their conceptual approach to agriculture. In what ways did their view of agriculture differ from our own? Such differences provide useful insights for restructuring research so that it will yield advances in tropical agriculture, advances that will be more sustainable and more compatible with local people's behavior and beliefs.

The farmer-based component of our approach was controversial. Some reviewers and university administrators doubted that farmers had anything to offer. The "top-down" view is widely and strongly held in academic circles. We had to fight for our

---

[1]Discussing the University of Hawaii's TropSoils project, the *TropSoils Technical Report* (1989) states that "The principal goal of the TropSoils program is to uncover principles which will enable resource-poor farmers to adopt soil management practices that will increase family income and farm productivity and, at the same time, preserve land quality. The research strategy is designed to ensure that social, cultural, economic, and environmental factors that enhance adoption of a soil management innovation are made an integral part of the research plan. To achieve its goal, the project conducts a major portion of the soil-management research with farmers and in farmers' fields using systems-based research, crop simulation models, and "expert systems."

collaborative research with farmers, and this detracted from our efforts.

The team, and other reviewers and administrators, felt that the farmer-based component contributed valuable insights and kept us on track as we developed technologies useful to low-income and subsistence farmers. I am convinced that this component not only kept our research effort grounded in the real world—enhancing the probability of its ultimate use—but also provided us with creative ideas that we would have missed without such direct input from farmers.

Problem-solving

Problem-solving, as we interpreted it, ensures that research is related to real-world problems. FSR&D—like TropSoils research in general[1]—is not purely academic. It is designed to deal with the nexus of agriculture, food supply, and poverty. Our definition of research priorities incorporated this applied component.

But there is another way in which we did not comply with this element of the FSR&D guidelines—I think, beneficially. A focus on problem-solving implies looking at a group of people practicing agriculture and focusing one's attention on their problems, then working to solve those problems. However, the number of problems one can identify—at least in an area like Sitiung—is phenomenal. Solving all the problems, like understanding all of culture, is impossible.

A more realistic, and I would argue more fruitful, approach is to seek out *opportunities*. Researchers are surrounded by problems that cannot escape notice. But, in my experience, opportunities arose as we looked holistically at the people's way of life, as we discussed our ideas with them, as we came to understand their ways of viewing agriculture.

The shift from a negative search for problems to a positive one for opportunities alters researchers' interactions with farmers. Because it helps reveal the potential in rural people, the search for opportunities can empower farmers, based as it is on the assumption that they have something positive to offer, an assumption amply warranted by evidence in the literature (see, for example, Clay 1988, Building on Local Agricultural Knowledge 1989, Chambers, Pacey, and Thrupp 1989).

Additionally, overwhelming agricultural problems, though solvable, may be indicators of basic ecological flaws in approach. In many cases, it is

Transporting rubber.

Tarmin, a driver, Stacy, a nutritionist, and Dan, a soil scientist, measure rice yields in a Pulai field.

more productive to sidestep a problem, taking a new or different tack. This requires the kind of opportunistic approach we used.

The utility of this opportunism, incidentally, applies to colleagues as well. I found, not surprisingly, that scientists differ in their interests. One colleague immediately and enthusiastically worked with me on the collaborative trials; another was inspired by studies of farmers' world views; a third wanted to collaborate with me on surveys about specific questions of farmer practice. It pays to take advantage of such interests, rather than trying to force the unwilling. I have already described how we benefited from our access to spouses' skills within the team.

Iterative/Dynamic

In the case of research on people in soil management, the iterative process went like this: Early on, the collaborative work with transmigrants reinforced the team's interest in land clearing, tillage, organic matter, and pasture grasses. As the importance of home gardens became clear, we undertook to improve home garden production and our understanding of this complex subsystem. As we comprehended the important differences between transmigrant and Minang farming systems, we redoubled our efforts to document how the local system functioned. We wanted to build on indigenous knowledge and experience, rather than to import models from other ecological contexts. We tried to incorporate into the project more attention to tree crops.

We began with the assumption that we would be unable to "get it right the first time." Our applied sciences are too young, our understanding of the systems of which we are a part too incomplete. We accepted that we would have to try, fail, and try again, probably repeatedly. The general intra-team acceptance of this notion allowed us the freedom to be creative, to try unusual things. It also helped agricultural scientists make use of my findings without any sense of blame. We determined research priorities—both theirs and mine—together and repeatedly.

Our willingness to experiment and accept the possibility of failure required us to start small (from an American perspective). Starting small, conducting inexpensive experiments and studies, was also sensible, given the financial resources of the Indonesian organizations with which we worked. We had to consider the sustainability of the research effort.

We learned that some people—perhaps particularly university-based people controlling funds—find the iterative approach difficult. They are uncomfortable with responding to feedback from ongoing activities and making changes consistent with that feedback. Some scientists, guarding the reputations of all scientists, refuse to acknowledge ignorance.

But developing sustainable agriculture will require that we acknowledge our ignorance as well as our expertise. An iterative approach recognizes human fallibility and our ability to learn from experience and from farming women and men. Sustainable agricultural development will proceed more quickly, in my view, if we begin by acknowledging the probability of error, and our continuing willingness to work on rectifying it.

Though some have consoled us on one "failure" or another, in my view each of our activities contributed to a better understanding of soil management. Sustainable agriculture cannot evolve without such failures. Global diversity precludes one standardized system; the process of developing many, locally appropriate, and differing components of systems will require an iterative approach—a willingness to try again.

Interdisciplinary

The difficulty of establishing and maintaining effective working relationships across disciplines is well known. Although unsuccessful interdisciplinary teams are probably more common than successful ones, our experience in Sitiung definitely fell into the latter category. I attribute our success to the team-building exercise we underwent in Honolulu in late 1982 (described in Appendix V), to hard work, and to good luck.

There is no question that our research benefited from our interdisciplinary cooperation. By working together, TropSoils agricultural scientists and I were able to forge critical links between farmers and experiments and between research approaches with very different requirements. Without my presence, our agricultural scientists would have been unlikely to develop collaborative trials on farmers' home gardens or to have noted the significant ethnic differences in soil and crop management (Colfer 1987). Similarly without continuing interaction with soil scientists, looking at transmigrants' residue management would probably not have occurred to me. I would not have understood the significance of differing tillage methods. I would have been unable to conduct soil analyses in various indigenously defined land types.

Fascinating and fruitful discussions came out of our differing academic traditions. I was persuaded to measure many things that would not have been considered necessary within my own discipline; conversely, soil scientists learned the importance of addressing issues that are not amenable to the experimental designs and statistical tests that they learn to consider the defining characteristic of science. They began to conceive their experiments as part of a developing human system. All of our research efforts benefited.

