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An Indigenous Agricultural Model from West Sumatra: A Source of Scientific Insight

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SUMMARY

A long-cycled, rice and rubber based swidden system was investigated among the Minangkabau of Pulai, West Sumatra, in 1985–86, as part of the Tropsoils Project. This paper first describes the conceptual framework used by these people with regard to their land. The production and income that derive from their diverse agricultural activities are then discussed. Our conclusions are that (1) tree crops can be effectively and beneficially incorporated into a system that includes food crops, (2) diversified systems make sense in these high risk environments and (3) both sexes are important in this kind of agriculture. We urge scientists to broaden their traditional research paradigm so as to incorporate and improve on systems like the one described here.

INTRODUCTION

Agricultural research in the Humid Tropics has been conducted, by and large, using a conceptual model which assumes land scarcity, field crops, and

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labour intensive management by men. Recently, there has been some recognition that this model is, in many ways, inappropriate to the marginal, unirrigated upland areas where we are beginning to work (e.g. Harwood, 1979; Cebaterov & Shaver, 1982; Altieri, 1984; Kepas, 1985). Models and research methods developed in areas, such as much of Java, characterized by productive soils, high population densities, and irrigation may not be so appropriate in areas like Indonesia's Outer Islands (e.g. Kalimantan, Sulawesi, Sumatra).

This paper, reporting investigations conducted by TROPSOILS researchers in Sitiung, West Sumatra, is written in support of the development of new models for agriculture in humid tropical rainforest areas (while recognizing the importance of maintaining some rainforest in its natural state). Some of the development objectives reflected in the following discussion include: ecologically sound and sustainable cropping systems, reduced human labour input for similar or enhanced agricultural productivity, maintenance or improvement of the dual subsistence–cash economy, and maintenance or enhancement of equity among people.

We first present the major features of an indigenous system of soil/land classification in Sumatra. We then discuss how these people use their land and other resources to subsist (and to some extent, prosper). We offer three main conclusions about agricultural systems in humid tropical environments like Indonesia's Outer Islands, using this Sumatran system as an example; and we conclude by encouraging a conceptual broadening or shift in agriculture's prevailing research paradigm.

METHODS

The studies reported here were undertaken in Pulai, West Sumatra, though occasional reference will be made to work done in East Kalimantan (representing another Outer Island system). Participant observation was used in Pulai over a 9-month period to provide a context for more focused studies. The ethnoscientific methods of taxonomy elicitation, triadic sorting of terms related to soil, and a loose version of componential analysis provided us with an understanding of the indigenous soil/land classification system. A small number of soil samples (19) was collected in various soil types (indigenously defined) and analyzed for Ca, Mg, P, K, exchangeable Al, and organic matter content, to help us to evaluate agricultural uses for these lands.

We also conducted two surveys toward the end of our work there. The first survey asked people about their land and other holdings, and the second, about their sources and amounts of income over the preceding year. Every

household ($n = 83$) was interviewed for the ownership survey; and 94% ($n = 78$) were covered in the income survey. Both surveys were planned and pre-tested by Colfer and Pak Syarif Lipati, a Pulai resident who served as field assistant. He then conducted most of the interviews with adults in their homes.

THE RESEARCH SITE

Pulai is a village composed of 432 Minangkabau inhabitants (Tropsoils census, 12/85), in West Sumatra in the central Sumatran peneplain. High on the southern bank of the Batang Hari River, it is one of many similar villages of indigenous people scattered throughout the 100 000 ha Transmigration area known generally as 'Sitiung'.

Pulai's landholdings are estimated at 1000 ha, though none is formally certified by the Government. Land is owned by clans, traditionally, and ideally inherited matrilineally (from mother to daughter). One clan, considered the first settlers in the area, in one sense, owns all the land. Formal alienation of land (by sale) is difficult, but access to use rights is quite flexible.

Rubber and paddy rice are the agricultural bases of the community, with considerable effort also devoted to upland rice. Coffee and fruit trees, requiring minimal labour, are important sources of income, as are logging, fishing and animal husbandry (water buffaloes, goats and chickens).

