ECONOMICS OF UPLAND RESOURCE DEPLETION : SHIFTING CULTIVATION IN THE PHILIPPINES

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ECONOMICS OF UPLAND RESOURCE DEPLETION: SHIFTING CULTIVATION IN THE PHILIPPINES[1/]

by

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I. INTRODUCTION

The two principal causes of deforestation in less developed countries today are land clearing for agriculture and wood gathering for fuel (Eckholm 1976). However, the practice of "shifting cultivation" has largely dominated

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1/ Based mostly on Chapter III of "Economic Analysis of Resource Conservation by Upland Farmers in the Philippines," Ph.D (Economics) Thesis, University of the Philippines, 1986.

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clearing of forested land for agricultural production[3/]. It is an agricultural system generally conducted "by a rotation of fields rather than crops, by short periods of cropping, alternating with long fallow periods, and by clearing by means of slash and burn" (Pelzer, 1968).

In the Philippines, such practice of the "kaingin" system, as it is termed locally, has usually succeeded logging activities. While debate on the relative damage inflicted by upland agriculturists and loggers on the forests still remains unresolved, it is perhaps more important to note that occupancy in the country's uplands reached fourteen million (14.0 M) individuals in 1980 (M.C.Cruz, et al, 1986). The effects of land-use systems by such population, which represents some 30 percent of the national total, therefore, cannot be understated.

We attempt to provide a systematic investigation of agricultural systems practiced in the uplands by starting with a formal treatment of the shifting cultivation problem.[4/] We investigate the optimum rate of use of forested land from society's viewpoint and from the

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[3/] "Shifting cultivation", shifting field agriculture", "swidden farming", "slash-and-burn farming" and "kaingin" are terms which have been used by various authors to indicate, generally, similar agricultural systems and are used interchangeably in this paper.

[4/] The economics of adoption of soil conserving technologies by upland communities who are participants of development projects shall be presented in a subsequent working paper.

individual uplander's viewpoint, given traditional choices between timber production or agricultural production through slash and burn farming. Here, swidden farming is explained in terms of a standard resource economic model on open access exploitation, the discounting bias, and zero valuation of the externalities involved, as well as constraints which are specific to upland resource use.

Sections 1 and 2 discuss the varying degree of completeness of markets for the products/effects of upland resource use. Specifically, dissimilar valuation of the external, environmental, and future effects resulting from agricultural use of forest land is the major determinant of rates of use of upland soil resources. In addition, the resulting time paths of resource stocks, scarcity rent, agricultural production and prices are discussed under varying decision rules followed by the different resource-users.

Section 3 subsequently hypothesizes the likely behavior of forest land use under specific Philippine conditions of accessibility and tenure, and presents some insights on shifting cultivation in various parts of the country. This is followed by a discussion of the implied policy tools in Section 4.

II. A NORMATIVE MODEL OF OPTIMUM USE OF FOREST LANDS FOR AGRICULTURAL PRODUCTION : RESOURCE OPTIMIZATION UNDER COMPLETE MARKETS

Consider the following relationships depicting agricultural production on forest land which adopts the basic natural resource exploitation model, as presented by Howe (1979, Ch. 5):

(1) $Q(t) = [L(t), S(t), t]$

where $Q(t)$ = agricultural crops planted in forest land;

$L(t)$ = composite labor-capital input;

$S(t)$ = stock of forested land and soil resources therein; and

t = time.

Howe includes S(t) as an argument to the production function for a natural resource commodity to reflect what he calls "stock effects" (ibid, p.91), and which he defines as: "(a) an increase of extraction costs (*for the derived commodity*) as *(resource)* depletion proceeds; and (b) a reduction in future use due to a finite limit to the total quantity of the <u>in situ</u> resource" (ibid, p.72; italics inserted). An example of such stock effects include higher effective logging costs for cutting smaller sized trees.

We differ in our treatment of S(t) as we adapt the model for the use of upland resources which include both forests and soil resources. Under the shifting agriculture system, the flow of services from forested uplands proceeds as follows. Immediately after standing forests are felled, the resulting cleared area, which still contains forest litter, provides enough fertility for agricultural production. When the clearing is also accompanied by burning of trees, the soil resources are enhanced by the burnt biomass; that is, the addition of slightly burned vegetation results in an increase of the organic matter and nitrogen content after burning (Sanchez, 1976). Thus, an immediate (i.e., current) positive stock effect results or $(\partial Q/\partial S(t)) > 0$; uplands which are forested are therefore better sites for agricultural production, compared for example, with non-forested uplands (e.g., grassland, pasture land) of the same slope.

Unless soil conservation measures are taken, however, continued agricultural production may not be feasible due to soil structure deterioration, and to erosion of the topsoil which is no longer protected from rainfall (usually heavy in the tropics) by forest litter. Thus, it becomes more difficult to "extract" agricultural products from forest land because the nutrients earlier provided by the burnt stock of forest vegetation are no longer available, or are less, for the subsequent cropping cycle. In this manner, the negative stock effects hold. These effects are described by Howe as a cost experienced in the <u>future</u> due to current use of a given resource stock.

We expect $(\partial Q/\partial L(t)) > 0$, and $(\partial^2 Q/\partial L^2(t)) < 0$ from the usual behavior of production (law of diminishing returns).

Equation (2) is an inverse demand function for agricultural crops/commodities, given p(t) as the composite price of such products:

(2) $p(t) = D[Q(t), t]$

The next relationship shows social benefits, which include the use of agricultural products, as well as the value of environmental services of untilled forest land, S(t):

(3) $SB(t) = \int_0^{Q(t)} D[\eta(t), t]\, d\eta + E[S(t)]$

Here, we integrate over Q(t) to indicate that we are valuing the area under the demand curve, and estimating consumers' surplus.

The environmental services E[S(t)] which are provided by a stock of forests may pertain to the minimization of soil erosion as well as others such as windbreaks, ecological diversity, and the provision of oxygen. The present study focuses largely on soil erosion as the primary concern among the off-site forest services. Larger stocks of forest lands lead to more environmental services, thus $(dE/dS) > 0$.

Subsequently, we now investigate the production of agricultural crops on forest lands which involves direct costs such as the opportunity cost of labor-capital, and the loss of environmental services due to a reduced forest land area. Indirect costs include those imposed on the future, in particular, the foregone harvest from secondary forests, and increasing difficulty of raising agricultural crops due to decreasing soil fertility.

Setting r as the social discount rate and w as the unit opportunity cost of the labor-capital input, the optimization problem for agricultural production on forest land becomes:

$$(4) \quad \underset{L(t)}{\text{Max.}} \int_0^\infty \left[\int_0^{Q(t)} D(\eta,t)\,d\eta + E\,[S(t)] - wL(t) \right] e^{-rt}\,dt$$

$$\text{subject to :} \quad (4.1) \quad S(t) = S(0) - a \int_0^t Q(T)\,dT,$$

$$(4.2) \quad S(t) \geq 0.$$

Equation (4), (4.1) and (4.2) describes an optimal control problem where L(t) is the decision variable and S(t) the state variable. Equation (4) says that we are maximizing net social benefits, or subtracting current production cost, wL(t), from equation (3) over a perpetual time period. Thus, under complete markets, the agricultural product, environmental services and future effects of using part of forested uplands for crop production are all considered. Presumably, this occurs when the decisions made are based on societal concerns.