As team leader (preceded by frequent periods as "acting team leader"), I had considerable influence in project direction within our soil-management mandate. Having a nonagricultural scientist as team leader seemed to reduce intra-team competition. I believe my gender had a similar effect, rendering my observations and suggestions less threatening. Perhaps the other team members expected a woman to be concerned about human issues. I felt more free than a man would have been to incorporate the alien qualitative aspects that were so important. My anthropological orientation ensured continued attention to human factors. Appendix I should confirm that conventional soil-management research continued as well. The activities reported in this bulletin represent a small percentage of the total research undertaken in Sitiung.

As a social scientist working with a soils project, I had an unusual degree of administrative support. While on campus, I had worked closely with Goro Uehara (TropSoils program coordinator at UH), who fully understood the difficulties of interdisciplinary interaction. He provided crucial administrative backing and strong personal support for the full integration of my findings into the project. He sometimes had to face strong objections from powerful people—interestingly, not Indonesians—as he supported our efforts to work with farmers and to attend to human concerns in our research priorities. Without his consistent backing, I doubt that I would have been able to influence research direction so consistently.

None of this is meant to belittle the good will and intentions of my co-workers. It would be impossible to deny the role of hard work and good luck in developing congenial interdisciplinary teams—and we had those. But I remain convinced that the team-building process was crucial.

Three elements in our standard operating procedures seemed to contribute to intra-team camaraderie and effective cooperation. First, we had a decentralized decision-making structure. Although we discussed our plans with each other, and sought input from everyone, neither I nor the previous team leader ever refused to allow a team member to conduct a project he or she felt was important—so long as there was sufficient money and personnel to carry out the project. An authoritarian, hierarchical kind of organization would have been less likely to engender personal commitment and ready cooperation from scientists. Just as we were striving for farmer-scientist collaboration, we sought participatory decision-making within the team.

Second, for any particular activity, and for the team as a whole, there had to be reliable coordination to ensure that deadlines and goals were met. The team leader or the leader of an activity saw to it that each discipline had a fair part in decision-making and that each team member's responsibilities were clear.

Last, the issue of joint authorship on team projects was a touchy one and needed care in handling. We made it a policy to include the names of all those who worked on a particular activity insofar as possible. Typically, the leader or a member would write a first draft and ask for input from involved colleagues. The name of the person who drafted the work would be first, and others would follow either alphabetically or according to contribution. The simple stratagem of using "we" rather than "I" in drafts let people know that they too would get credit for whatever we did.

Winnowing rice in Pulai.

Complementary

Complementary refers to the fact that farming systems research is not and should not be the only research approach. In Sitiung, farming systems research was designed to complement conventional station-based research. Throughout the studies described in this bulletin, soil scientists from the Center for Soils Research, University of Hawaii, and North Carolina State University were conducting conventional agronomic experiments. The TropSoils project had its own research station, including lab and field facilities.

A people-oriented approach was one factor guiding our research directions on station. Research findings from the more conventional and rigorous experiments were also used to help us plan appropriate cropping patterns, fertilizer regimes, and other aspects of soil management in our trials with cooperating farmers.

Responsible to Society

This principle is the one we considered the most vague. A commonly cited example is a case in which the activities of farmers upstream might adversely affect people downstream. An FSR&D project should be aware of such potential impacts and strive to avoid them.

In Sitiung we undertook several activities—

A Pulai farmer.

some unsuccessful—specifically focused on environmental concerns. Our interest in tree crops, for instance, was partly motivated by a concern for broader environmental protection, and we lobbied for greater attention to tree crops.

In September 1984, Dr. Soleh Sukmana, Fahmuddin Agus, and I began collaborative work with four Sitiung VC families whose sloping fields made up a small catchment area. Our primary goal was to develop acceptable and economically viable cropping patterns (including fruit-bearing trees, pasture grasses, and rice) that would reduce soil erosion. The record-keeping study was part of this activity. Two problems, combined with our personnel restrictions, resulted in the abandonment of this collaborative effort:

--the inability to get coconut seedlings in a timely fashion;

--the surprise implementation of a separate government project to pay the same farmers to terrace (a practice that our component research suggested was questionable given Sitiung's thin topsoils).

Carl Evensen came to Sitiung in late 1984, primarily to work on land-reclamation issues. He conducted research on fast growing trees (e.g., *Gliricidia sepium, Albizia falcataria*, and *Calliandra calothyrsus*), which could be used for green manure and fodder, as well as for conserving soil. Several team members did research on green manures—*Calopogonium mucunoides, Crotalaria usaramoensis*, and *Centrosema pubescens*, after we determined that these grew well in Sitiung. We planned a collaborative project in which farmers would take cuttings from our pasture-grass evaluation (CIAT Regional Trial B) and evaluate them from the human perspective. But time constraints again interfered, allowing only informal implementation. After I left in mid-1986, Carl prepared a demonstration plot of fast-growing tree species in Sitiung VC. He and Stacy organized a workshop to show farmers the qualities and growth performance of the various fast-growing tree species.

Certainly we were all concerned about environmental issues. But we had no one expressly responsible for the sustainability of our efforts. To reach a new plateau in agricultural development work—something called "sustainable agriculture"—we will need to do more than we have done.

We also addressed the question of equity. The project was under considerable pressure[2] to focus exclusively on transmigrant agriculture. There was also a widespread assumption that men were farmers and women were homemakers, or should be. Our project devoted considerable effort to broadening the official view of needed research and strategies for development. By mid-1986, our research had expanded to encompass the agroforestry system of the Minang; we had also conclusively demonstrated the active involvement of women of all ethnic groups in farming. We were unable to implement our planned collaborative trials with Minang farmers because of personnel constraints, and the collaboration with women planned for the home garden trials was the least successful component of that research. The stage was set, however, for advancing both of these activities.

[2]"Pressure" in the Indonesian context is considerably more subtle than among Americans. Suffice it to say that there was consistent official interest expressed in transmigrant problems, little in indigenous problems.

Improvements Needed for a More Sustainable Agriculture

The integration of agroecological and training/ extension components is, in my view, essential for the development of sustainable agriculture.

Agroecological Component

The effective integration of the agroecological component in agricultural research-and-development projects will, in my view, require two additional elements. First, ecologists with appropriate subfields should be hired and well-integrated into teams of social and agricultural scientists. Chance visits and interaction with people in environmental fields have convinced me that by not working closely with such people we have been missing important opportunities to make our work more productive and, indeed, sustainable.

For example, Erick Fernandez, an agroforester from North Carolina State University, briefly visited Sitiung in July 1986. He had a wealth of knowledge about fruit trees—very important in local farming systems. He knew, for instance, which species produced more leaf litter, important in increasing soil organic matter. He explained the possibility of genetically manipulating a species to lengthen the fruiting season—critical for reducing marketing problems that result from seasonal oversupply of fruits such duku, or rambutan.

Herwasono Soedjito, a botanist and human ecologist from the Bogor Herbarium, could have described and helped manipulate the stages of forest regeneration in Minang and perhaps also in transmigrants' fields. With help from someone like him, we could have identified valuable, nonconventional forest foods and other products for experimentation. He could have helped us plan experiments within the forest cover. In this way, we could have found ways to use forests more intensively, rather than converting them to other uses.

