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AGRICULTURAL SITE SELECTION AMONG PERMANENT FIELD FARMERS: AN EXAMPLE FROM EAST KALIMANTAN, INDONESIA

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ABSTRACT.—Traditional cultivators usually examine a number of environmental variables before choosing a site for agricultural production. In contrast to most studies of site selection, which focus on procedures followed by shifting cultivators, this article discusses the criteria employed by a population of permanent field cultivators of East Kalimantan, Indonesia. The Lun Dayeh, irrigated rice farmers of the Kerayan Subdistrict, differ from shifting cultivators in many of the criteria they employ in selecting a site, in their pattern of long-term observation of selected factors, and in their willingness to substantially alter the site. Important in their choice of a potential agricultural site is an assessment of the amount of labor that is required to render that site acceptable for permanent cultivation.

INTRODUCTION

Many detailed studies of traditional farming systems have noted the great competence of tribal and peasant cultivators in judging and distinguishing the subsistence potential of particular parts of their territories. It has been shown, for instance, that most farmers do not select sites for new agricultural fields randomly, nor for arcane magical reasons. Farmers choosing cultivation sites review both past and present conditions; they recall the cropping history, if any, of an area and carefully examine the standing vegetation—its age and composition—before selecting a location for a new year's field (Conklin 1957, Clarke 1971, Watters 1970). Sound judgement of soils and their capabilities for agricultural production also enters into decisions on siting of farms (Conklin 1957, Richards 1939, Allan 1965), as do several other concerns, among them relative distance to farms of relatives and co-workers (Freeman 1970, Deegan 1973), and proximity to other fields worked by the same household (Padoch 1982).

Geographers and anthropologists are not alone in noting the knowledge that many pre-industrial populations have of the physical characteristics of their environments. Development planners, among them agronomists, agricultural economists, and others have concluded that especially in the agriculturally marginal tropical environments that are often largely unknown to university-trained scientists, indigenous tribal peoples can be extremely competent consultants on the use and development of their own territories (Brokensha *et al.* 1980).

Most studies of traditional soil classification and agricultural site selection have focused on the procedures by which shifting cultivators choose an area for their annual farms. With few exceptions (e.g. Conklin 1980), little has been written on the knowledge of soils and other environmental variables that preindustrial or pre-literate permanent field cultivators possess. This is at least partly because many swiddeners annually choose where to farm, while most permanent field farmers, as the designation implies, cultivate the same fields each year. The latter tend to live at far higher population densities and farm what land they already own. Patterns of land tenure therefore tend to be by far the most important determinants of where a farm is situated. Most permanent field

farmers choose a new site to put into cultivation very infrequently and thus researchers rarely have the opportunity to observe the procedures involved in selecting new areas for permanent fields.

"Permanent field farming" encompasses many different types of resource use and therefore the environmental variables that farmers consider vary greatly from one agricultural system to another. In all instances, however, decisions of where to site a permanent field take into account long-term agricultural suitability; swiddeners commonly need judge only whether an area will support cultivation for a year or two. Thus choices made by permanent field farmers will differ from those of swiddeners in two general ways: first, a great deal of long-term observation is usually involved in making selections of permanent sites. And second, since they regard the new field as a long-term investment and frequently are willing to change several environmental factors to make the site more acceptable, the choices made by permanent field cultivators typically include an estimate of the amount and type of labor needed to put a particular area into a useable state. Shifting cultivators engage in far less environmental manipulation other than the clearing of sites.

THE LUN DAYEH OF NORTHEASTERN BORNEO

The Lun Dayeh of East Kalimantan in Indonesia practice both shifting and permanent field irrigated cultivation of rice and a number of subsidiary crops[1], and are noted throughout much of Borneo for their abundant annual rice harvests (Padoch 1985). The success of Lun Dayeh farming has been attributed by many not familiar with the group's homelands to extremely favorable natural conditions for agriculture, particularly to fertile soils. A closer examination, however, shows that the Kerayan Subdistrict, where most of East Kalimantan's Lun Dayeh live and farm, is a highly varied region, blessed only in very limited areas with exceptionally good conditions for rice production. The success of Lun Dayeh agriculturists is more reasonably attributed to their detailed knowledge of the environments they exploit, to their sound judgments of where to site their fields, and to their good management practices.