Equation (4.1) is an accounting equation for the stock of forested land; the constant a (>0) reflects the effect of upland agricultural production on the reduction of forest land, while S(O) denotes the initial stock of forested land. Equation (4.2) is the non-negative condition of S(t). The rate of change of S(t), is therefore:

$$(5) \qquad \dot{S}(t) = -a \cdot Q(t)$$

For purposes of manageability, we incorporate the constraint equation (5) into (4) and multiply the whole equation by $\int_0^\infty e^{rt}\,dt$ or equivalently, e^{rt}, to form the current value Hamiltonian function which depicts the rate of net social benefits at instant t:

$$(6) \qquad H = \int_0^{Q(t)} D(\eta, t)\,d\eta + E\,[S(t)] - wL(t) - a \cdot u(t)\,Q(t)$$

Here, u(t) is the current value Lagrange multiplier, which is equal to $\lambda \cdot e^{rt}$, corresponding to constraint (5). The first two terms of (6) show the direct and environmental benefit rates; the third term pertains to the opportunity cost of labor-capital inputs, while the last term represents sacrifices imposed on future periods.

Differentiating H with respect to $L(t)$ gives us:

$$(7)\quad \frac{\partial H}{\partial L(t)} = D\,[Q(t), t]\,\frac{\partial Q(t)}{\partial L(t)} + \frac{dE[S(t)]}{dS(t)} \cdot \frac{dS(t)}{dQ(t)} \cdot \frac{\partial Q(t)}{\partial L(t)} - w - a \,.\, u(t)\,\frac{\partial Q(t)}{\partial L(t)}$$

Obtaining $(\partial H/\partial L(t)) = 0$, we derive the following basic condition on price, cost and rent:[5/]

$$(8)\quad p(t) = -\frac{dE\,[S(t)]}{dS(t)} \cdot \frac{dS(t)}{dQ(t)} + \frac{w}{\frac{\partial Q(t)}{\partial L(t)}} + a \,.\, u(t)$$

That is, the marginal social value of agricultural products derived from forest land at any time must include three components. The first term on the right covers the marginal loss of environmental services. This is positive since $dS/dQ < 0$. The two other components are the marginal production cost (the second term), and the marginal user cost (or scarcity rent) on the on-site resources being used up which are not replenished because secondary forests are wiped out (third term). The marginal cost of producing agricultural commodities from forest land, according to society's viewpoint, therefore includes environmental, production and inter-temporal costs.

5/ The appendix presents the details of the mathematical derivations.

Once the right hand side of eq. (8) exceeds p(t), it no longer pays for society to produce the next unit of agricultural commodity on forest lands. Hence, society is better off obtaining additional agricultural products from other sources such as the lowlands or the international market.

The movement of scarcity rents on in situ resources now may be seen from the following:

(9) Basic condition 2 :

$$u(t) + [p(t) - a \cdot u(t)] \frac{\partial Q(t)}{\partial S(t)} + \frac{dE}{dS(t)} = r \cdot u(t)$$

From equation (8), $[p(t) - a\ u(t)] > 0$; thus, given that $(\partial Q/\partial S) > 0$, and $(dE/dS) > 0$, then $(\dot{u}(t)/u(t))$ in equation (9) is positive. Here we can see that when the optimum size of forest land is carried forward, three types of benefits are enjoyed by society (left-hand side of (9): (a) increase in its value; (b) reduction of future production costs of *agricultural* commodities; and (c) the value of additional environmental services (Howe 1979, p.93; italics inserted). The sum of these benefits should yield the socially required rate of return r on the value of u(t), the scarcity rent.

Hence, the first basic condition (eq. 8), tells us the optimal rate of producing agricultural crops on forest land while basic condition 2 (eq. 9) shows the optimal stock of forest lands.

III. THE PRIVATE INDIVIDUAL'S USE OF UPLAND SOIL RESOURCES: RESOURCE OPTIMIZATION UNDER INCOMPLETE MARKETS

After having derived societal decision rules, we now discuss individual decision-making criteria. We tackle three cases of private resource users : those with secure land tenure; those without property rights ; and the special case of shifting cultivators.

3.1 The Private Resource-User With Secure Land Tenure

A potential upland cultivator in a perfectly competitive setting for agricultural products would likely ignore the off-site environmental services provided by the stock of *in situ* resources. The corresponding formulation of his objective function, with the omission of E [S(t)], would result in:

$$(10) \quad \underset{L(t)}{\text{Maximize}} \quad \left[\int_0^{Q(t)} D(\eta, t)\, d\eta - wL(t) \right] e^{-rt}\, dt$$

subject to: (10.1) $\dot{S}(t) = -a \cdot Q(t)$

(10.2) $S(t) \geq 0$.

The corresponding basic conditions would be:

$$(11) \quad \hat{p}(t) = \frac{w}{\frac{Q(t)}{L(t)}} + a \cdot \hat{u}(t)$$

$$(12) \quad \dot{\hat{u}}(t) + [\hat{p}(t) - a \cdot \hat{u}(t)] \frac{Q(t)}{S(t)} = r \cdot \hat{u}(t)$$

Equation (11) implies that the "private cost" $\hat{p}(t)$ of agricultural crops raised in the uplands would be lower than the social cost p(t) indicated earlier in equation (8) because off-site environmental costs are ignored; that is, the value of equation (11) is less than that of eq. (8) by the factor [- (dE(S)/dS) . (dS/dQ)] > 0. Therefore, given the same demand curve for agricultural products faced by both types of decision-makers, an individual would produce more agricultural crops, or would convert a larger, forested upland area for agriculture use, as against the area that society would consider. As a result, _in situ_ rent given in equation (12) would rise faster. That is, solving for u and $\dot{\hat{u}}$ in the two equations for the second basic conditions, (9) and (12) respectively, a difference of the magnitude (dE/dS) > 0 implies $\dot{u} < \dot{\hat{u}}$. Hence, when the market is incomplete because the off-site environmental effects of converting forested uplands to agricultural croplands through swidden farming are not included in the exchange, larger areas tend to be deforested and scarcity rent rises faster.

Furthermore, private decision-making also differs from public choice in terms of the time preference rate: an individual normally uses a rate higher than what a public planner would apply, or $\hat{r} > r$.[6/] Solving thus for the r's, comparing equations (9) and (12), and bearing in mind that $(\dot{E}/dS) > 0$, we obtain even a wider gap between $\dot{u}$ and $\dot{\hat{u}}$.

3.2 The Individual User Without Secure Land Tenure

Reaction to the effects of changing land-use from timber production to agricultural production may additionally differ according to varying property rights. An upland cultivator who has exclusive, secure use of soil resources for a given upland area would be more responsive to the on-site, future effects of a decreasing stock of soil resources than one without property rights.

When rights to use public land are not secure, the stock effects (of decreasing forests) may be excluded, or $u(t) = 0$. In this case, the corresponding basic conditions would be:

$$(13) \quad \tilde{p} = \frac{w}{\frac{\partial Q(t)}{\partial L(t)}}$$

$$(14) \quad \dot{\tilde{u}}(t) = \tilde{r} \cdot \tilde{u}(t), \qquad \text{or} \qquad \frac{\dot{\tilde{u}}(t)}{u(t)} = \tilde{r}$$

The price that the cultivator attaches to his produce tilled, public, (erstwhile) forest land is equivalent only to his valuation of the effort that went into agricultural production, as depicted by eq. (13).

6/ That is, assuming the time preference rate is properly reflected by r, for purposes of a simpler exposition.