Three main aspects of this system strike us as important for developing appropriate models and research agendas for humid tropical rainforest areas in Indonesia: (1) The indigenous views of soils and agriculture, (2) the diversity of income sources, so important in this high risk environment and (3) the effective utilization of the productive labour of both men and women.

MINANG VIEWS OF AGRICULTURE: AN OVERVIEW

There is a tendency for Javanese (as well as Western) farmers and scientists to view agricultural systems in terms of fixed plots of land of specified size to be cultivated repeatedly and therefore intensively with field crops like 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 use of irrigation water.

The Minang, however, farming in an area where even now land availability is not really a major 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 fairly 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.

Topography and water availability

The most general set of categories relate to water and topography (Fig. 1). 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*. They are said to be reserved for annual crops; however, visible inspection reveals numerous fruit trees (though no rubber), bananas (*Musa paradisiaca* L.), pandanus (*Pandanus candelabrum* Beauv.), bamboo (*Bambusa vulgaris* Schrad., *Guadua angustifolia* Kunth), and the sago palm (*Metroxylon* sp).

The rolling hills and sloping soils most predominant in the area are called *dare'*. Mountains are called *gunueng*. The emphasis in this investigation (see below) was on *dare'* since most Pulai (and Outer Islands) lands fall into this category.

Our small number of soil samples only allow for tentative conclusions; but the trends are 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 in the area, 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 indicate the benefits of periodic sediment deposition of

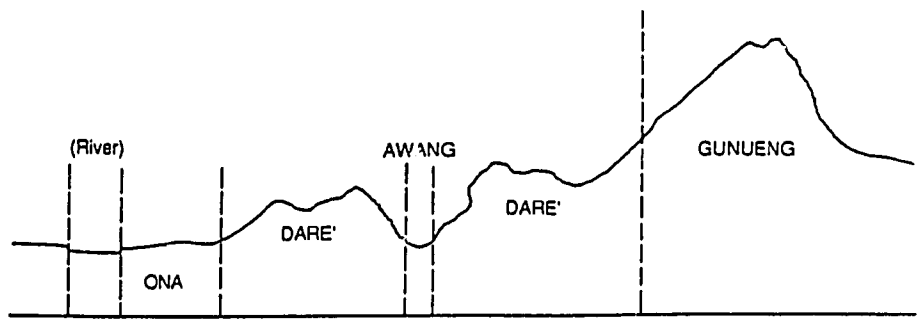

Fig. 1. Minang topographical categories, Pulai, West Sumatra, 1986.

relatively basic materials from upstream, and the general desirability of these soils for agriculture, vis-a-vis others in the area.

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 ricefields (*ladang*), and orchards (*kabun*).

The current *pakarangan* of Pulai are on *dare'*. Crops include coffee (*Coffea* spp), coconut (*Cocos nucifera*), rambutan (*Nephelium lappaceum*), duku (*Lanseum domesticum*), mango (*Mangifera indica*), and guava (*Psidium guajava*), as well as the more exotic *kwini* (*Mangifera odorata*), *ambacang* (*Mangifera foetida*), *kedondong* (*Spondias dulcis*), *jambak* (*Eugenia malaccensis*) and others we have not identified.

Kabun can be subdivided by crop: Citrus (*Citrus* spp), coffee, rubber (*Hevea brasiliensis* Willd.), rambutan, duku, and one annual crop, chili (*Capsicum annuum* L.). Upland ricefields and orchards also tend to be found on *dare'*.

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 perhaps the heart of the agricultural model of the Minang in Pulai (Fig. 2). Each of the stages is described below, as it fits in with the Minang agricultural system.

Ladang (*newly cleared land, planted to rice* (Oryza sativa))
Forest clearing is begun with slashing of underbrush and small trees by women, followed by felling of large trees by the men. *Ladangs* are cleared originally to plant upland rice. Rice is viewed strictly as a subsistence crop; the need to sell it is a cause for shame to Pulai residents. Yet it 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, using a dibble method (with men dibbling and women putting seed in the holes).

There are a number of indigenous varieties or ecotypes 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. In a few unstructured interviews on the subject, 14 varieties of regular upland rice, six of glutinous rice, and two of paddy rice were elicited.