The TropSoils team was dominated by agriculturalists. Even when our team was at its largest--21 full-time scientists and technicians--I was the only full-time person trained in the human sciences.[3] Although several team members had soil conservation and rehabilitation as their major emphases, with some backup from our collaborating institutions, they were solidly within the field of agriculture.

This brings me to the second important agroecological component: the ecological world view. Ecologists, like anthropologists, are interested in systems, complex wholes, processes. Agroecological analyses have been conducted for years in Indonesia in a variety of ecological niches.

Bringing this holistic ecological perspective into the agricultural research process is critical for the development of sustainable agriculture. In this, I am not saying that ecology has all the answers. Indeed, much of the work of agroecologists—like that of many anthropologists—has been only of academic interest. The practicality of agricultural scientists must be brought together with the environmental awareness of ecologists.

My vision of sustainable agriculture requires that three functions be performed, presumably by representatives of three fields: ecology—to ensure attention to environmental concerns and to note environmentally benign opportunities for research and development; anthropology—to gain access to indigenous knowledge and to coordinate collaboration with farm families; and agriculture—to design experiments and develop technologies that fit the environment and the people.

Projects such as these, though, must build on the kind of approach outlined in this bulletin. Such teams must work with rural people in rural sites on real problems and opportunities; they must communicate and cooperate with each other; they must try, test, evaluate, and revise their research-and-development efforts; they must make their findings usable on a broader basis. Perhaps most importantly, they must be willing to take risks, and try unorthodox approaches—because that is what we will need if we are to develop sustainable agriculture in the humid tropics.

---

[3]We had a number of nonagricultural, short-term consultants (nutritional geography, psychology, sociology, fisheries management) and college students (agricultural economics and rural studies, rural sociology, nutrition) lasting from one to two months. Stacy Evensen (nutritionist) worked with us half-time for over a year. Stephenie Kan (agricultural economics MS student) began nine months of research in April 1986.

Carrying forage.

Training and Extension Component

For any human endeavor to be sustainable, the people involved must have the necessary knowledge to continue that endeavor. This applies to research-and-development activities as well as to farm work.

The TropSoils project at Sitiung did not have mandated on-site training[4] or extension components. Although we tried to incorporate some of these functions informally, our efforts were, in my view, insufficient. Any project having sustainability as its focus should have an explicit component for training its own team members, as well as any collaborators. The TropSoils setting represented an ideal opportunity—largely missed—to train young Indonesian scientists in the kind of research described and envisioned in this bulletin. Our scientists were predominantly newly graduated, bachelor-level soil scientists—open to new approaches.

Certainly the simple process of working on the team involved a kind of passive training. We did provide a lecture series on soil science; we organized periodic seminars on our research proposals and progress; and we provided English training insofar as we could. But this was not enough.

By August 1990, when I returned to Sitiung for a brief visit, it appeared that none of the collaborative activities we had initiated had continued. Drastic reductions in funding, both U.S. and Indonesian, certainly had an impact. But a greater early emphasis on training on-site probably could have increased the longevity of our research initiatives. Research on sustainability, by definition, must be measured in decades.

The issue of extension was briefly discussed above. For most of my involvement with the project, we were expressly prohibited from conducting extension activities. This was eventually acknowledged to be counterproductive. One of the advantages of FSR&D has always been that it can serve both functions simultaneously.

Some of the local extension personnel—graduates of technical high schools—were very enthusiastic about collaborating with us. We were unable to do so formally, but we welcomed them to our plots, and they sometimes came to our homes for informal discussions about agricultural matters. How much better it would have been to involve them directly. Such involvement carries the potential of multiplying the impact of research results geometrically; and we could have exposed them to the more egalitarian and bottom-up approaches current in extension.

[4]A formal, U.S.-based training program was planned, but none of our junior collaborators (those eligible for the funding) spoke English well enough to pass the TOEFL. Only after I left did Fahmuddin Agus, one of our outstanding collaborators, go to the U.S. for training.

In Sum

I have tried to summarize the research results relating to people and soils conducted within the TropSoils project in Indonesia between 1983 and 1986. I have also tried to convey the approach we took to identifying researchable topics; to undertaking that research, in collaboration with local farmers and scientists; and to making those research results available to others.

I am proposing a version of farming-systems research that is holistic, farmer-based, iterative, opportunity-identifying and problem-solving, interdisciplinary, complementary. and socially responsible. I am also proposing that this approach can serve as a basis for developing the more sustainable agricultural systems we are seeking. Developing these sustainable systems, however, will require two major additions to what TropSoils did in Sitiung.

First, an ecological perspective must be integrated into research such as this, requiring greater attention to sustainability issues than we were able to give with our disciplinary complement. Second, greater attention to training within such projects can improve local scientists' chances of sustaining research after projects end. Broader, more formal cooperation with local extension personnel can increase the amount of local spinoff. Such cooperation can also provide additional opportunities for testing the technologies research teams develop.

There are indeed great challenges before us in our attempts to fashion truly sustainable agricultural systems. Yet my years among rural Third World villagers convince me that we have just begun to tap their potential. Sustainability will only be a dream until the advances of science are wed to the experience, values, and knowledge of rural people.

References

Agus, Fahmuddin, M. K. Wade, and Jusuf Prawirasumantri. 1985. Pengaruh berbagai cara pasca bukaan lahan terhadap sifat tanah dan produksi tanaman. In *Proceedings.* Centre for Soil Research Annual Technical Meetings, Bogor, Indonesia.

Agus, Fahmuddin, C. Colfer, S. Evensen, and Jamalinal. 1986. Farmers' and crops' responses to different sources of fertilizers. *TropSoils field research brief* 34.

Agus, Fahmuddin, C. Colfer, S. Evensen, Sholeh, and R. G. Dudley 1989. Effects of different sources of fertilizer on soil properties. In *TropSoils technical report, 1986-87*, ed. N. Caudle and C. B. McCants, 233-236. Raleigh: North Carolina State University.

Altieri, M. 1987. *Agroecology: The scientific basis of alternative agriculture.* Boulder: Westview Press.

Altieri, M., and S. B. Hecht (ed). 1989. *Agroecology and small farm development.* New York: CRC Press.

Building on Local Agricultural Knowledge. 1989. *Agriculture and Human Values* VI (3). Theme Issue.

Caudle, Neil. 1988. Some sociolinguistic factors relevant to agricultural development in transmigration areas of West Sumatra, Indonesia. Informal TropSoils document. Raleigh: North Carolina State University.

Chambers, Robert. 1990. Complexity, diversity and competence: Towards sustainable livelihoods from farming systems in the 21st century. Paper presented at the Asian Farming Systems Research and Extension Symposium, Hyderabad, India (Nov.).

Chambers, R., A. Pacey, and L. Thrupp. 1989. *Farmer First: Farmer Innovation and Agricultural Research.* London: Intermediate Technology Publications.