Public land is hence used at a faster rate for swidden farming; a smaller stock of forests results and user cost rises at a faster rate. That is, solving for $\dot{u}(t)/u(t)$ in equations (9), (12) and (14) would yield the following relationships: $(\dot{\tilde{u}}/\tilde{u}) > (\dot{\hat{u}}/\hat{u}) > (\dot{u}/u) > 0$, with the differences being accounted for by exclusion of the terms $[\partial Q(t)/\partial S(t)] > 0$, $[dE[S(t)]/dS(t)] > 0$, and $a.u(t) > 0$.

Indeed, with the absence of property rights for tilling the uplands, the upland resources which include the forests are even depleted at a faster rate because the stock effects are excluded in decision-making. Moreover, insecurity of tenure leads to an even higher discount rate. Thus, comparing equations (14) and (12), and $\tilde{r} > \hat{r}$, the faster marginal user cost rises because land is depleted at a faster rate.7/ Figure 1 shows the results of decisions arrived at by various users of forest land. The forest area used for agricultural production by society (aQ) is less than that determined by private individuals ($a\tilde{Q}$ and $a\hat{Q}$), and by the individual without property rights who uses the largest area (i.e., $aQ < a\hat{Q} < a\tilde{Q}$).

In the special case of the shifting cultivator, which we shall discuss more fully in section 2.4 below, the area aQ is furthermore cultivated frequently by several users, thereby resulting in faster depletion of soil resources.

7/ Scarcity rent being equal to zero, in fact, implies $\dot{\tilde{u}}/\tilde{u} = \infty$.

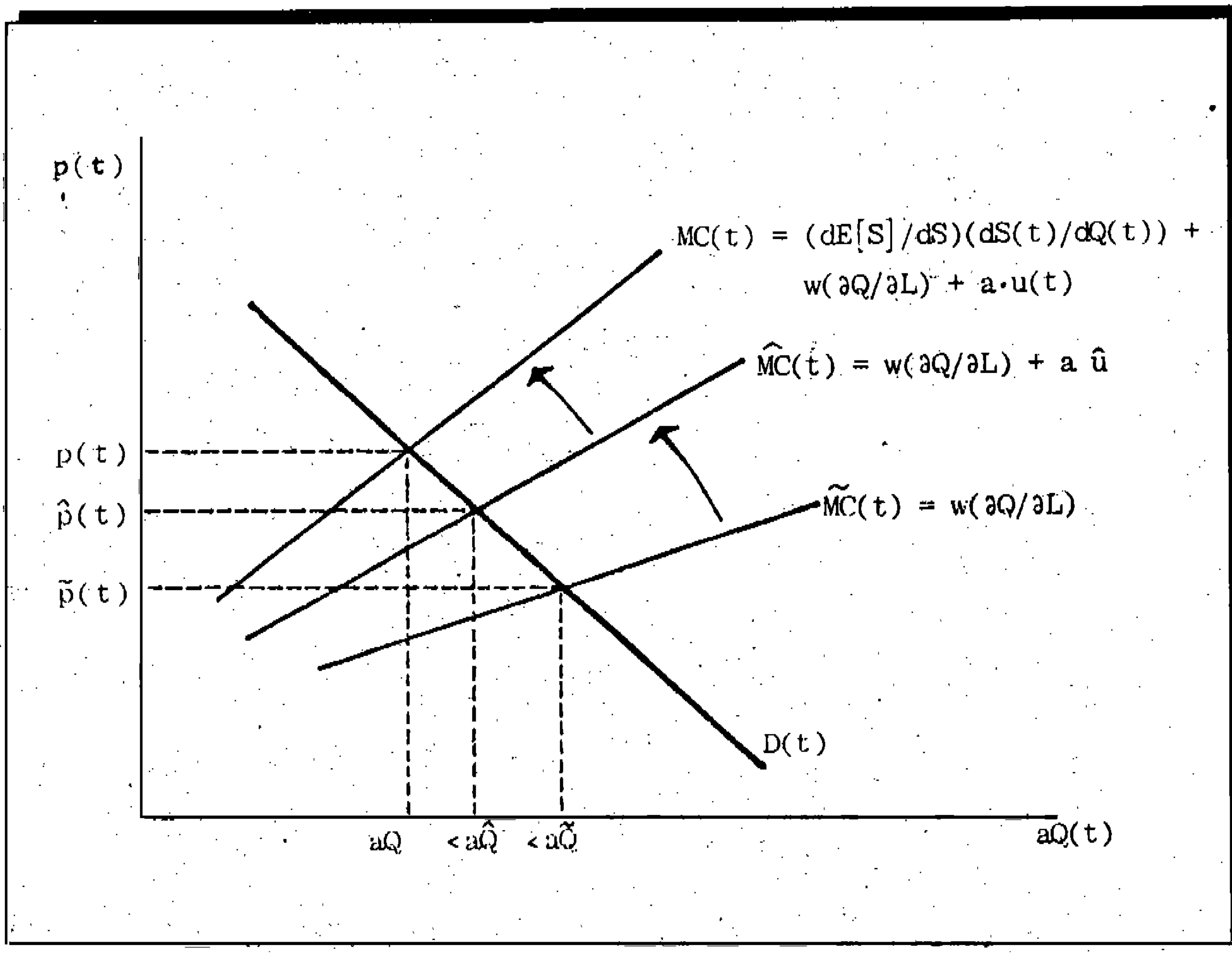


FIGURE 1: DETERMINATION OF AREA FOR AGRICULTURAL PRODUCTION BY VARIOUS DECISION MAKERS

L E G E N D :

Decision-maker	Marginal Cost	Area for Agricultural production
society	MC	aQ
individual with property rights	$\widehat{MC}$	$a\hat{Q}$
individual w/o property rights	$\widetilde{MC}$	$a\tilde{Q}$

3.3 Behavior of S, Q, p and u over time

Given these, we may now proceed to determine the time paths of forest (and soil) resource stock, agricultural production in the uplands, price of agricultural commodities and scarcity rent for the three cases discussed above. We focus on resource supply factors, therefore abstracting from changes in demand for both agricultural products, forest products and amenities. We assume that for varying resource-based products and services, relative prices will hold.

We compare forest soil resource use by society, where the market is complete, with resource use by an individual decision maker who disregards the off-site amenities from resource stock, but who internalizes stock effects because property rights exist. We obtain from equations (8) and (11) the relationship, $\dot{p}(t) > \hat{p}(t)$, since $[-dE[S(t)]/dS(t)) \cdot (dS(t)/dQ(t))] > 0$. Thus, the private sector resource user would attribute a lower agricultural commodity price $\hat{p}(t)$, produce at a higher level $\hat{Q}$, and the resource stock would initially decrease at a faster rate.

Further, since the social discount rate is lower than the individual's discount rate, or $\hat{r} > r$, the initial $[\hat{p}(t) - a\ \hat{u}(t)]$ of the private user is less than that for society; and, he also excludes (dE/dS). Hence, the terms $\dot{\hat{u}}(t) > \dot{u}(t)$ in equations (9) and (12). Scarcity rent thus increases faster for the individual who uses the resource stock more rapidly.