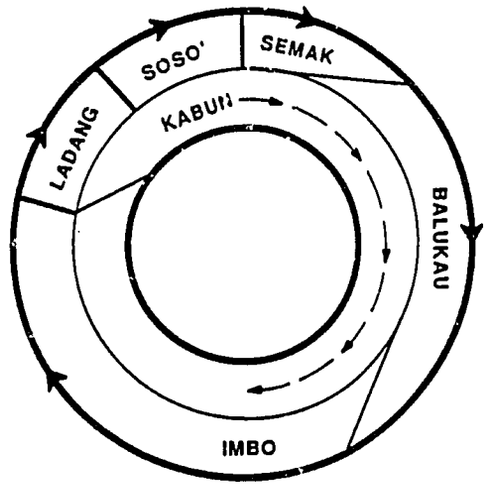

Fig. 2. Indigenous agroforestry cycle, Pulai, West Sumatra, 1986.

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, 1982). 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 in among the growing rice. The most common tree crop is rubber, but fields usually have a few jackfruit (*Artocarpus heterophyllus* Lam.) and stinkbean (*Pithecellobium jiringa*). Fruit trees, planted here and there, include *kedongong*, *ambacang*, guava, *petai* (*Parkia speciosa*) and *jambak*, as well as other unidentified species.

Annuals, planted in small areas, include chili, sorghum (*Sorghum bicolor*), cucumber (*Cucumis sativus*), corn (*Zea mays*), eggplant (*Solanum nelongena*), long beans (*Vigna sesquipedalis* L.), mung beans (*Phaseolus aureus* Roxb.), bittermelon (*Momordica charantia* L.), and angled loofah (*Luffa acutangula* L.). Because of distances to market and 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 '1001' kinds of weeds. Extensive lexicons normally indicate areas of indigenous knowledge, sometimes having great potential for use. These weeds are also, of course, the first stage of forest regeneration. Table 1 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 in West Java. Weeds may make an important contribution to production of a second crop, since they help cover the soil and should increase organic matter content in the soil.

TABLE 1
Nineteen Weeds from an Upland Field Sitiung, West Sumatra, Identified by Herwasono Soedjito. Herbarium Bogoriense—1986

Vernacular name	*Scientific name*	*Family*
Sawi nggeng (male)	*Erechtites hieracifolia* (L.) Ragin 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 duduc'	*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

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, trampled to some extent during the harvesting process. 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 kg/ha to 1250 kg/ha. Once harvest is completed, the field becomes *soso'* (field in its second year after forest clearing).

The decision to plant or not to plant the same field in a second year depends primarily on the rice harvest the first year, though factors such as labor availability and alternate sources of income certainly have an impact on the decision. If the harvest was relatively abundant, a decision to plant again is more likely. The increase in weeding required the second year is also

a consideration, as is the difficulty of clearing a new field. Other field crops are normally not grown (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 (*Ananas comosus* L.) frequently planted the first year are bearing. Chilis often continue to bear. The need to check up occasionally 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 gardens. 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 hectare, with spacing averaging 4·9 m (range: 2·8–7·8 m) between trees. In the process, we also measured slope with an inclinometer, getting what seemed to be a fairly unskewed range from 0–47%.

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 further away where rubber is growing to maturity surrounded by *semak*.

Balukau (secondary forest, probably <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 8 years. Jackfruit and stinkbean continue to bear. Durian (*Durio zibethinus*), a highly valued crop, and *cebodak hutan* (forest jackfruit, *Arthocarpus* sp) 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 10–12 years the tree requires to mature. Pulai people therefore express no interest in trying to grow it commercially.

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 in 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 secondary or primary 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 2 shows some *imbo* products. We have included a number of plants we have been unable to identify (1) to indicate the diversity and (2) in the hope that some readers may recognize them.