Chapman, Barbara. 1984a. Preliminary analysis of the Sitiung diet survey, April 1984. Internal TropSoils report (June).

Chapman, Barbara. 1984b. General information about Sitiung including household data, income generation and agricultural production data. Internal TropSoils report (December).

Chapman, Barbara. 1984c. Interpretation of Sitiung diet survey data in the context of nutritional adequacy on Java. Internal TropSoils report (December).

Clay, Jason. 1988. *Indigenous peoples and tropical forests: models of land use and management from Latin America.* Cambridge: Cultural Survival.

Colfer, Carol J. Pierce. 1981. Women, men and time in the forests of East Kalimantan. *Borneo Research Bull.* 13(2):75-85 (also EAPI Reprint No. 25, East-West Center, Honolulu, Hawaii).

Colfer, Carol J. Pierce. 1982. Women of the forest: An Indonesian example. In *Women in natural resources: An international perspective*, ed. Stock, Force, and Ehrenreich. Moscow, Idaho: University of Idaho Press.

Colfer, Carol, J. Pierce. 1983a. Change and indigenous agroforestry in East Kalimantan. *Borneo Research Bull.* 15(1,2):3-21;70-87.

References

Colfer, Carol J. Pierce. 1983b. Integrating participants: Farming systems lessons from Hawaii. In *Farming systems in the field: Proceedings of Kansas State University's 1982 farming systems research symposium*, ed. Cornelia Flora, 206-214.

Colfer, Carol J. Pierce. 1987. Social science and soil management: An anthropologist's role in the TropSoils project. *Farming Systems Support Project Newsletter* 5(1):15-18.

Colfer, Carol J. Pierce. 1988. The human face of an agricultural system: Pulai, West Sumatra. TropSoils research report.

Colfer, Carol J. Pierce. 1991a. Gaining acceptance in the field: An example from West Sumatra. *The naked anthropologist: Tales from around the world*, ed. Devita. Belmont: Wadsworth Publishing.

Colfer, Carol J. Pierce (1991b). Indigenous rice production and the subtleties of culture change: an example from Borneo. *Agriculture and Human Values* (in press).

Colfer, Carol J. Pierce. (n.d.) Food consumption among the Minangkabau: Implications for agricultural research in Indonesia. Submitted to Farming Systems Research and Extension, 14 May 1990.

Colfer, Carol J. Pierce, Mike K. Wade, Atin Kurdiana, and Suwandi. 1984a. Incorporating farmer conditions and preferences into farming systems research. Paper presented at the World Bank, October 14, and the Home Food Production Systems Workshop, Cornell University, Ithaca, N.Y., October 16.

Colfer, Carol J. Pierce, Russell Yost, Veronica Kasmini, and Atin Kurdiana. 1984b. Time allocation studies: A method for home food production systems. Keynote Address, Home Food Production Systems Workshop, Cornell University, Ithaca, N.Y., October 16.

Colfer, Carol J. Pierce, Carl Evensen, Stacy Evensen, Fahmuddin Agus, Dan Gill, Ann Wade, and Barbara Chapman. 1985. Transmigrants' gardens: A neglected research opportunity. Paper presented at the Center for Soils Research Annual Technical Meetings (March), Bogor, Indonesia.

Colfer, Carol J. Pierce, M. K. Wade, C. Evensen, I. Putu Gedjer Widjaja-Adhi, Fahmuddin Agus, and D. Gill. 1987a. Collaborative research with farmers on upland fields. In *TropSoils technical report, 1985-86*, ed. N. Caudle and C. B. McCants, 158-159. Raleigh: North Carolina State University.

Colfer, Carol J. Pierce, and Russell Yost. 1987b. Time-allocation study. In *TropSoils technical report, 1985-86*, ed. N. Caudle and C. B. McCants, 159-162. Raleigh: North Carolina State University.

Colfer, Carol J. Pierce, Herman, M. K. Wade, D. Gill, and C. Evensen. 1987c. Farmers' perceptions of constraints to agriculture. In *TropSoils technical report, 1985-86*, ed. N. Caudle and C. B. McCants, 164-65. Raleigh: North Carolina State University.

Colfer, Carol J. Pierce, Herman, Dan Gill, and Barbara Newton. 1987d. Indigenous knowledge systems related to soil management. In *TropSoils technical report, 1985-86*, ed. N. Caudle and C. B. McCants, 156-157. Raleigh: North Carolina State University.

Colfer, Carol J. Pierce, Evi Martha, Mira Elfina, Fahmuddin Agus, Vickie Sigman, and Stacy Evensen. 1987e. Intrahousehold decision-making. In *TropSoils technical report, 1985-86*, ed. N. Caudle and C. B. McCants, 157-158. Raleigh: North Carolina State University.

Colfer, Carol J. Pierce, Evi Martha, and M. Sudjadi. 1987f. Women: An under-recognized Indonesian resource with potential for growth. TropSoils report submitted to Centre for Soils Research (February).

Colfer, Carol J. Pierce, Barbara Newton, and Herman. 1987g. Ethnic differences can make a difference in agriculture. *TropSoils Communique's*. 4(1):4-6.

Colfer, Carol J. Pierce, Barbara Chapman, Bartholomeus Weid, Harry Apriadji, and Liek Irianti. 1987h. Nutrition/income survey. In *TropSoils Technical Resport, 1985–86*, ed. N. Caudle and C. B. McCants, 157-158. Raleigh: North Carolina State University, pp. 152–163.

Colfer, Carol J. Pierce, Dan Gill, and Fahmuddin Agus. 1988. An indigenous agroforestry model from West Sumatra: A source of insight for scientists. *Agricultural Systems* 26:191-209.

Colfer, Carol J. Pierce, Fahmuddin Agus, Dan Gill, M. Sudjadi, Goro Uehara, and M. K. Wade. 1989a. Two complementary approaches to farmer involvement: An experience from Indonesia. In *Farmer first: farmer innovation and agricultural research*, ed. Chambers, Pacey, and Thrupp, 151-157. London: Intermediate Technology Publications.

Colfer, Carol J. Pierce, Barbara Newton, and Herman. 1989b. Ethnicity: An important consideration in Indonesian agriculture. *Agriculture and Human Values* 6(3):52-67.

Colfer, Carol J. Pierce, Dan Gill, Barbara Newton, and Herwasono Soedjito. 1989c. Indigenous knowledge systems related to soil management. In *TropSoils technical report, 1986-87*, ed. N. Caudle and C. B. McCants, 202-221. Raleigh: North Carolina State University.

Colfer, Carol J. Pierce, Evi Martha, Vickie Sigman, Kathleen Wilson, Russell Yost, Marian Rauch, and Michael Wade. 1989d. Intrahousehold decision-making. In *TropSoils technical report, 1986-87*, ed. N. Caudle and C. B. McCants, 222-230. Raleigh: North Carolina State University.

Colfer, Carol J. Pierce, Russell Yost, Fahmuddin Agus, and Stacy Evensen. 1989e. Expert systems: A possible link from field work to policy in farming systems. *AI: Applications in Natural Resource Management* 3(2):31-40.