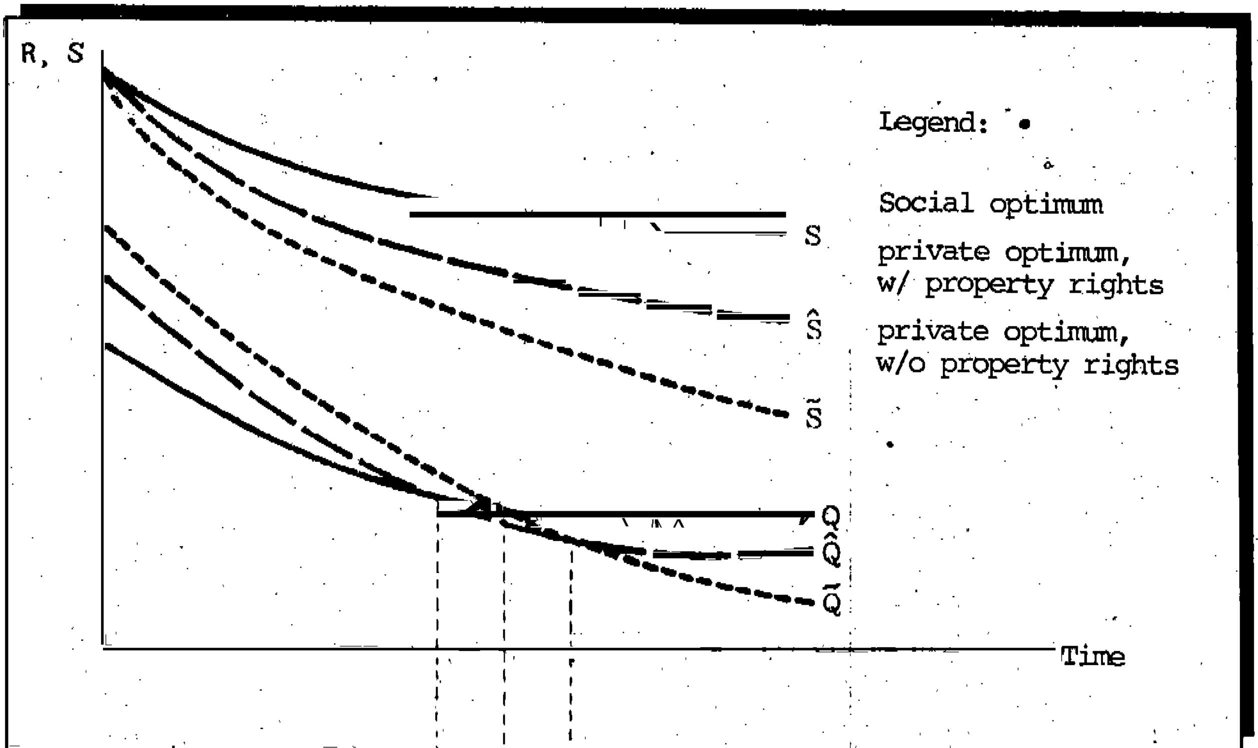
After a longer time has elapsed, however, lower resource stocks would result in higher incremental costs in extracting the resource-based product. In addition, rents rise at faster rates or $\dot{\hat{u}} > \dot{u}$. Eventually, $\hat{p}(t) > p(t)$ when $\hat{Q}(t) < Q(t)$ (Figure 2).

In the case of a resource user who has no tenure in the uplands, or the shifting cultivator, the situation is even worse: the initially higher agricultural production would decrease rapidly to lower levels, and scarcity rent would increase rapidly. This means that during an earlier point in time, $\tilde{Q} > \hat{Q}$ and $\tilde{p} < \hat{p}$ because the resource user who has no tenure disregards even the stock effects of production. Scarcity rent would rise at a higher rate, or $\dot{\tilde{u}} > \dot{\hat{u}}$, virtually affecting agricultural commodity production. Thus, during a latter point in time, $\dot{\tilde{p}} > \hat{p}$ when $\tilde{Q} < \hat{Q}$.

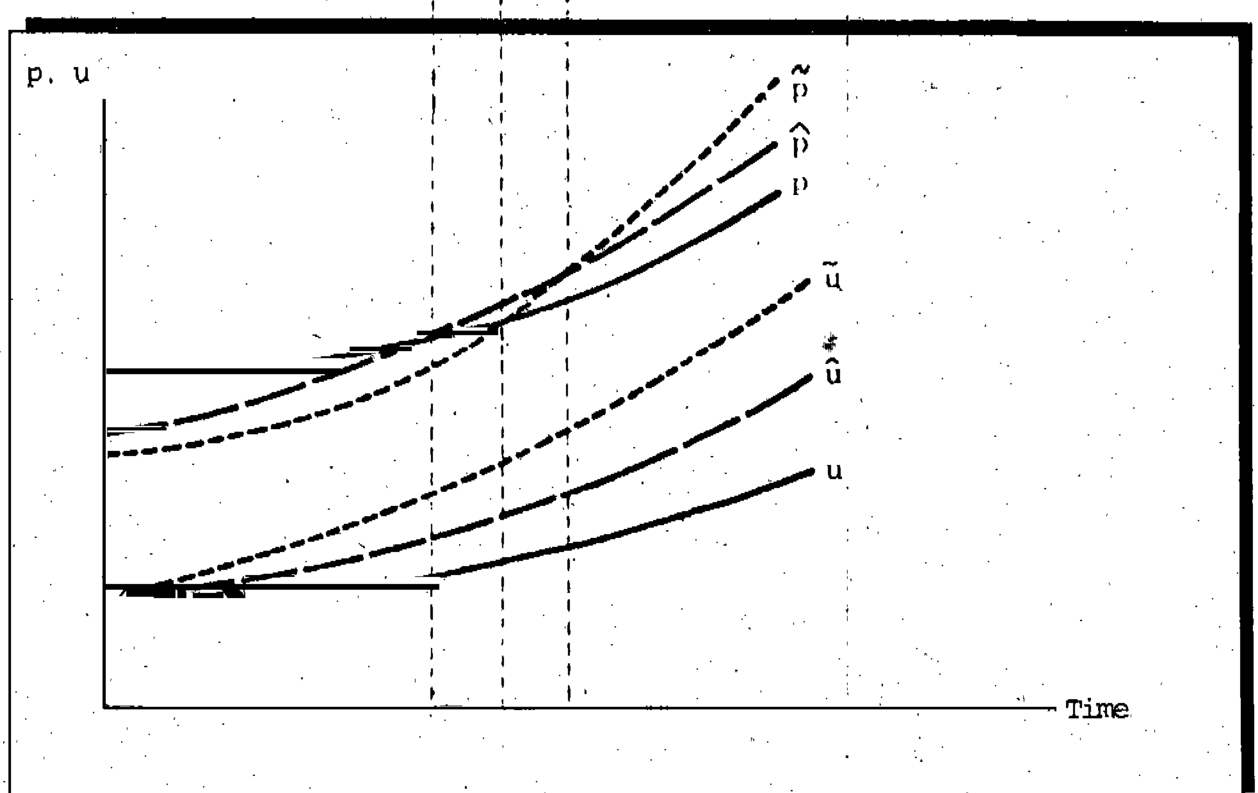
3.4 The Shifting Cultivator

For upland farmers occupying inadequately secured public forests, the land may be tilled many times over by several cultivators in a similar fashion, thus crowding occurs in the exploitation of open access fishery resources, specially under conditions of high unemployment, or lack of alternatives in the economy (Clark 1973), and high man-land

FIGURE 2: TIME PATHS OF S, Q, p AND u.