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

TABLE 2
A Sample of Products from Pulai 'Primary 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 11/85 price: US$9·00/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. Used to be 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. 11/85: US$0·38/stick in market; US$0·35/stick to collector.
lipai	*rumbia* (Indonesia). Fan shaped palm used for roofing. Grows on special hilly areas (Licuala).
Wood products	
commercial 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. 1/86 price: US$25/$m^3$ at roadside; US$30 cm^3 at sawmill.
tonam	*marsawa* (Indonesian). 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 US$100/kg, (1/86). Probably aloe wood, in Kalimantan found in genus *Aquilaria*, family Thymelaeaceae). Tree must be destroyed to discover *garu's* presence/absence.
Fruit trees	local names for *rambutan*-like (*Nephelium lappaceum*) fruits include *kuduk biawa', kudung tunjuk*, and *buah soni*. *Duku*-like (*Lanseium 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*)

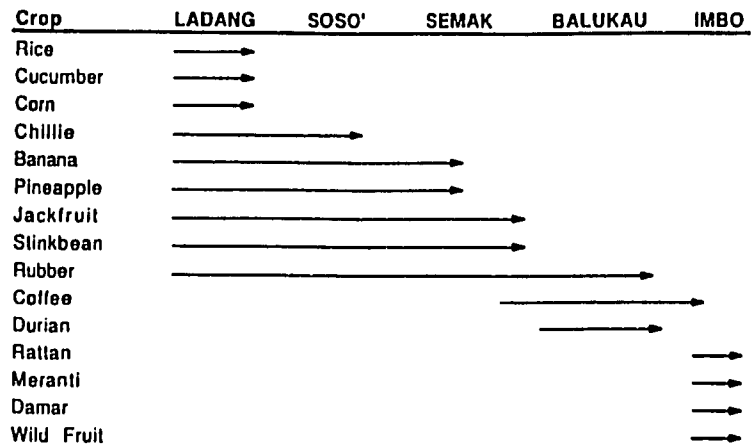

Fig. 3. Representative 'crops' by stage of forest regeneration, Sitiung, West Sumatra, 1986.

in development efforts in the area. Figure 3 shows representative 'crops' by stage of forest regeneration (see Colfer, 1983*a*, for a Kalimantan version; see also TAD (1981) for a partial inventory from Kalimantan forests).

In this section, we have tried to convey the perspective of Pulai residents as they view their land. They categorize according to topography and availability of water; agricultural use; and stage of forest regeneration. With this partial world view in mind, let us turn to some questions of land use and income.

MINANG LAND USE AND SOURCES OF INCOME

The facts that the Minang match their crops to the kind of land (slope, soil quality, water availability), and that they manage to keep a good portion of their land under a forest cover, are desirable ecologically. But to evaluate a system like this from a practical point of view, more information is needed. How much land does this system require? How much income do they get from their agricultural efforts? Would it be feasible for the system to be borrowed or adapted for the transmigrants? Is it worthwhile to devote research dollars to try to improve it?

Land use

The differing interpretations of actual land ownership in Pulai have already been mentioned (p. 191). Table 3 presents data on land use and use rights as reported by Pulai's residents. Taking all the land that was considered to be under agricultural use by Pulai households in June, 1986, the total is only

TABLE 3
Ownership and Hectarage of Pulai Fields, Using Local Field Categories June, 1986

	Total number of fields	*Total ha*	*Women's number of fields*	*Total ha*	*Men's number of fields*	*Total ha*	*Joint number of fields*	*Total ha*
Paddy ricefield *sawah*	63	18·9	11	3·2	2	0·5	50	15·1
Upland ricefield *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

93·2 ha, or just over 1 ha per family. Given the nature of swidden cycles, this is an underestimate of the land use needs. However, the fact that rubber is a long-term crop (perhaps 30 years), combined with minimal weeding and other management practices in Pulai, allows the process of soil regeneration under forest cover to proceed congruent with agricultural use. (Whitten *et al.* (1984) also note the comparative hospitality of such minimally managed rubber 'plantations' for wildlife).

The 1985–86 year involved the clearing of 13 new *ladangs*, and the use (for rice) of 15 which had been cleared the previous year (*soso'*). By June, 1986, only two new fields had been cleared, and people maintained they intended to clear no more that year. This is in marked contrast to some swidden systems which involve forest clearing every year for almost every family (*cf.* Colfer, 1983*b*). The fact that 63 of the 91 ricefields were permanent paddy rice fields reduces the need for regular forest removal.