Conway, Gordon. 1985. Agroecosystem analysis. *Agricultural Administration* 20:31-55.

Conway, Gordon. 1987. The properties of agroecosystems. *Agricultural Systems* 24:95-117.

Dove, Michael. 1990. Review article: Socio-political aspects of home gardens in Java. *Journal of Southeast Asian Studies* 21(1):155-163.

Dudley, Richard G., Endang Hidayat, and C. J. P. Colfer. 1989. A survey of small fish ponds. In *TropSoils technical report, 1986-87*, ed. N. Caudle and C. B. McCants, 243-248. Raleigh: North Carolina State University.

Evensen, Carl, Carol J. Pierce Colfer, Michael Wade, and Herman. 1985. Constraints to crop production in Sitiung, West Sumatra: A comparison of researcher and farmer perceptions. Paper presented at the International Workshop on Farming Systems Research, Sukarami, West Sumatra.

Evensen, Carl, R. Yost, Yo. Kanehiro, and R. Guyton. 1989. Pasture grass and legumes for the humid tropics. In *TropSoils technical report, 1986-87*, ed. N. Caudle and C. B. McCants, 265-271. Raleigh: North Carolina State University.

Evensen, Stacy and C. J. P. Colfer. 1989. Farmer practice and production. In *TropSoils technical report, 1986-87*, ed. N. Caudle and C. B. McCants, 237-243. Raleigh: North Carolina State University.

Feldstein, H., and S. Poats, eds. 1989. *Working Together: Gender Analysis in Agriculture*. (Vols. I & II). West Hartford: Kumarian Press.

Gerber, John. 1990. Agricultural systems ecology: Research and education for a sustainable agriculture. Paper presented at a USAID Workshop on Sustainable Agriculture, Lusaka, Zambia (September).

Gilbert, E. H., D. W. Norman, and F. E. Winch. 1980. Farming systems research: A critical appraisal. *MSU Rural Development Paper No. 6*. East Lansing, Michigan: Dept. of Agricultural Economics, Michigan State University.

Gill, Dan, M. K. Wade, C. J. P. Colfer, C. L. I. Evensen, and Fahmuddin Agus. 1986. On-farm research in Sitiung, West Sumatra, with emphasis on maize. Paper presented at the MARIF On-farm Research Workshop, Malang, E. Java, March 24-27.

Grove, Thurman L., Clive A. Edwards, Richard R. Harwood, and Carol J. P. Colfer. 1990. The role of agroecology and integrated farming systems in agricultural sustainability. Keynote address at the workshop to plan USAID's Sustainable Agriculture and Natural Resource Management (SANREM) CRSP, National Academy of Sciences, Washington, D.C., November 13-16.

Hart, Robert D., and Michael W. Sands. 1990. Sustainability: Abstract goal or operational objective? Paper presented at the Annual Meeting of the Association for International Agriculture and Rural Development, Washington, D.C., June 12-14.

Hildebrand, P. E. 1979. Summary of the Sondeo methodology used by ICTA, ICTA, Guatemala.

Hildebrand, P. E. 1981. Combining disciplines in rapid appraisal: The *sondeo* approach. *Agricultural Administration* 8(6):423-432.

Hildebrand, P. E., and Federico Poey. 1985. *On-farm agronomic trials in farming systems research and extension.* Boulder: Lynne Rienner.

Johnson, Allen. 1975. Time allocation among the Machiguenga. *Ethnology* 14(3):301-310.

Kato, Tsuyoshi. 1982. *Matriliny and migration: Evolving Minangkabau traditions in Indonesia.* Ithaca: Cornell University Press.

Keirsey, David, and Marilyn Bates. 1984. *Please understand me: Character and temperament types.* Del Mar: Prometheus Nemesis Book Company.

KEPAS. 1985a. *The critical uplands of Eastern Java: An agroecosystems analysis.* Jakarta, Indonesia: Kelompok Penelitian Agro-ekosistem, Agency for Agricultural Research and Development.

KEPAS. 1985b. Tidal swamp agroecosystems of Southern Kalimantan. Workshop report on the sustainable intensification of tidal swamplands in Indonesia, held at Banjarmasin, South Kalimantan, July 18-24, 1983. Jakarta, Indonesia: Kelompok Penelitian Agro-ekosistem, Agency for Agricultural Research and Development.

Kolb, David. 1971. Individual learning styles and the learning process. Working paper, Alfred P. Sloan School of Management, MIT, Cambridge, Mass.

Martha, Evi. 1985. Peranan wanita dalam proses pengambilan keputusan dan kaitannya dengan pertanian [Women's status in decision-making and its links to agriculture]. TropSoils research report (August).

Martha, Evi. 1986. Peranan wanita tani dalam proses pengambilan keputusan di lingkungan keluarga dan masyarakat daerah transmigrasi Sitiung I [Farm women's status in decision-making in the family and community context, Sitiung Transmigration Area I]. TropSoils research report (July).

Naim, Mochtar. 1971. Merantau: Causes and effects of Minangkabau voluntary migration. Occasional paper no. 5. Singapore: Institute of Southeast Asia Studies.

Naim, Mochtar, and Herman. 1984. Tree crop farming system pattern in Koto Padang, Sawahlunto/Sijunjung District, West Sumatra. TropSoils research report (translated by Fahmuddin Agus and C. Colfer).

Naim Mochtar, Herman, Fahmuddin Agus, and C. J. P. Colfer. 1987. Minang tree-farming study. In *TropSoils technical report, 1985-86,* ed. N. Caudle and C. B. McCants, 165-166. Raleigh: North Carolina State University.

Peluso, Nancy. 1983. Networking in the commons: A tragedy for Rattan? *Indonesia* 35: 95-107.

Pelsuo, Nancy. 1990. Studying household dependence on forests and trees: A method and a trial study. Draft report to FAO, Community Forestry Unit.

Penny, D. H., and Meneth Ginting. 1984. Pekarangan, petani dan kemiskinan: Suatu studi tentang sifat dan hakekat masyarakat tani di Sriharjo pedesaan Jawa [Home gardens, farmers and poverty: A study of the features and facts of the farming community in Sriharjo, rural Java]. Yogyakarta: Gadjah Mda University Press and Yayasan Agroekonomica.

Perry, Douglas. 1985. The economics of transmigrant farming. *Bulletin of Indonesian Economic Studies* 21(3):104-117.

Pulungan, H., A. A. Reese, J. E.van Eys, and W. L. Johnson. 1985. Survey of small ruminant farmers in Sumatra. Working paper no. 47, Small Ruminant CRSP, Balai Penelitian Ternak, Pusat Penelitian dan Pengembangan Peternakan, Bogor, Indonesia.

Schwede, Laurel. 1989. Family strategies of labor allocation and decision-making in a matrilineal, Islamic society: The Minangkabau of West Sumatra, Indonesia. Ph.D. dissertation, Cornell University, Ithaca, N.Y.