a. time paths of agricultural production and stocks of forest lands



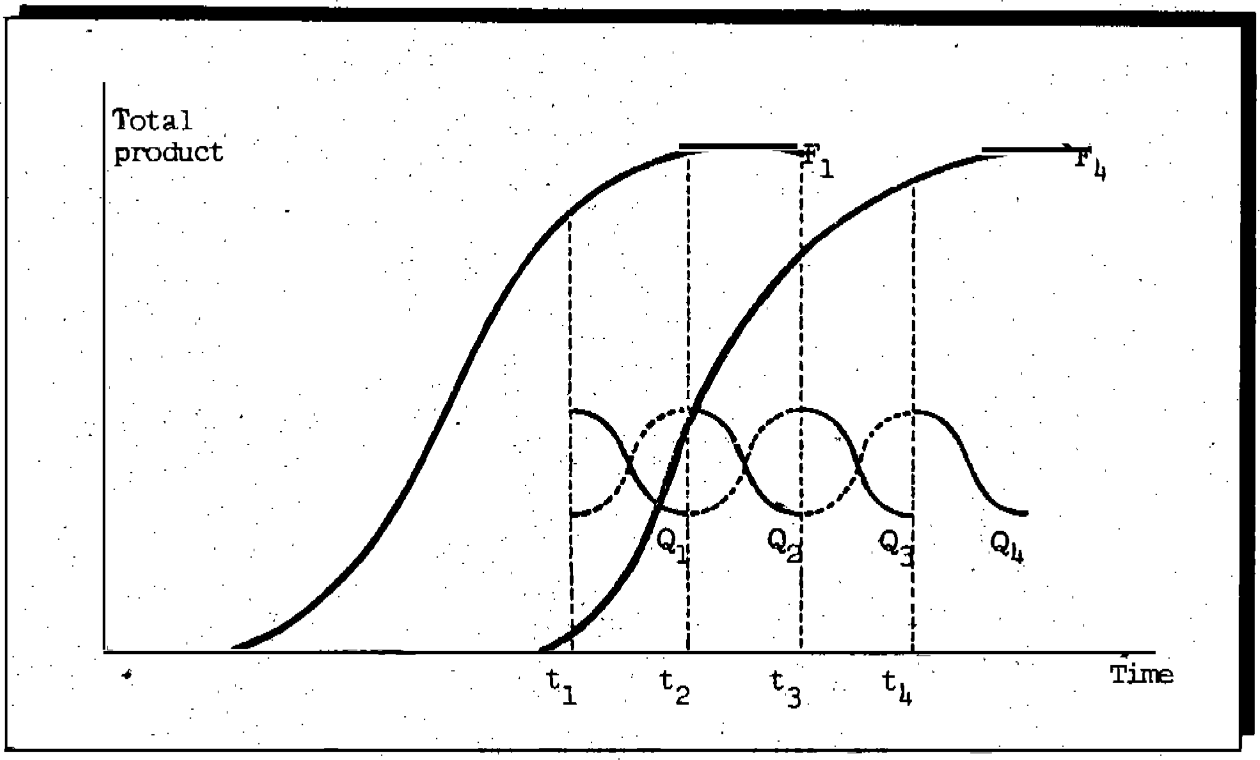
b. time paths of agricultural product price and scarcity rent ratios. In addition, under tropical conditions where a stringent time constraint for land preparation is imposed by seasonal patterns, and effective labor availability is low (e.g., few tools are used and hiring labor is not feasible because incomes are low or surplus labor are not available in the uplands during the planting season), the farmer is induced to adopt a time-saving land preparation technique, that of slash-and-burn farming, or kaingin-making.

If time is the only variable input, the relevant portion of a total product curve for a slash-and-burn type of agriculture is the downward sloping section, that is, when average agricultural productivity declines. Indeed, it is only the first harvest after felling and burning has occurred when agricultural production is highest. In figure 3, the curves with solid lines illustrate the negative portions of the total product curves for agricultural production. Fast depletion of top soil resources follows after the rains come, resulting in lower subsequent yields. Most shifting cultivators therefore till the field for only 1-3 years, after which the invasion of weeds makes further cultivation too laborious, and shifting to another field is more desirable.

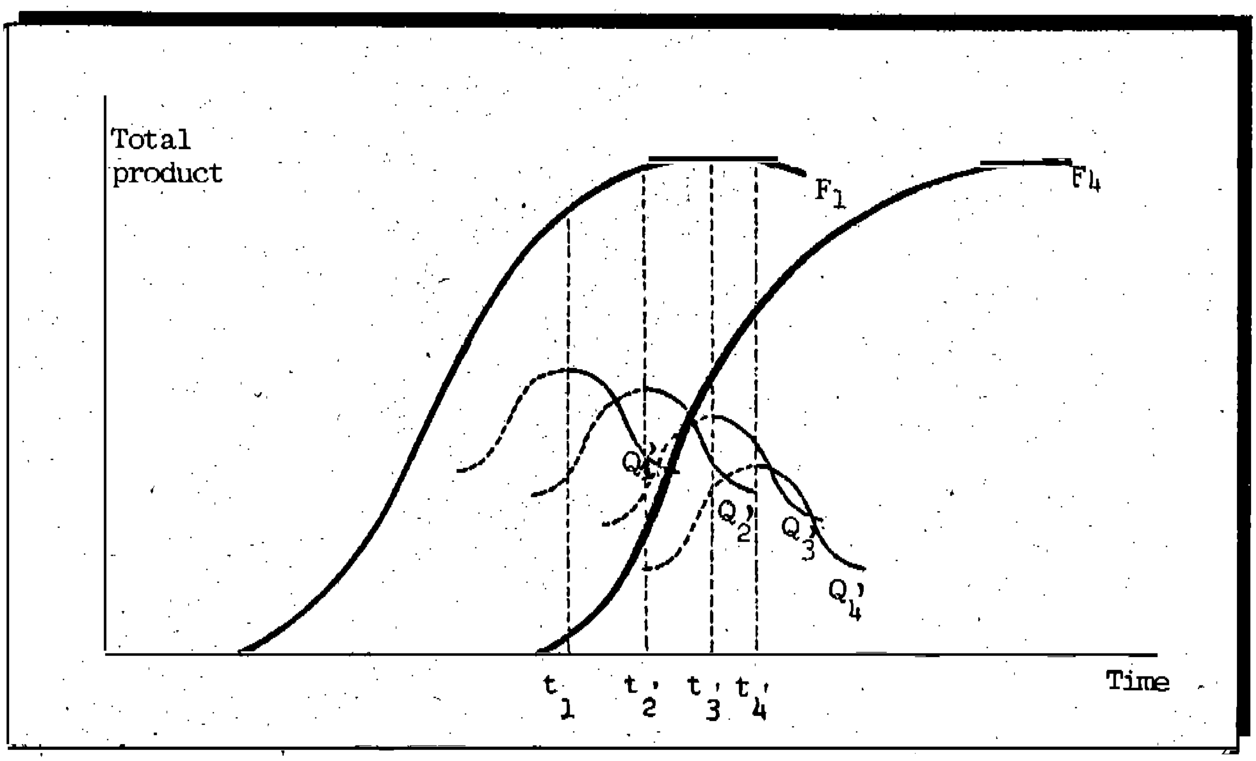
The shifting cultivator who has tenure avoids stock effects by either developing better, land-conserving, soil-use technology, or adjusting his consumption pattern to suit the availability of produce from the land, and/or seek other sources of livelihood. The latter choice implies that during the fallow period during which the soil is able to replenish itself, the piece of land is protected from encroachment by other users; this is feasible under a given system of property rights. Indeed, the evolution of commonly determined rules on resource exploitation by a community of resource users has been documented (e.g. W. Cruz, 1982 for the Philippine fisheries' case and Lynch, 1984 for examples of cultural minority groups in the country's uplands). The practice of shifting to another field is thus a process of avoiding higher marginal user cost (and allowing on-site soil conservation through the natural process of regeneration).