Food production and income

The concern of many researchers and policymakers that the introduction of tree crops (as a cash source) should not erode the subsistence base (e.g. Lappe & Collins, 1978) is legitimate. However, in Pulai, the subsistence base appears alive and well. In 1986, 44% of the land considered under cultivation was devoted to rice production. And the Pulai view that selling one's rice is a shameful act effectively ensures that rice produced in Pulai is consumed there.

The dominance of women in rice production is not clear from survey data alone. However, regular visits to ricefields and participation in planting, weeding, and harvesting work parties revealed a virtually all-female world.

Land preparation for paddy rice, dibbling on upland fields, and transporting grain home, were the exceptions.

Although land is generally considered to be matrilineally inherited in the Pulai (Minang) system, there are actually two kinds of inherited property: 'Pusako tinggi' and 'Pusako randah'. 'Pusako tinggi' (or high inheritance) refers to property, such as land and housing, which belongs to the clan, and is thus inherited matrilinearly.

'Pusako randah' (or low inheritance) is property that is acquired by a nuclear family's own endeavours. It can include land and housing, if bought with a man's salary. This kind of property does not belong to the clan, and can thus be passed on to a man's own children (in contrast to his sisters' children).

The traditional abundance of land in the Pulai area has meant that none of these rules has been terribly important for an individual's access to land. In practice, people who want to cultivate land have little trouble getting permission from the appropriate clan leaders. And husbands and wives generally consider land they cultivate to belong to both of them.

However, it is widely agreed in Pulai that in case of divorce (not uncommon), clan land and the house and lot normally stay with the woman and her children. Property acquired jointly may be divided equally between the husband and wife. But the bias in Pulai regarding land ownership is definitely in the woman's favour.

Ricefields provide the subsistence base for Pulai. Women do most of the work on the ricefields (see Freeman, 1970; Colfer, 1981, 1985, for similar Dayak patterns in Borneo, where land ownership and inheritance are bilateral). Pulai women, ultimately, are the owners of land (though their brothers are the formal clan leaders and are important decision-makers regarding clan lands).

Table 4 provides information on ownership of ricefields and on the dollar value of the agricultural produce from these fields. Since rice is *not* sold, converting it to dollars is a bit misleading; but we have done so to provide some estimate of one kind of value of this kind of 'income' (and of women's labour). Although Pulai's people report women (solely) 'owning' $<8\%$ of the ricefield hectarage, women are reported to control $>17\%$ of the rice produce (income, in Table 4). Rice is much more available to women than is money. If the market value of rice were included in the total cash income figures below, it would comprise just over 17% of Pulai's total income.

Rubber production and income

Most of the rubber, though *viewed* basically as a men's affair (Colfer *et al.*, 1986), belongs to women (Table 5). Rubber provides about 20% of the total

TABLE 4
Ownership of Ricefields and Rights to Income, by Sex, Pulai, West Sumatra, 1985–86

Owner/ beneficiary	*Means of production*			*Rights to income*[a]	
	Number of fields	*ha owned*	*% of total ha*	*US dollars*	*% of rice income*
Women	11	3·21	7·8	1 908	17·4
Men	4	2·07	5	356	3·2
Joint	76	35·64	87·1	8 712	79·4
Total	91	131·92	99·9	10 976	100

[a] 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 US dollars (US$1 = Rp. 1 127 (June 1986)). Pulai residents, however, do not sell their rice.

cash income for the village, including income from people's own orchards and tapping of other people's trees. The standard arrangement for tapping is that the tapper gets two-thirds of the rubber and the orchard owner gets a third.

Rubber is viewed by the Minang as a ready source of cash. Although they consider many other activities as more profitable, rubber requires virtually no care (once it's established); and it can be tapped or not tapped, according to circumstances.