The site selection criteria employed by one Lun Dayeh population have been described (Deegan 1973) and are, according to the report of the researcher, largely similar to those used by swiddeners throughout the tropics; the height or age of vegetation covering a plot is apparently the prime factor considered. These farmers, recent immigrants to the Lawas Damit Basin of Sarawak, are, however, quite atypical among Lun Dayeh agriculturists. They are mainly shifting cultivators and have few irrigated rice fields. The wet rice cultivators living in the Kerayan uplands of East Kalimantan, Indonesia, the traditional Lun Dayeh homeland, observe other environmental factors and emphasize different criteria in choosing sites for their irrigated permanent fields.

The Kerayan Subdistrict.—The Kerayan Subdistrict, located in the northeastern corner of the District of Bulungan, along the border with Malaysia, comprises an area of 3,930 km^2 (Fig. 1). Topographically, it is a region of hills, often steep, divided by several broad, flat valleys. The area was described in general terms by Schneeberger in 1945. Since then, no specific information on the topography or geology of this region has been published. The geology and soils of the neighboring parts of the Malaysian state of Sarawak were recently surveyed, mapped, and described (Eilers and Loi 1982); the maps, unfortunately, stopped at the international frontier. Although a government-sponsored preliminary geologic survey of the Kerayan Subdistrict was carried out in 1980, the information gathered has not been made available to the public.

The volume on northern interior Sarawak and information given by the geologic surveyers in the Kerayan (J-L. Nagel, pers. comm.) both suggest that the area is underlain