Shaner, W. W., P. F. Philipp, and W. R. Schmehl. 1982. *Farming systems research and development: Guidelines for developing countries.* Boulder: Westview Press.

Sherman, D. George. 1981. The culture-bound notion of 'soil fertility': On interpreting non-western criteria of selecting land for cultivation. In *Blowing in the wind: Deforestation and long-range implications*, 487-511. Williamsburg, Virginia: Studies in Third World Societies.

Sigman, Vickie, C. J. P. Colfer, Russell Yost, and Kathy Wilson. 1989. Farm-based research in the TropSoils project, Sitiung. In *Working together: Gender analysis in agriculture*, Vols. I, II, ed. Feldstein and Poats. West Hartford: Kumarian Press.

TAD. 1981. *Forests for Food.* Samarinda, East Kalimantan: TAD-Materialen II.

Thompson, John, and C. Evensen. 1985. CIAT regional trial B—establishment phase. *TropSoils Research Brief* No. 19.

Thrupp, Lori Ann. 1989. Legitimizing local knowledge: From displacement to empowerment for Third World people. *Agriculture and Human Values* 6(3):13-24.

Trangmar, Bruce, R. S. Yost, M. Sudjadi, M. Soekardi, and G. Uehara. 1984. *Regional variation of selected TopSoils properties in Sitiung, West Sumatra, Indonesia.* Honolulu: HITAHR Research Series 026, University of Hawaii.

Transmigration Office statistics, Mess Transmigrasi, Sitiung I, Kec. Sawahlunto Sijunjung, West Sumatra, 1983.

Tripp, Robert. 1982. Time allocation in Northern Ghana: An example of the random visit method. *The Journal of Developing Areas* 16(3):391-400.

USAID. 1990. Telegram for worldwide distribution to all USAID Missions, from AID/ST/AGR/ EPSA:TGROVE:DC

Vayda, Andrew P. 1983. Progressive contextualization: Methods for research in human ecology. *Human Ecology* 11(3):265-281.

Vayda, Andrew P., C. J. P. Colfer, and Brotokusumo. 1980. Interactions between people and forests in East Kalimantan. *Impact of Science on Society* 30(3):179-190. Also available as East-West Center Environment and Policy Institute reprint No. 13, and reprinted in *Culture and conservation: The human dimension in environmental planning* 1984:211-228.

Wade, Michael K., Fahmuddin Agus, and Carol Colfer. 1985a. The contribution of farmer-managed research in technology development. Paper presented at International Farming Systems Workshop, Sukarami, West Sumatra, December.

Wade, Michael K., C. J. P. Colfer, and D. Santoso. 1985b. Utilization of on-farm experimentation for agronomic technology development. Paper prepared for the Journal Series of North Carolina Agricultural Research Service, Raleigh, North Carolina.

Wade, Michael K. and Pedro Sanchez. 1984. Productive potential of an annual intercropping scheme in the Amazon. *Field Crops Research* 9:253-263.

Woelfel, J. D. and E. Fink. 1981. *Science and human communication: A theory of cultural processes.* New York: Academic Press.

Appendix I

TropSoils Field Research Briefs

#1. Wade, Mike, and Al-Jabri (1984). P Fertilization and Maintenance, 4 pp.

#2. Heryadi and Mike Wade (1984). Effect of Green Manuring on Food Crop Response to Lime and P Fertilization, 4 pp.

#3. Wade, Mike, and Djoko Santoso (1984). Phosphorous Rates and Methods of Application, 4 pp.

#4. Makarim, A. Karim, and D. K. Cassel (1985). Tillage and Soil Amendments for Land Reclamation of a Bulldozed Area in Sitiung, West Sumatra, Indonesia, 3 pp.

#5. Gill, Dan, and Gene Kamprath (1985). Corn Yield and Soil Response to K at Three Lime Levels in Sitiung I. 4 pp.

#6. Gill, Dan, Gene Kamprath and Mike Wade (1985). Upland Rice Yield and Soil Response to K Applied at Three Lime Levels in Sitiung 2, 3 pp.

#7. Agus, Fahmuddin, Michael K. Wade, and Jusuf Prawirasumantri (1985). Effects of Post Clearing Methods on Soil Properties and Crop Production, 3 pp.

#8. Gill, Dan, Antonius Kasno, and J. Sri Adiningsih (1985). Response of Upland Rice and Soil K Levels to K Fertilization and Green Manure Applications at Sitiung 5, 3 pp.

#9. Wade, Mike, and Al-Jabri (1985). P Fertilization and Maintenance, Sitiung Ia', 3 pp.

#10. Al Jabri and Mike Wade (1985). Lime Reaction Rate and Effectiveness. 6 pp.

#11. Gill, Dan, Gene Kamprath and Mike Wade (1985). Response of Soybeans and Soil K Levels to K Applied at Three Lime Levels in Sitiung II, 2 pp.

#12. Gill, Dan, and Gene Kamprath (1985). Response of Peanuts and Soil Base Levels to Applied K at Three Lime Levels in Sitiung I, 3 pp.

#13. Gill, Dan, Antonius Kasno, and J. Sri Adiningsih (1985). Response of Soybeans and Soil K Levels to K Fertilization and Green Manure Applications at Sitiung 5, 3 pp.

#14. Wade, Mike and Djoko Santoso (1985). Phosphorous Rates and Methods of Application, 5 pp.

#15. Wade, Mike, E. J. Kamparth, and Djoko Santoso (1985). Residual and Maintenance Rates for Lime, 3 pp.

#16. Evensen, Carl, Russell Yost, and Mike Wade (1985). Source and Management of Green Manure—Preliminary Uniformity Trial, 2 pp.

#17. Kamprath, E. J., M. K. Wade, and Heryadi (1985). Sulfur Responses and Reactions in Soils of Sumatera, 3 pp.

#18. Agus, Fahmuddin, Michael K. Wade, and Jusuf Prawirasumantri (1985). Effects of Post Clearing Methods on Soil Properties and Crop Production, 2 pp.

#19. Thompson, John, and Carl Evensen (1985) CIAT Regional Trial B - Establishment Phase, 6 pp.

#20. Evensen, Carl, and Russell Yost (1985). Alley Cropping Trial—Tree Establishment Period, 3 pp.

#21. Gill, D. W., and E. J. Kamprath (1985). Mungbean and Cowpea Response to Application of K at Three Lime Rates, 3 pp.

#22. Wade, Mike, and I. P. G. Widjaja-Adhi (1986). P Fertilization and Maintenance, Sitiung Ia', 3 pp.

#23. Wade, Mike and Al-Jabri (1986). Lime Reaction Rate and Effectiveness, 4 pp.

#24. Agus, Fahmuddin, M. K. Wade, and Jusuf Prawirasumantri (1986). Effects of Post Clearing Methods on Soil Properties and Crop Production, 3 pp.