The choice of burning as a technique of preparing the upland results in various degrees of declining land productivity, depending on the relationship among the population of upland cultivators, land area availability and the rules for governing the use of land. For areas with low man-land ratios, a "stable" system of shifting agriculture may result, where long fallow periods are followed (Figure 3a); the opposite case characterizes areas with high population density, and eventual shortening of the fallow period (Figure 3b). Similar such diagrams have been presented by Sanchez (1976, p. 384) which we reproduce here as Figure 4.

FIGURE 3: SHIFTING AGRICULTURE IN FOREST LANDS



a. stable shifting agriculture replacing
a forest managed for timber production



b. an unstable shifting cultivation system

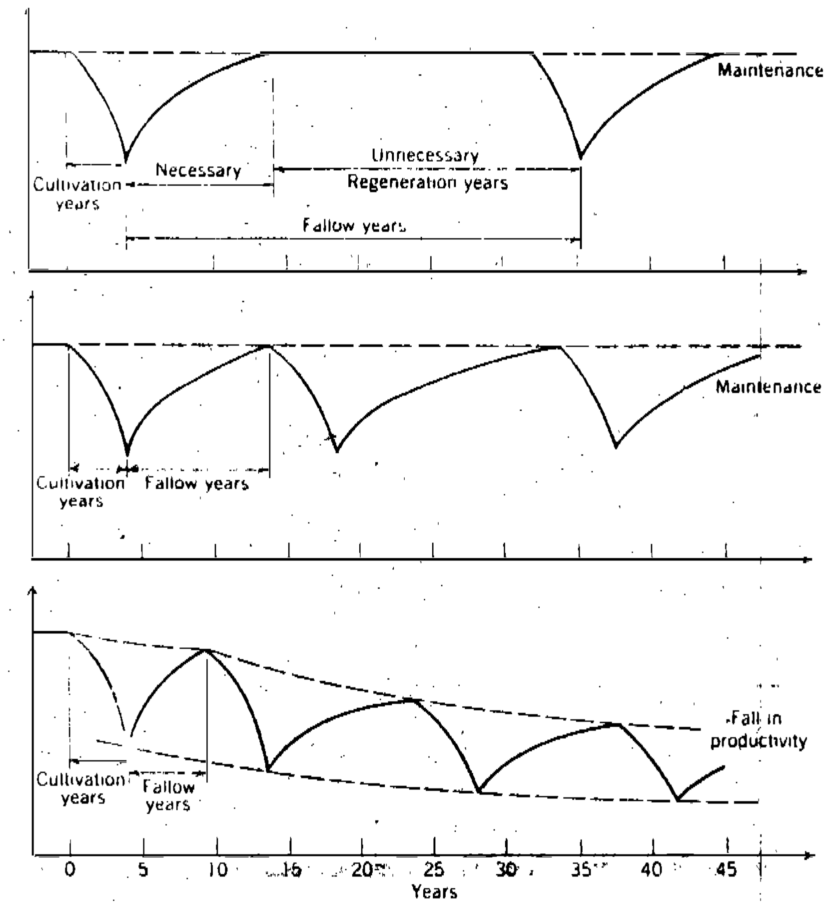


FIGURE 4: Theoretical relationship between length of fallow and soil productivity.

Source: Guillemen, R. 1956. Evolution de l'agriculture autochtone dans les savannes de l'Oubangui, Agron, Tropicale (France) 11:143-176; reproduced in Sanchez (1976), Figure 10.17, p. 384

The F-labelled curves refer to timber production from the forest which has been the traditional use of forest lands. The curves labelled 'Q' pertain to agricultural production. They are located below the F curves to signify lower current values of output.

Figure 3a depicts the first time the forest is used for agricultural production at t when the stand of trees shall have been harvested.[8/] Production of crops, signified by Q is thus conducted at the expense of future timber, and is indicated by the segment of curve F_4 that is covered during the time interval (t_1, t_4).

The dashed portion of curve Q_2 shows production of biomass by the untilled fallowed land which is used for cultivation again in year t_2. Figure 3a therefore shows a shifting of fields patterned in such a way that a given piece of forest land is used only at intervals which are equal and gives the same yield, other things remaining equal. A variant of this diagram which depicts a lengthening of fallow periods and increasing yields is not shown here.

The same piece of land when subjected to shifting agriculture, which occurs at shorter time intervals, shall result in productivity declines in the long-run. This is

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8/ The determination of t is the subject of another area of study and is treated as a given here. The reader may see Samuelson (1976) for this.

depicted in Figure 3.1b where the fallow periods decrease, ($t_2' < t_2$, $t_3' < t_3$, $t_4' < t_4$), and agricultural production declines ($Q_2' < Q_2$, $Q_3' < Q_3$ and $Q_4' < Q_4$).

This figure shows both user cost and <u>on-site</u> stock effects of depletion but it does not present the off-site environmental effects of slash-and-burn farming. Thus, only the concerns of the individual decision makers (timber manager and the shifting cultivator) are presented.

IV. SOME INSIGHTS FROM THE PHILIPPINE EXPERIENCE

We now present some data which support the various points we raised in the preceding discussion by citing evidence gathered by several researchers on <u>kaingin</u>-making. We focus first on "stable" systems which are usually, but not always, evolved by members of cultural minorities.

Table 1, which presents data on labor-use, was gathered by Conklin (1957) on swidden farming by the <u>Hanunuo</u> in Mindoro, and has a cycle of at least eleven years. We note that felling of climax forests (stages 2 and 3), relative to other activities, such as interplanting, protection, weeding, and harvesting, are more labor-using. This is true for the agricultural use of secondary forests (woody or bamboo type), except for the felling activity which is more intensive for the thick climax (old-growth) forests. Burning hastens the conversion of biomass from the felled trees, compared to the alternative of decay which could take several years.

TABLE I

LABOR-USE IN HANUOO SWIDDEN FARMING

Stages	Activity	Man-days of New Swidden in Second Growth: Climax Forest	Woody	Bamboo
1	Site Selecting	.8	.4	.4
2	Slashing	.8	12.5	18.8
3	Felling	43.8	18.8	5.0
4	Fire breaking	1.2	5.0	5.0
	Burning	.5	.2	.2
	Reburning	21.9	12.5	6.2
5	Planting Maize	1.2	1.2	1.2
	Planting Rice	18.8	16.2	16.2
	Interplanting	37.5	37.5	37.5
	Replanting	.6	.6	.3
	Fencing	18.8	18.8	18.8
	Protecting	18.8	9.4	9.4
	Guarding	50.0	25.0	25.0
	First Weeding	12.5	18.8	18.8
	Second Weeding		25.0	25.0
	Thinning & Last Weeding	25.0	31.2	31.2
6	Harvesting Maize	10.0	10.0	10.0
	Harvesting Rice	37.5	37.5	37.5
	Storing Rice	3.8	3.8	3.8
	Cleaning	25.0	25.0	25.0
-8	Non-grain Cultivation and Harvesting	62.5	62.5	62.5
	Total	397.5	371.9	358.1

N.B.: Conklin's original figures which were expressed in man-hours were converted to man-days using a factor of 8 man-hours per man-day.

SOURCE: Conklin (1957).

The highly seasonal pattern of producing crops from the rainfed uplands is depicted by Figure 5, for the Batac of Palawan Island. Various supplementary activities with differing abilities to produce food are undertaken by this group. Some of the non-farm sources of livelihood include collection of forest products, fishing, and participation in the labor market.