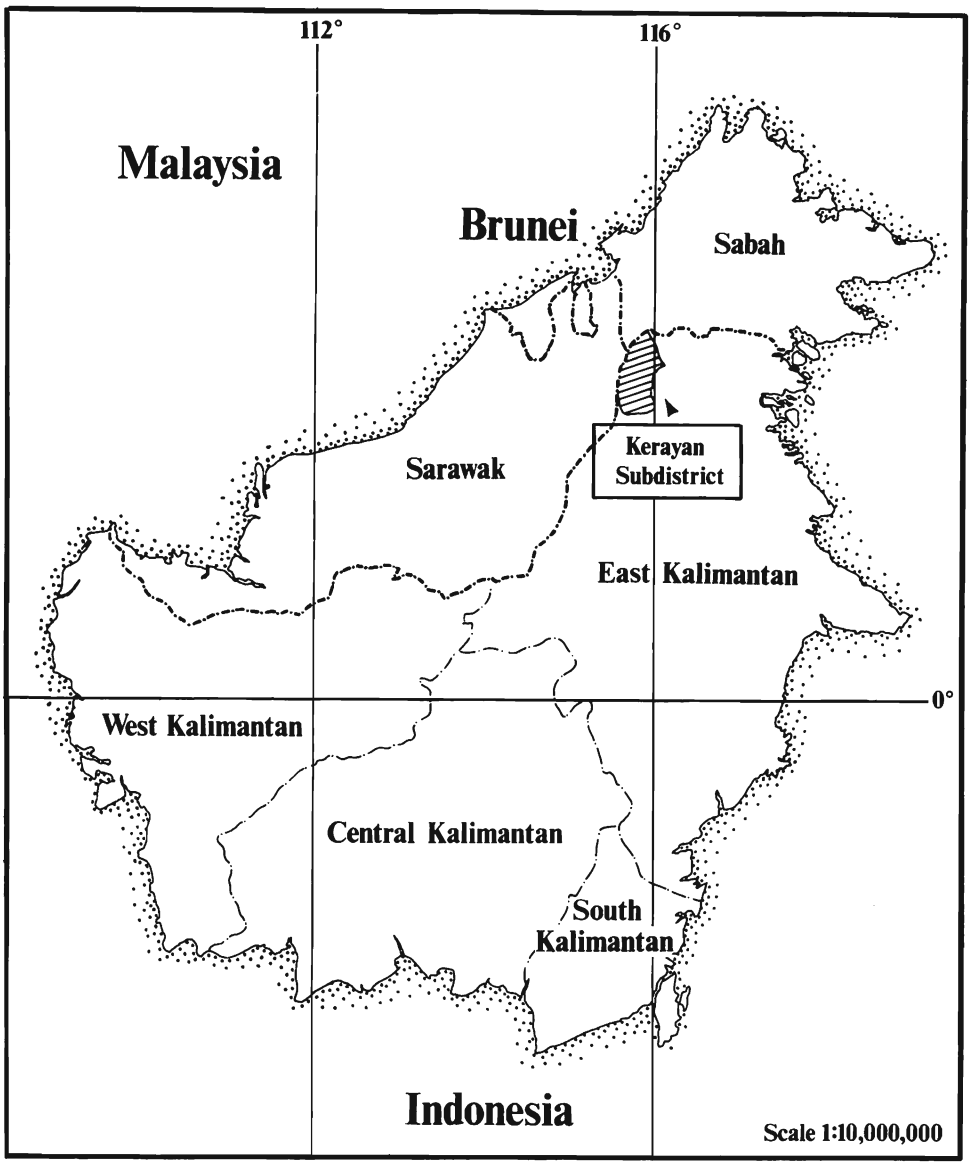

FIG. 1—Map of Borneo (Kalimantan) indicating the location of the research area.

largely by alternating bands of sandstones and shales, which give rise both to the broken topography and the variable soils of the region. The principal river draining the area, the Kerayan, and its tributaries, the Lutut and the Bawan, have their headwaters in the Subdistrict and are surprisingly slow flowing, silt-laden streams. Only farther downriver does the Kerayan become a rushing rapid-filled river more characteristic of upland Borneo waters (see Schneeberger 1945, for details on the area's topography).

The underlying parent materials—sandstone and shale—have contributed to the formation of sandy and clayey soils characteristic of the Kerayan area. A chemical analysis of representative soils of the region (Padoch 1981: Appendix 1) showed that the soils

of the Kerayan are typically very poorly suited for agriculture. They are very low in pH (averaging about 4.0 in the uppermost layers, with a range between 4.8 and 3.3) and have extremely high levels of aluminum saturation. Suggestions that the productivity of Lun Dayeh agriculture stems largely from the exceptional fertility of the soils are not supported by these analyses.

The settlements and the permanent rice fields of Lun Dayeh farmers in the Kerayan are located in valleys lying approximately 900 m above sea level. Some of the major hills rise perhaps 1000 m above the inhabited valleys and are typically cloaked with mature hill dipterocarp forests. Several areas of lower heath vegetation, known as ***kerangas***, dominated by species of rhododendron, are also encountered in the region. All these areas are situated on very acid white sand soils and many are poorly drained. Tea-colored "black-waters" typically flow off these areas. The local inhabitants deny that they ever cleared or otherwise disturbed these patches of low vegetation, and indeed they always avoid such sites in choosing areas for agricultural production.

Considerable stands of secondary vegetation in various stages of regrowth can be seen, particularly around a number of the newer villages. These patches are evidence of recent clearing for shifting cultivation. No extensive areas of grass, apart from the "village greens" around which most settlements are grouped, are found in the Subdistrict.

The population of about 10,000 persons is composed almost entirely of farming households. Larger villages comprising several hundred inhabitants are located in the few particularly broad and flat valleys of the region where extensive areas of irrigated rice land are also found. Narrower valleys tend to be farmed by members of smaller settlements. The human population density for the entire Subdistrict is only about 2.2 persons per km^2, and considerable areas for future expansion of both wet and dry rice agriculture continue to be available.