Dove (1980) documents the same strategy in West Kalimantan. Among the Kantu', however, women are the primary tappers, having relinquished

TABLE 5
Ownership and Control of Income from the 52 Rubber 'Orchards' Reported in Pulai, West Sumatra, June 1985–86

Owner/ beneficiary	*Ownership*		*Control*	
	Rubber trees	*ha*	*Income in US$*[a]	*% of total income*[b]
Women (32 fields)	7 800	18·7	1 492	2·8
Men (9 fields)	3 100	7·4	4 450	8·6
Joint (11 fields)	3 650	8·8	1 422	2·7
Total	14 550	34·9	7 364	13·8

37 families (43% of all Pulai families) owned these fields.
[a] US$1 = 1 127 (June 1986).
[b] This is the % of total village cash income, deriving from rubber, controlled by each category (women, men and pairs).
[c] Rounding error.

some of their previous dominance in rice cultivation to men. In contrast to Pulai farmers, the Kantu' plant their rubber trees along the river's edge, taking advantage of the trees' greater tolerance of occasional major flooding relative to rice.

In Pulai rubber provides a fairly secure source of cash, facilitating the flexibility that characterizes the Minang in their approach to economic endeavours (see Vayda *et al.*, 1980, for a similar approach, in East Kalimantan).

Diversity in the agricultural system

The Sitiung environment is one characterized by risk. The onset of the rains is unreliable, occurring anywhere between August and November. There are periodic dry spells, despite the 2500 mm average annual rainfall. Plant available water in these soils is low and thus crops often experience drought stress after only a few days without rain. Conversely, in areas near the many rivers, floods can inundate whole fields temporarily. Crops are subject to a vast array of pests, including fungi, insects and mammals (pigs, monkeys and rats) which can rapidly decimate a field.

Prices for many crops vary dramatically as well, so that farmers never know when they plant something what its price will be when they harvest it. The local price of rubber was at its highest since 1910 in early 1984 (US$ 0·38/kg) and proceeded to plummet over the succeeding years (to US$ 0·13/kg, in mid-1986). In early 1986, coffee prices were unusually high (US$ 2·00/kg for dried beans). Chili ranges from US$ 0·44/kg to over US$ 3·55/kg!

The Minang response to all this uncertainty has been to diversify. Table 6 presents the aggregated percentages of total cash income from various tree crops, including logging and tapping activities. Neither rice production nor the 49% of cash income deriving from non-agricultural sources is included. There are nine tree crops for which income was reported in Pulai for 1985–86, accounting for approximately a quarter of all cash income reported by the village. The small amounts of money earned from each (like the comparatively smaller incomes of women) may deceive people as to their importance. Rural life in Indonesia is kept together, in 'bits and pieces', by many small sources of income.

The variety of crops precludes devastation from any one pest or another. It increases the probability that the price will not fall on all at the same time (the prices quoted below are those reported by Pulai residents for the 1985–86 year). And such variety has important seasonal advantages. October and November are the rice weeding season; December and January are the time for rambutan (US$ 0·44/100 fruits) and duku (US$ 0·18/kg).

TABLE 6
Percentages of Total Cash Income Deriving from Important Tree-related Sources, Pulai, West Sumatra, June 1985–86

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[a]	4·3	0·4	0·8
Banana	0·1[a]	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[a]	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[a]	10·4	34·7	5·5

* Means an amount between 0 and 0·001.
[a] Rounding error.

Coffee, though it bears throughout much of the year, produces most in March, April 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. Coconuts (US$ 0·09/nut) bear all year and provide another ready source of small amounts of cash.

Jackfruit, not considered by Pulai residents to be a source of income, is a very important part of everyone's diet. The tree bears in less than two years, and its immature fruit is eaten as a vegetable. Mature jackfruit is eaten (and sold) as a fruit. Another tree crop that qualifies as a food crop is stinkbean (US$0·18/100 beans). It is a cherished part of Pulai's diet.

From the perspective of individual farmers, an important advantage of tree crops is the minimal labour input required, compared to the daily care that must be lavished on field crops in the Sitiung environment. Indeed, Naim & Agus (1985) report almost no care being devoted to tree crops in Koto Padang (another nearby Minang village).

Another risk avoidance mechanism used in Pulai (as well as in Long Segar, East Kalimantan (Colfer, 1983*b*)) is geographical dispersion of fields. Pulai

inhabitants own 233 fields (Table 3), av raging 2·8 fields per family. Any given calamity is unlikely to affect all o. one's fields.