Indeed, the capacity of other uplands with similar geoclimatic conditions to support people depends on the agricultural system being used. Table 2 presents an attempt by Rice (1981) to evaluate three systems in terms of maximum allowable population density. The first system, labelled "single-crop-intrusive" refers to predominantly pasture use of the upland, resulting in an agricultural cycle that is quite lengthy. As a system that is assumed to be the major source of livelihood (as far as Rice's computations are concerned), it has a very low potential for supporting large numbers of people. Rice notes that this system is normally practiced by lowlanders living in clusters (1981, p. 80).

The second pattern depicted in Table 2 is that of shifting cultivation where a single crop is planted. According to Rice, the Ikalahans of Nueva Vizcaya typically practice such a system. The agricultural cycle is eighteen (18) years, a small fraction compared to the previous system's seventy-five (75) years. The third system, which

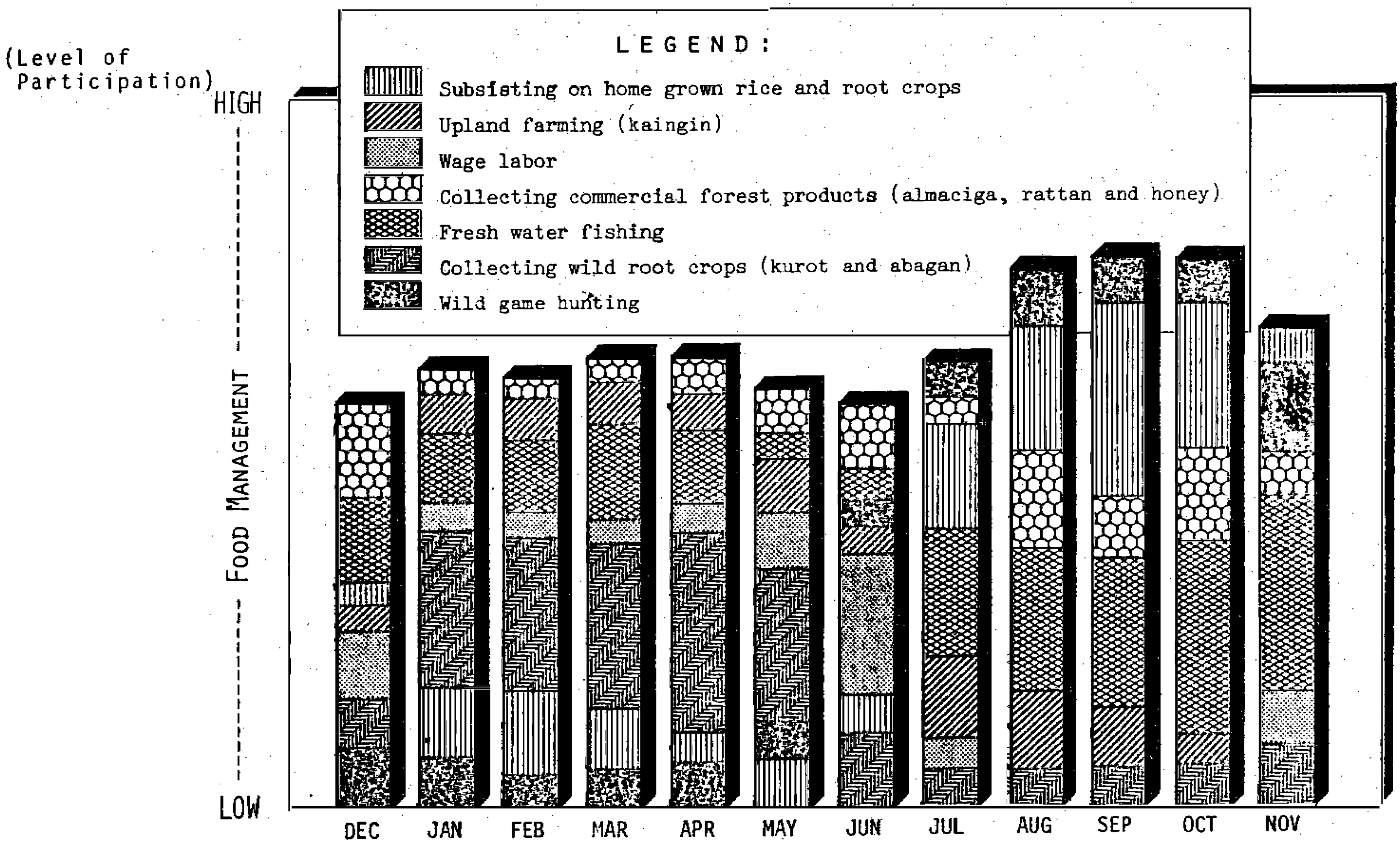

FIGURE 5: RELATIVE INTENSITY GRAPH OF VARIOUS SUBSISTENCE ACTIVITIES OF THE BATAK IN ONE AGRICULTURAL YEAR

SOURCE: Cadeliña (1981), Figure 2, p. 92.

TABLE 2

EXAMPLES OF UPLAND AGRICULTURAL SYSTEMS EVALUATED IN TERMS OF ALLOWABLE POPULATION DENSITY

	Traditional Single Crop Intrusive	Non-Traditional Systems: Single Crop Indigenous	 Indigenous Inter-Cropping
a. Usual period of cultivation	5 years	4 years	5 years
b. Subsequent pasture use	40 years	–	–
c. Required fallow period	30 years	14 years	11 years
d. Total agricultural cycle (a+b+c)	75 years	18 years	16 years
e. Utilization rate (a/d)	7%	22%	31%
f. Cultivated land needed per family as observed	1.4 ha.	1.0 ha.	0.7 ha.
g. Agricultural land needed per family (c/e)	20 ha.	4.5 ha.	2.3 ha.
h. Agricultural and watershed land needed per family	420 ha.	49.5 ha.	25.3 ha.
i. Maximum allowed population density per 1000 hectares	2.4 fam.	20.2 fam.	39.5 fam.

Source: Rice (1981), Table 2, p. 80.

is swidden farming with multiple crops, yields more and is therefore able to support a larger group of people. This system is usually observed of the T'boli of Mindanao and the Kalingas of Northern Luzon.

An important aspect presented by Rice which is not usually tackled by other researchers, at least in empirical terms, is the watershed area implied by the three upland systems (item h of Table 2). This implies a recognition of the environmental service provided by forests in the uplands.

Table 3 presents data on upland rice productivity for a group of erstwhile lowlanders now cultivating a portion of a major watershed in Luzon. It shows decreasing yields over time for a watershed whose condition has been characterized as critical from the environmental point of view, and implies urgency for solving the upland degradation and cultivation problems where non-cultural minorities are concerned.

V. IMPLIED POLICY TOOLS

To derive the various policy tools available to the public decision maker, we rewrite the set of first basic conditions for optimization by society; the private user who has property rights; and the "squatter" on forest lands respectively, as follows:

TABLE 3

AVERAGE LAND PRODUCTIVITY IN A TRADITIONAL KAINGIN FARM IN PUTING LUPA, MT. MAKILING, 1978-1980

Year	Production Per Hectare (cavan)
1978	26.74
1979	13.89
1980	8.68

Source: Corpuz (1984), Table 28, p. 88

$$(8) \quad p(t) = w/[Q(t)/L(t)] + a \cdot u(t) - (dE[S(t)]/dS(t)) \cdot (dS(t)/dQ(t))$$

$$(11) \quad \hat{p}(t) = w/[Q(t)/L(t)] + a \cdot u(t)$$

$$(13) \quad \tilde{p}(t) = w/[Q(t)/L(t)]$$

We note the assignment of property rights, which restricts access to the uplands by other users, would encourage the upland cultivator to consider at least the marginal user cost, or $a \cdot u(t)$ (i.e., (3.11) versus (3.13). Furthermore, a comparison between equations (3.8) and (3.11) shows that the additional policy tool that would allow such user to take into account some of the off-site environmental effects would be to tax him at a rate which approximates $[-dE[S(t)]/dS(t)] \cdot [dS(t)/dQ(t)]$, or impose environmental charges. Application of the policy tools discussed would result in rotation of the relevant marginal cost curves, as indicated in Figure 1. These would lead to an optimal agricultural use of forest land from the public standpoint.