Most Kerayan farmers who mainly cultivate permanent wet rice fields use the same fields each year, and thus exercise little choice in locating their annual cropping areas. Because of population growth, however, some Lun Dayeh households are expanding their fields or making new ones and therefore are choosing new areas for agriculture. Moreover, in response to a government sponsored resettlement program, as well as to a desire on the part of many Lun Dayeh to live nearer to sources of market items, medical care, and schools, several villages have moved to new locations in the last fifteen years. The inhabitants of these recently resettled villages, among them the community of Long Umung along the Lutut River, are now selecting areas suitable for permanent field cultivation and are constructing new irrigated and bunded pond-fields. Thus, an unusual opportunity to observe how Lun Dayeh farmers choose sites for new agricultural undertakings, including new inundated rice fields, now exists.

AGRICULTURAL SITE SELECTION

Data concerning the criteria and procedures used for choosing new farming sites were collected in 1980 over a period of nine months of observation and participation in agricultural activities. Informal questioning of a large number of Long Umung's farmers, both men and women, provided the major part of the data presented here. Much information was also gathered not by direct questioning but rather by recording comments made by Lun Dayeh farmers as they went to and from their fields, observing the agricultural potential of areas passed, and as they worked at agricultural tasks. Somewhat more formal interviews were conducted with three persons—Binyamin Barok Siran, the headman of the village of Long Umung, his wife Ripka rigo, and Barok Tai, an older farmer; these three informants contributed a large part of the information and confirmed or corrected much of the data that had been collected by observation. Information on soil types was gathered primarily from these three persons, although many more of Long

Umung's inhabitants participated in soil sample collection, color and texture evaluation, and lengthy discussions of agricultural worth. All interviews and discussions were conducted in the Lun Dayeh language.

Long Umung is a relatively new village having been settled approximately thirteen years ago by Lun Dayeh migrants. When these settlers first arrived at their new site along the upper Lutut, they produced the rice they needed by cultivating impermanent swiddens. Virtually every year since their move to the Long Umung site, however, these farmers have been opening up more and more land for permanent field agriculture and reducing the size of their swiddens accordingly. The area around Long Umung offers considerable opportunities for irrigated field cultivation although abundant room for continued shifting cultivation can also be found.

When determining the use to which a plot of land in the Kerayan should be put, farmers consider many variables. As in other wet rice farming areas (Conklin 1980), the topography, particularly the slope, of the area is an extremely important criterion. The farmers of Long Umung also assess the previous agricultural history of the site, and its vegetative, pedological, and hydrological characteristics before deciding on its use as a permanent, dyked and inundated field, a temporary swidden, a house site, or an area to be left in natural forest vegetation.

To be a prime site for inundated permanent field farming, a plot of land should be located not far from the farmer's home. It should also be flat and extensive, close to a clear stream which flows in all seasons but is not subject to excessive natural flooding, with heavy, fertile soils (as indicated by the soil color and texture and/or by the size and type of vegetation covering the plot), and, if it has previously been cultivated, it should have a history of abundant rice production. Although most plots available for development now do not possess all of these desirable characteristics, a number of environmental factors can and usually are altered to some degree to approach more closely the ideal, even though such alterations are usually costly in time and labor.

Location of fields.—General considerations such as distance from the site of residence, as well as distance from other areas farmed by the same household, are rarely mentioned in published discussions of agricultural site selection. However, since location often influences the time and effort a farmer must put into activities such as travel, crop protection, and the building of irrigation facilities, distance is often important in the decision of where to locate a field whether it is to be a swidden or an irrigated farm. Farmers especially wish to locate permanent fields close to permanent homes. Swiddens can often be made far from the village; a small shelter can serve as a temporary residence for a year or so until that field is no longer intensively cultivated (Freeman 1970; Padoch 1982, on *dampa*, temporary Iban residences).

The recent directive from the Indonesian government to group small villages in interior Kalimantan into larger population concentrations, has met with some resistence in the Kerayan, since for many farmers such a move involves spending additional time in walking each day to and from fields. Lun Dayeh, like many other cultivators also attempt to locate new farms close to other farms being worked in the same season; a wide scattering of fields increases the labor required in protecting crops from the depredations of sparrows, monkeys, and other animals. (The Lun Dayeh construct ingenious systems of alarm devices over large fields which can be operated by just one person sitting in a central location.) If fields are far apart, more labor, for many households a scarce resource, is required for proper protection of fields[2].