#25. Gill, Dan, and Antonius Kasno (1986). Rice Response to K Fertilization, Residue Management and Green Manure Application in Sitiung V, 4 pp.

#26. Wade, Mike, Dan Gill and I. B. Aribawa (1986). Mg Fertilization for Annual Food Crops, 3 pp.

#27. Wade, Mike, E. J. Kamprath, and Djoko Santoso (1986). Residual and Maintenance Rates for Lime, 3 pp.

#28. Wade, Mike, and Al-Jabri (1986). Lime Reaction Rate and Effectiveness, 4 pp.

#29. Wade, Mike, I. P. Gedjer, and Putu Wigena (1986). Continuous Function (many-mini) Trial: Soybean Response to Lime, P, K, Mg and Green Manuring, 8 pp.

#30. Wade, Mike, I. P. Gedjer, and Putu Wigena (1986). Lime Residual and Maintenance: With special "blocking" design, 5 pp.

#31. Gill, Dan, I. B. Aribawa, and Mike Wade (1986). Mg Fertilization for Annual Food Crops, 4 pp.

#32. Evensen, Stacy (1986). Farmer Practice and Production Study—Characterization of Home Gardens in Aur Jaya [Sitiung VC], 8 pp.

#33. Evensen, Carl, and Russell Yost (1986). Alley Cropping Experiment—1985-86 Growing Season, 7 pp.

#34. Agus, Fahmuddin, Carol J. P. Colfer, Stacy Evensen, and Sholeh (1986). Farmer and Crop Responses to Different Sources of Fertilizers: A Farmer-Managed Study on Home Gardens, 9 pp.

#35. Evensen, Stacy (1986). Farmer Practice and Production Study—Soil and Crop Management Practices in Aur Jaya [Sitiung V], 6 pp.

#36. Evensen, Carl and Russell Yost (1986). Source and Management of Green Manure—1985-86 Season, 8 pp.

Appendix II

List of Conclusions from Work with Farmers
(excerpted from Wade, Colfer, and Santoso 1985b)

For researchers working in a region, a culture, or an environment new and different from their previous experience, reaching conclusions is deemed a vital exercise in establishing a proper research program. In this instance, some of the tangible benefits were the following:

1. Utilization of organic materials, particularly when incorporated, equalled or alleviated crop response to inorganic lime and fertilizers.
2. Use of lime and organic materials provided stable or consistent yield improvement across a wide range of environments.
3. Farmer management (though not always specifically identified and quantified) was more important to crop yields than fertility, native or amended, as measured by soil analysis.
4. Replication within farms should be used for farmer-managed trials.
5. Farmers prefered simple rotations to complicated cropping patterns, despite researcher proven advantages.
6. Farmers insisted that tree crops be included in the systems for agronomic, economic, and conservation reasons.
7. Transmigration farmers are extremely resource-limited and must rely on government-supported crop improvement programs for inputs. Therefore, research findings must be directed toward policymakers as well as farmers.

Some specific component research topics were identified and initiated in the TropSoils research program as a result of this farmer-managed trial:

1. Phosphorous fertilizer application methods and management,
2. Tillage, lime and burning interaction on newly cleared soils,
3. Crop residue recycling on fertilizer requirements, and
4. Green manure management techniques.

Appendix III

List of Plants Mentioned in Text
(blank indicates no term in that language)

English	Indonesian	Minang	Latin
			Albizia falcataria
Angled loofah	Oyong	Pitulo	*Luffa acutangula*
Bambara groundnuts	Kacang Bogor	Kacang Bogor	*Voandzela subterranea*
Bamboo	Bambu	Batuang	*Bambusa vulgaris*
Banana	Pisang	Pisang	*Musa spp.*
Bittermelon	Pare	Pario	*Momordica Charantia*
			Calliandra calothyrsus
			Calopogonium muconoides
Cassava	Ubi kayu	Ubi kayu	*Manihot esculenta*
			Centrosema pubescens
Chili	Cabe	Lado	*Capsicum annuum*
Citrus	Jeruk	Limau	*Citrus spp.*
Clove	Cengke	Cangkeh	*Eugenia aromatica*
Coconut	Kelapa	Karambia	*Cocos nucifera*
Coffee	Kopi	Kopi	*Coffea spp.*
Corn	Jagung	Jaguang	*Zea Mays*
Cowpeas	Kacang tunggak	Kacang tunggak	*Vigna sinensis*
			Crotalaria usaramoensis
Cucumber	Ketimun	Antimun	*Cucumis sativus*
Duku	Duku	Duku	*Lanseum domesticum*
Durian	Durian	Durian	*Durio zibethinus*
Eggplant	Terong	Taruang	*Solanum melongena*
Elephant grass	Rumput gajah	Rumpuik gajah	*Pennisetum purpureum*
Forest jackfruit	Nangka hutan	Cebodak hutan	*Artocarpus* sp.
Ginger	Jahe	Jae	*Zingiber officinale*
			Gliricidia sepium
Guava	Jambu Biji	Paraweh	*Psidium Guajava*
Jackfruit	Nangka	Cebodak	*Artocarpus heterophyllus*
	Jambak	Jambak	*Eugenia malaccensis*
	Kedondong	Kadondong	*Spondias dulcis*
Locust bean	Petai	Patai	*Parkia speciosa*
Longbeans	Kacang panjang	Kacang panjang	*Vigna sesquipedalis*
Mango	Ambacang	Ambacang	*Mangifera foetida*
Mango	Kwini	Kwini	*Mangifera odorata*
Mango	Mangga	Mangga	*Mangifera indica*
Mucuna bean	Mukuna		*Mucuna mocunoides*
Mungbean	Kacang hijau	Kacang padi	*Phaseolus radiatus*
Pandanus	Pandan	Pandan	*Pandus spp.*
Papaya	Papaya	Kalikih	*Carica papaya*
Peanut	Kacang tanah	Kacang tanah	*Arachis hypogaea*
Philippine mahogany	Meranti (mainly)	Marantiah	*Dipterocarps*
Pineapple	Nanas	Naneh	*Ananas comosus*
Rambutan	Rambutan	Rambutan	*Nephelium lappaceum*
Rattan	Rotan	Rotan	*Calamus sp.*
Rice	Padi	Padi	*Oryza sativa*
Rubber	Karet	Karet	*Hevea brasiliensis*
Sago	Sagu	Sagu	*Metroxylon*
			Sesbania
Sorghum	Sorgum		*Sorghum spp.*
Soybean	Kedele	Kedele	*Glycine Max*
Starfruit	Belimbing	Balimbiang	*Averrhoa Carambola*
Stinkbean	Jengkol	Jariang	*Pithecellobium jiringa*
Sugarcane	Tebu	Tabu	*Saccharum officinarum*
Taro	Keladi	Taleh	*Xanthosoma Mafaffa*

Appendix IV

Examples Illustrating Expert-System Rules

Rule 1
IF: location is in Bali, Java, or arid Outer Islands
THEN: results of this system should be applicable probability=50%