Fully a fifth of Pulai's cash income in 1985–86 came from logging. The usual dipterocarps (*Shorea, Dipterocarpus, Dryobalanops*; see Whitten *et al.*, 1984, for an ecological discussion of these forests in Sumatra) of Indonesia were being cut for export (mainly *meranti*, called Philippine mahogany in the US). However, Pulai logging methods are comparatively benign (due to their small scale). Small groups of 3–7 men use a handsaw, or chainsaw, to cut carefully selected trees. The logs may be taken out whole, or cut into beams in the forest. They are then dragged out along narrow paths by water buffaloes to the river or road. Log trucks ply all the roads, and marketing does not appear to be a problem.

This hand picking of logs is a form of selective logging. As in the case of timber companies, the best individuals of commercial species are selected, perhaps leaving genetically inferior stock for future reproduction (Kartawinata, 1979). (However, as of February 1987, such logging had been banned by the Government.)

CONCLUSIONS

The people of Pulai provide us with an example of one way to live reasonably well in these marginal upland areas of the humid tropics. Their standard of living—though still low—is noticeably higher than that of the transmigrants who are trying, with government encouragement, to transplant a settled agricultural system to this Outer Island. The indigenous farmers have not considered it in their best interests to adopt the intensive system promulgated for transmigrants, with its high labour and input requirements (*cf.* Fulcher, 1983, for a discussion of the same phenomenon in East Kalimantan).

Several points can be made with reference to what can be learned from farmers in Pulai. These include:

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 some of the leaf litter that is generally viewed as important for soil regeneration; they are more aluminum-tolerant; their deeper rooting systems often preclude 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 labour; and they provide a saleable product for human maintenance.

We view the Pulai practice of matching kinds of land and crops as desirable, even if the crops are tree crops. We suggest that an improved agroforestry system that utilizes the forest rather than transforming it into agricultural land may be a sensible goal for those marginal lands of the humid tropics that must be converted for human use. Any system in such areas should probably include both a cash and a subsistence component.

A diversified system in high-risk environments like humid tropical rainforest areas has important advantages

Risks from crop disease, insect and animal depradations, uncertain water availability, and price fluctuations can be reduced by depending on a variety of crops, as Pulai's 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 and coconuts and rambutan income. Diversification of crops and dispersion of fields is an effective risk aversion mechanism in such high risk environments.

Both sexes actively participate in such forest agriculture

The women of humid tropical rainforest areas (including Outer Island women) typically have rights to land and traditionally recognized agricultural roles. They are often dominant in rice production and in the home garden. The global concern to protect the subsistence base will require general recognition of women's contribution in the subsistence sphere. Further, research and extension efforts will be most effective if they build on the existing roles and knowledge of *both* sexes.

What are the specific research implications of these kinds of findings? They suggest that there is potential value in broadening our definition of worthwhile research. A shift in the scientific world view may be called for. In many agricultural research projects, the management of a single field crop is investigated and manipulated 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 of indigenous humid tropical rainforest systems; see, for example, Siskind, 1973; Murphy & Murphy, 1974; Moran, 1979, 1983, for South American examples; Kunstadter *et al.*, 1978 for Thailand), more is needed. We need to look at interactions *among* crops. Selection of crops needs to fit both the type of land and the human systems in the area (or vice versa).

The fact that we *can*, at great effort and expense, increase the production of potatoes in the humid tropics is somewhat beside the point. How much more efficient and beneficial to use research dollars allocated for the humid tropics to investigate the feasibility of growing indigenous minor forest products like rattan, bamboo, or dyes for sale (*cf.* TAD, 1979, 1981; Peluso 1983); or the potential of small-scale planting of dipterocarps by farmers to assure their future supply of timber for market; or the selection and breeding of forest fruit trees to lengthen the harvest season, increase production, or improve marketability (Erick Fernandez, personal communication, 1986).

Some of these important research topics are amenable to study using traditional agronomic research designs. Others are not. Researchers in fields that look at 'wild' populations (e.g. ecology, fisheries and wildlife, some branches of forestry) can offer some assistance and experience with alternate research designs. The necessity of borrowing or creating new methods of investigation should be taken as a scientific challenge, not as an excuse for inaction as it sometimes is. We applaud the current interest, in some quarters, in developing methods for study and improvement of these complex indigenous systems.

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