Topography, Water, and Drainage.—Swiddeners consider a broad range of topographic conditions acceptable for swidden sites; slopes of up to 40° are often farmed in Borneo. However, in selecting a plot for an irrigated pond-field, minor differences in topography

become important. Flat valleys are ideal and slopes are avoided, if possible, because although topography can be and usually is altered somewhat, a great deal of labor is consumed in this task. Ideally, valleys should also be wide and long so that large areas can be enclosed and served by a single set of engineering works for irrigation and drainage. As the Kerayan Subdistrict is rather sparsely populated, terracing of sloping lands is still minimal. Most farmers continue to be successful in locating plots where farms of significant size can be made with minimal earth moving. Such opportunities are clearly decreasing.

At present Lun Dayeh consider almost level terrain to be a *sine qua non* for establishing a new agricultural plot, another requirement is a nearby source of water of suitable quality and availability. Two kinds of water are distinguished by Long Umung farmers: black (tea-colored) waters and clear waters. It has been pointed out by researchers, particularly those working in the Amazon Basin (Sioli 1975; Klinge 1967), that black waters generally flow off white sand soils and are poor in nutrients and low in pH. Although no analyses were done of Kerayan black waters, their chemical characteristics were assumed to be similar and indeed, the Lun Dayeh, also aware of the nutrient poverty of such black waters, avoid them in selecting areas for the practice of wet rice cultivation. Waters used for irrigating rice fields are always clear.

Availability of water is as important as quality. Farmers casually observe potential areas for wet rice cultivation throughout a year or more to determine whether sufficient irrigation water is apt to be available in all seasons of the agricultural year. Again, as with topography, water availability is a condition which can be altered and generally is changed somewhat by the construction of irrigation canals, bamboo aqueducts, and water gates. All these alterations, of course, require considerable labor and farmers attempt to minimize the changes that must be made by carefully selecting a proper site.

Areas that are naturally inundated can serve as favorable sites for wet rice farming only if the water is not too deep and the area does not flood excessively at any time during the year. Farmers often make note of the depth of standing water on such a site each time he or she passes through the area over a period of several years. Occasionally very deep areas are made shallower by dumping earth into the site, but because of the large investment of labor required for such improvements, deeply inundated areas are generally avoided.

Soils and Vegetation.—While permanent field wet rice cultivators differ from swiddeners in considering factors such as topography and water quality and availability in making site selections, they also take into account soils and vegetation, the two prime criteria that concern shifting cultivators. Their judgements here differ as well: permanent field farmers can and do choose at times to considerably modify the soils of their sites; swiddeners, as a rule, do not. As pointed out in several other studies of indigenous soil classification systems, color and texture of soils tend to be considered most prominently when sites for agricultural plots are chosen (Conklin 1957, Reina 1967, Carter 1967). The Lun Dayeh also focus largely on these two qualities.

Soils are classified by color into "white" ***(mebuda')***, "black" ***(mitem)***, "red" ***(masia')***, and "yellow" ***(mebirar)***. ("Red" and "yellow" are rather poor translations of the last two; the distinction between "red" and "yellow" and ***masia'*** and ***mebirar*** is made very differently by an English-speaking investigator and a Lun Dayeh farmer.) Cutting across each of these color categories are classifications relating largely to soil texture, that is "sandy" ***(mebada')***, "clayey" ***(mesalit)***, "very hard or heavy clay" ***(metueh)***, and "stony" ***(grifere)***. There is also a term, ***meroko***, for a layer or mat of roots that overlies some soils, a condition found in several sites around Long Umung. And there are two other general terms or categories applied to soils: one, ***mebaleng***, denoting a generally fertile and easily worked soil, which is often an alluvial soil and ***metugeh***, a generally infertile,

poor soil, which is often also ***metueh*** or a very heavy clay. A few other soil type names are used to refer to very specific soil types such as ***tana' luyan***, a bright red heavy clay and ***tana' mefayeh*** or ***bada' buda'***, an almost pure white sand, a soil to be avoided in almost any agricultural undertaking.