Rule 5
IF: location is in the Sitiung area of West Sumatra
THEN: results of this system should be applicable probability=95%

Rule 7
IF: ethnicity is Minangkabau
THEN: landowner is normally considered to be a corporate matrilineal clan
and religion is Muslim
and people value rice and no-till and water buffalo

Rule 9
IF: ethnicity is Kenyah Dayak
THEN: land is viewed as abundant
and most crops planted probably require minimal management
and farm includes upland field

Rule 11
IF: ethnicity is Javanese transmigrant
THEN: landowner is normally considered to be a male household head
and land is viewed as very limited
and rights to land are traditionally certified and private
and women's agricultural labor is recognized as necessary but not preferred
and ethnicity is symbolized by farming and small-scale female trade
and world view is hierarchical and authoritarian
and domestic animals may include <2 cows and goats and chickens and 2 or more cattle
and most crops planted probably require intensive management
and people value fertilizer and hoeing and cattle

Rule 22
IF: ethnicity is Javanese transmigrant
and farm includes paddy field
and crops are vegetables
THEN: vegetables may include swamp cabbage

Rule 34
IF: location is in Long Segar, East Kalimantan
and farm includes upland field
and agricultural labor is sufficient or abundant
THEN: field is >1 ha – 5 ha
and field is newly cut from forest >30 years old and planted

Rule 101
IF: location is in Piruko, West Sumatra
THEN: [FEMAGLAB] is given the value 9
and [MALAGLAB] is given the value 16
and [FEMMARKET] is given the value 1
and [MALMARKET] is given the value 0
and [FEMHOE] is given the value 1
and [MALHOE] is given the value 8
and [FEMWAGLAB] is given the value 4
and [MALWAGLAB] is given the value 8
and [HOMGARTIME] is given the value 5
and [DRYFLDTIME] is given the value 11
and [SAWAHTIME] is given the value 8
and [FEMCUTNCARRY] is given the value 4
and [MALCUTNCARRY] is given the value 4

Rule 119
IF: location is in the Sitiung area of West Sumatra
and field crop is mungbeans or corn or chili
THEN: risks include insufficient fertility of soil and aluminum toxicity.

Rule 138
IF: location is Koto Padang or Pulai, West Sumatra, or Long Segar, East Kalimantan, or Long Ampung, East Kalimantan
and land preparation is dibble stick
and people value no-till
THEN: experiments on intensive tillage methods are appropriate
Probability=5%

Rule 143
IF: ethnicity is Javanese transmigrant or Sundanese transmigrant
and animals may include cattle or goats
and farm includes home garden
THEN: people use barnyard manure
(See Fahmuddin, et al. 1987)

Rule 146
IF: location is in Long Ampung, East Kalimantan
THEN: money is rarely used and in short supply
and selling produce is difficult and disvalued and rare
and access to location is difficult on foot and expensive by small plane

Rule 154
IF: fertilizer is a kind requiring incorporation
and land preparation is hoeing
and most crops planted probably require intensive management
THEN: experiments on intensive tillage methods are appropriate
probability=80%
and experiments on levels and kinds of commercial fertilizer are appropriate
probability=80%

Rule 168
IF: location is in the Sitiung area of West Sumatra
and ethnicity is Javanese transmigrant
and field crop is upland rice or cassava or paddy rice
THEN: this food is a staple

Rule 172
IF: location is in a difficult place to reach
and money is rarely used
and selling produce is difficult
and nutritional status is adequate
THEN: people's agricultural goals are not to maximize production

Rule 220
IF: (1) [PROPBOUGHTFOOD]> [PROPGARDFOOD]+ [PROPDRFLDFOOD]+ [PROPHOMGARFOOD]
and (2) people's diets are generally adequate
THEN: (1) experimental crops should be those crops now grown for sale by the people
Probability = 75%

Qualifier 76 (a number is chosen for use in rules)
IF: people's diets are generally
1. protein-poor
2. carbohydrate-poor
3. vitamin-poor
4. adequate

Appendix V

Working Together: Setting the Stage

By the time I came to TropSoils, I already had considerable experience working on teams composed of different disciplines; and I had been working with agricultural scientists for two years. I understood the difficulties in interdisciplinary research:

—Various disciplines use terms differently resulting in frequent misunderstanding. The term "data" for a soil scientist refers to a series or matrix of numbers; "data" for an anthropologist includes qualitative fieldnotes, based on repeated observations of behavior. "Culture," "technology transfer," and myriad other terms have completely different meanings.

—Some disciplines emphasize systems; others are more experimental. The former (like anthropology, ecology) investigate interactions among parts in complex wholes. The latter (like soil science, agronomy) want to eliminate the extraneous and make comparisons by manipulating small numbers of factors in comparatively controlled settings. Such conceptual differences provide ample opportunity for conflict—though both approaches are needed.

—Natural and physical sciences, considered "hard," have higher prestige, more power, and typically greater access to resources than do social sciences ("soft"). This means there is a danger that social scientists' input may be marginalized, particularly when such input is difficult or impossible to quantify (e.g., values or indigenous knowledge).

Hal MacArthur and I, in an effort to avoid such problems on the TropSoils project, planned a six-week team-building period in Honolulu. Besides training on language, FSR&D, and Indonesia, we set the stage for effective intra-team communication. First, we invited communication specialists to advise the team on how best to keep communication channels open. We spoke with the people contributing to our substantive training and explained our interest in encouraging good teamwork. We asked them to avoid conveying unnecessary biases against other disciplines.

We arranged for the team members to take the Myers-Briggs Personality Type Indicator[2] and had a campus psychologist meet with the team. She pointed out the strengths of each team member, based on our test results. She emphasized the utility of building on our respective strengths and using our differences in a complementary and constructive fashion. Having team members take tests of this kind alerts them to the legitimacy of differences among people and to the advantages these can bring to a team.

On the TropSoils team, for instance, the test results suggested that one member was quiet, abstract, and analytical; another was enthusiastic, creative and full of new ideas; a third was down to earth and good at keeping things on schedule. Knowing these differences helped us to use each other's skills and perhaps more easily forgive each other's foibles.

Another experience that contributed to our *esprit de corps* was a two-week field trip to another TropSoils research site (Yurimaguas, Peru), while we awaited permission to begin our own project. This trip followed the team-building experience in Honolulu. It provided an opportunity for us to see each other under adverse (if stimulating) conditions, to learn more about our interests and expertise.

Throughout the project, there seemed to be a fundamental recognition that each individual had strengths and intelligence. If one of us didn't understand something, other team members seemed to recognize that the obstacle might be differing jargon, differing educational experiences, differing assumptions. We simply tried harder to explain—and eventually we would get the message across.

---

[1]Some of this discussion of interdisciplinary work is presented in more detail in Colfer 1983b.

[2]In a similar, earlier interdisciplinary group, we had used Kolb's (1971) Individual Learning Styles Inventory. Keirsey and Bates (1984) have a shorter, easier to score, version of the Myers-Briggs.