A problem may arise, however, with respect to the feasibility of imposing environmental charges on subsistence farmers whose minimal cash income, if any, would make such policy tool unimplementable. It may even be argued, that subsidies may be a more effective incentive for encouraging soil conservation at least in the short-run.[9/]

[9/] See Baumol and Oates (1975) for a discussion of taxes versus subsidies as environmental policy tools.

More importantly, the end result of a stable shifting of fields still implies that there are periods during rotations when an upland area is under fallow and cannot provide subsistence. For those who rely on the uplands as a major source of livelihood, this implies the need for a large area of land to be worked out, 1/n<u>th</u> of an area at a time for a rotation period of n years. Moreover, within a given year during which land is cropped, there is an off-farming season (dry months) when food requirements need to be met, either through surplus production (implying again, working on a large tract of land), or through other food sources such as hunting, fishing, and the like. That is, given a land-use technology that has detrimental effects on soil conservation, and is land-extensive, the potential for supporting a growing population is severely limited. Therefore, there is a case for developing a more efficient, land-saving, less soil-erosive type of technology for producing non-timber crops in the uplands.

The discussion thus points out the need for securing rights to use upland resources for agricultural use, and encouragement of alternative technologies which are soil-conserving. The case for agro-forestry, subsidies for soil-conserving upland farmers, control of upland resource use and well-defined rights for such use cannot therefore be overemphasized.

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APPENDIX

MATHEMATICAL ANNEX

Optimum Agricultural Use of Forest Lands: Soil Conserving Technology (Agroforestry) Unknown

Given the following first three equations for the agricultural production, function (1), agricultural demand function (2), and social benefits from agricultural products and environmental services from resource stocks:

(1) $Q(t) = \alpha\,[L(t), S(t), t]$

where $\dfrac{\partial Q}{\partial L(t)}, \dfrac{\partial Q}{\partial S(t)}, \dfrac{dQ}{dt} > 0$

and $\dfrac{\partial^2 Q}{\partial L^2(t)}, \dfrac{\partial^2 Q}{\partial S^2(t)}, \dfrac{d^2 Q}{dt^2} < 0$

(2) $p(t) = D\,[Q(t), t]$

(3) $SB(t) = \int_0^{Q(t)} D[\eta(t), t]d\eta + E\,[S(t)], \quad \dfrac{dE}{dS} > 0$

Net benefits from resource use is maximized as follows:

(4) $$\underset{L(t)}{\text{Max}} \int_0^\infty \left[\int_0^{Q(t)} D[\eta(t), t]\, d\eta + E\,[S(t)] - wL(t)\right] e^{-rt} dt$$

s.t. $S(t) = S(0) - a \cdot \int_0^t Q(T)dT$

$S(t) \geq 0$

From the first constraint of equation (4), we obtain:

(5) $\dot{S}(t) = -a \cdot Q(t)$

Using (4) and (5) the following current value Hamiltonian may be formed:

(6) $\mathcal{H} = \int_0^{Q(t)} D(\eta,t)\, d\eta + E\,[S(t) - wL(t)] - a \cdot u(t)Q(t)$

where u(t) is the current value multiplier associated with equation (5), and is equal to λe^{rt}.

(7) $$\frac{\partial\mathcal{H}}{\partial L(t)} = D[Q(t),t]\,\frac{\partial Q(t)}{\partial L(t)} + \frac{dE[S(t)]}{dS(t)} \cdot \frac{dS(t)}{dQ(t)} \cdot \frac{\partial Q(t)}{\partial L(t)}$$

$$- w - a \,.\, u(t)\,\frac{\partial Q(t)}{\partial L(t)}$$

Or, substituting (2) gives:

$$\frac{\partial\mathcal{H}}{\partial L(t)} = p(t)\,.\,\frac{\partial Q(t)}{\partial L(t)} + \frac{dE[S(t)]}{dS(t)} \cdot \frac{dS(t)}{dQ(t)} \cdot \frac{\partial Q(t)}{\partial L(t)}$$

$$- w - a\,.\,u(t)\,\frac{\partial Q(t)}{\partial L(t)}$$

Setting $\frac{\partial\mathcal{H}}{\partial L(t)} = 0$ and dividing by $\frac{\partial Q(t)}{\partial L(t)} > 0$, we obtain:

(8) $$\frac{\partial\mathcal{H}}{\partial L(t)} = p(t) + \frac{dE[S(t)]}{dS(t)} \cdot \frac{dS(t)}{dQ(t)} - w - a\,.\,u(t) \leq 0$$

Thus, we have basic condition 1 as:

(9) $$p(t) = -\frac{dE[S(t)]}{dS(t)} \cdot \frac{dS(t)}{dQ(t)} + \frac{w}{\frac{\partial Q(t)}{\partial L(t)}} + a\,.\,u(t)$$

The second basic condition may be so obtained by differentiating as follows:

$$(10)\quad \dot{u}(t) = r \cdot u(t) - \frac{\partial H}{\partial S(t)}$$

$$= r \cdot u(t) - \left[D[Q(t), t] \frac{\partial Q}{\partial S(t)} + \frac{dE[S(t)]}{dS(t)} - a \cdot u(t) \cdot \frac{\partial Q}{\partial S(t)}\right]$$

Again, using (2) and rearranging:

$$\dot{u}(t) = r \cdot u(t) - \left[p(t) \frac{\partial Q}{\partial S(t)} - a \cdot u(t) \frac{\partial Q}{\partial S(t)} + \frac{dE[S(t)]}{dS(t)}\right]$$

$$= r \cdot u(t) - [p(t) - a \cdot u(t)] \frac{\partial Q}{\partial S(t)} - \frac{dE[S(t)]}{dS(t)}$$

Thus, the second basic condition is:

$$(11)\quad \dot{u}(t) + [p(t) - a \cdot u(t)] \frac{\partial Q}{\partial S(t)} + \frac{dE[S(t)]}{dS(t)} = r.u(t)$$

For the private decision-maker's case where E[S(t)] is omitted as an argument in (4), the resulting basic conditions would be:

$$(9)'\quad \hat{p}(t) = \frac{w}{\frac{\partial Q(t)}{\partial L(t)}} + a \cdot \hat{u}(t)$$

$$(11)'\quad \dot{\hat{u}}(t) + [\hat{p}(t) - a \cdot \hat{u}(t)] \frac{\partial Q(t)}{\partial S(t)} = \hat{r} \cdot \hat{u}(t)$$

Further, when the S(t) is excluded as a constraint by the private individual who has not property rights we have the corresponding basic conditions as follows:

$$(9)''\quad \hat{p} = \frac{w}{\frac{\partial Q(t)}{\partial L(t)}}$$

$$(11)''\quad \dot{\hat{u}}(t) = \hat{r} \cdot \hat{u}(t)$$