This classification of soils is similar to the systems employed by swiddeners to find an appropriate site for a temporary field. What does distinguish Lun Dayeh observation and classification of soils from those employed by shifting cultivators is the care these permanent field cultivators take in examining soils in depth. Lun Dayeh farmers are well aware of the fact that soils vary with depth and take into account the possiblity that their efforts at leveling a site may result in their either removing or uncovering a soil layer that is either more or less desirable for rice production. Thus some farmers will dig to see what kinds of soils they are apt to uncover if they remove the top layer of soil in constructing a new field. Commonly occurring soil profiles, however, are rather well known and farmers know what sorts of "B" horizons are apt to be found under which "A" horizons. Thus, an informant stated that although a layer of ***tana' meroko*** or an almost purely organic root mat can be removed when a field is being made, this is rarely worth the effort and thus is seldom done because such root mats commonly overlie very poor ***mefayeh*** soils. It is recognized that changing the soil surface can result in the uncovering of both better or worse surfaces for rice production.

The possibilities for modifying a site's soils do not end with changes that result from leveling the area; particular sites may also be given different treatments depending on their shortcomings. Although Lun Dayeh pond field making involves far less soil preparation than is the norm in irrigated rice systems[3], plots with soils judged to be ***metugeh*** or hard and infertile are sometimes altered by tethering a water buffalo in the spot over a period of a week or so. The buffalo will both puddle the soil and fertilize it by defecating in the field. Thus a particular treatment can make a site more appropriate for cultivation. The shifting cultivator, employing a particular site for only a very limited period generally will not spend the time or resources on fertility enhancement procedures other than the burning of slashed vegetation and perhaps the spreading of the resulting ash.

Invariably the prime cirteria used by a shifting cultivator in determining whether a spot is suitable for a swidden are the height and general composition of the vegetation on it, often indications of the age of the stand. For the Lun Dayeh permanent field farmer height, or age of vegetation is only important if it serves to indicate whether the soils are so poor that nothing other than scrub growth will appear or whether the plot is regularly inundated. The swiddener's preoccupation with the age of the stand which determines the ease of forest clearance, the quality of the burn, and the quantity of the resultant ash, as well as the presence or absence of grasses and sedges that may become important pests do not concern the permanent irrigated field farmer.

Lun Dayeh cultivators survey vegetation to get some indication of the soils as well as to judge the flooding hazard at particular sites. Vegetation is important, as the presence or absence of particular plants indicates a number of conditions, a "gestalt" important for the rice farmer. The particular species that the informants at Long Umung suggested as especially useful for determining whether sites were suitable for the creation of permanent pond fields are listed in Table 1. It is interesting to note that judgements of Lun Dayeh farmers as to the suitability of a site, as shown by the presence or absence of these species of plants, were duplicated by a university trained ecologist well familiar with Borneo. Dr. Paul Chai, Forest Botanist of Sarawak, identified the plant specimens and, relying on his extensive general knowledge of local ecology, independently evaluated each plant as an indicator of agricultural potential. His ratings were exactly the same ratings as those of the Lun Dayeh informants. The nine species listed are those most commonly known and identified. Many Lun Dayeh informants could also name dozens

Table 1.—*Common plant species indicating agricultural potential.*

Species	Family	Lun Dayeh name	Condi. indicat.
Rubus moluccensis L.	Rosaceae	serinit	good
Selaginella aff. *brevipes* Fee	Selaginaceae	gugor	good
Piper aff. *caninum* Blume	Piperaceae	buyu' berek	good
Curculigo borneensis Merr.	Hypoxidaceae	lapa'	good
Cyrtandra trisepala C.B.L.	Gesneriaceae	taneb luba'	average
Lycopodium cernuum L.	Lycopodiaceae	lio fade	poor
Curculigo villosa Wall.	Hypoxidaceae	tamar	poor
Timonius finlaysonianus Hook f.	Rubiaceae	anur sia'	poor
Clethra lonspicata J.J.Sm.	Clethraceae	anur ferian	poor

of other plants, particularly tree species, which are characteristically found in association with known soil types and with known agricultural potential.

Areas that are deemed unsuitable for either permanent or swidden cultivation may still be used as house or village sites or may be left in natural forest. Such areas often still serve as sources of important subsistence products, among them spontaneously occurring fruits, leaves, fern shoots, and fungi. Animals are hunted in these forests, and materials for building, fuel, and handicrafts are collected.

SUMMARY AND CONCLUSIONS

Like shifting cultivators and other traditional agriculturists throughout the world, the Lun Dayeh of East Kalimantan's Kerayan Subdistrict weigh a number of environmental variables before selecting a site for a new agricultural field. While the environmental variables most important to swiddeners, including the composition and height of the vegetation covering the area are taken into account, Lun Dayeh permanent field cultivators tend to be more concerned with other environmental characteristics, including slope, water quality and availability, drainage, and soil quality both on and below the surface. Moreover, they attempt to judge the long-term acceptability of the site. Therefore, continuing observation of an area, often for years before it is first used, is not unusual. While the criteria for an acceptable site for an irrigated farm field are many, Lun Dayeh cultivators assume that some changes will be necessary to bring a field to the condition required. Therefore, a most important consideration is the amount of labor that will be needed to render a site acceptable for pond-field farming. Since population density in the Kerayan is still low and almost ideal areas are available at present, Kerayan Lun Dayeh farmers continue to reject any site that requires major improvements such as significant terracing work, the filling in of sites that tend to flood too deeply, or the digging of long irrigation canals. As most easily worked areas are claimed in the future, what is judged an acceptable site will certainly change, and the construction of ever more labor demanding engineering works will be considered necessary and reasonable.

A rather extreme example of another phase of this process is found among the Ifugao of Luzon. According to the reports of Conklin (1980), the Ifugao, in choosing a site, consider the incline of an area the most important criterion. Since flat or gently sloping lands are no longer available in Ifugao, an acceptable slope is far more steep than any site that the Lun Dayeh would attempt to exploit. Also important is availability of a

water supply upslope from the chosen site and location of materials necessary for the building of terraces in the vicinity of the selected area; these include walling rock, rough fill, and topsoil. In the Ifugao case, cultivators do not expect to find, but rather to create most of the conditions necessary for pond-field farming and their fields, in contrast to those found in the Kerayan, can be considered largely artifacts, since the soil, including subsoil and the entire surface of each terrace, have been created with human labor.

The willingness and ability to alter environmental conditions, which in large measure distinguishes Lun Dayeh pond-field farmers from their swiddening counterparts, is considerably more developed among wet rice farmers such as the Ifugao whose homelands offer fewer unexploited ideal sites for irrigated cultivation. A comparison of labor needed to create pond fields in different areas would be interesting but is difficult because of the great variability of sites available in each location (Conklin 1980; Padoch 1981). However, initial pond-field creation costs as well as subsequent labor for maintenance in regions like Ifugao surely far surpass those found in the Kerayan. With ever increasing alteration of the original environment, the need for human labor in maintenance constantly increases as well. The Lun Dayeh, therefore, in seeking out areas that naturally most closely approach the conditions desirable in an irrigated pond-field are minimizing not only initial construction costs, but also subsequent maintenance.

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NOTES

[1]General descriptions of swidden or shifting cultivation as well as of irrigated, inundated, wet, or sawah systems of rice production can be found in many publications, among them Hanks' *Rice and Man* (1972) and the introductory chapter to Geertz' *Agricultural Involution* (1963). Although the irrigated rice cultivation patterns employed by the Kerayan Lun Dayeh depart somewhat from the classic sawah techniques described in the above works (Padoch 1985), the general characteristics of Lun Dayeh farming, including their temporal aspects, are similar to the well-known models.

[2]For a general discussion on labor requirements in Kerayan Lun Dayeh agriculture see the article by Padoch (1985). Freeman's (1970) and Padoch's (1978) monographs on Iban swiddeners discuss the need for guarding crops from animal depredations in one area of Borneo.

[3]Lyn Dayeh irrigated rice farmers do not plow or puddle their plots, as do most wet rice farmers. For further discussion of agricultural techniques and labor expenditure in the Kerayan, see Padoch (1985).