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Shifting Cultivation in Asia-Pacific Region

—Major Cause of Deforestation—

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アジア・太平洋地域における移動焼畑農耕

—森林消失の主要原因—

村上公久

熱帯林消失の原因は、1. 移動焼畑農耕、2. 過放牧、3. 薪炭材採取である。最大の原因である移動焼畑農耕については「畑」という漢字が火扁（ひへん）から成っていることから解るように、農業の始源は焼畑農耕であり、現在もコスト・ベニフィット比では最大の最も効率の良い土地利用形態である。

開発途上国では人口圧が移動焼畑農耕を急増、拡大させ、土地保全を考慮した土地生産力の回復をはかりつつ焼畑を移動させてゆく伝統的な移動焼畑農耕を圧倒して、新興の無秩序で土地保全を無視した新しいタイプの移動焼畑農耕が卓越している。この新しいタイプの焼畑が森林消失の直接の原因なのである。

本報告ではアジア・太平洋地域における移動焼畑農耕の実態を考察し、森林資源保全の方途を検討する。

FOREWORD

In Asia-Pacific region (fifteen countries), deforestation rate from 1976 to 1980 was reported by Bostrom (1985) to be two million ha annually. August 1990, FAO of UN reported the rate during 1981 to 1990 as 4.7 million ha a year. Past ten years the deforestation speed of our region doubled than that of the previous time.

Impelled by both population pressure and shortage of food, people's demand for land use extends rapidly. This stress accelerates deforestation or degradation of forest in Asia-Pacific region and causes environmental problems of soil and water conservation.

Key words; Shifting Cultivation, Deforestation, Swidden, Conservation, Asia-Pacific Region

BACKGROUND

The increasing rate of deforestation in the Asia-Pacific region has been a mounting concern not only to the people in forestry sector and governments in the region who can foresee a growing shortage of woods and services that have been traditionally provided by the forest. There is also a worldwide concern that a further depletion of the forest cover in the tropics may adversely affect the environment far beyond their occurrence if not on global basis.

Reports from the countries in the region indicate that one of the major causes of deforestation is shifting cultivation in different forms (Scholz 1985, Sumitro 1985). Two examples will illustrate it. In Papua New Guinea, vast areas of forests (to the tune of 3.4 to 4.0 million hectares) have been converted into unproductive grassland of low economic value due to continuous practice of shifting cultivation. In Sarawak (Malaysia) provisional estimates indicate that the area of mature forest being destroyed annually is of the order of 30,000 ha. Based upon this figure, the net revenue loss to the economy of the state from shifting cultivation would amount to some M\$300 million per year. This includes the value of commercial timber destroyed, future employment opportunities lost and a deduction of M\$50 million which represents the revenue attributable to shifting cultivation (Hatch, 1980).

Shifting cultivation is, however, not an isolated phenomenon causing deforestation. It represents the whole way of life of the communities depending upon it. There is therefore a need to study all aspects — technical, socio-cultural, economic — in order to find alternatives which are compatible with the way of life and acceptable economy.

DEFINITION

Shifting cultivation is an ancient and a well known farming system in the tropics. The system varies in detail from place to place. Consequently, it has been variously defined and a number of terms have been used with emphasis on different aspects of the process. For example, Pelzer (1978) defined it as an agriculture system "which is characterized by a rotation of fields rather than of crops, by short period of cropping (one to three years) alternating with long fallow periods (up to twenty or more years but often as short as six to eight years) and by clearing by

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means of slash and burn". Waters (1971) further added to the above definition, "the almost exclusive use of human energy, employing machetes, digging sticks or hoe with the plough only rarely being used". Conklin (1961) described shifting cultivation as any agriculture system in which fields are cleared by firing and are cropped discontinuously. The FAO workshop at the Ibadan University (1982) tried to generalize the definition, according to which shifting cultivation is "a system in which relatively short periods of continuous cultivation are followed by relatively long periods of fallow". The question raised in the workshop was as to how long is a "relatively long period of fallow" and "at what point" a fallow becomes a short fallow.

Nye and Greenland (1960) and a majority of the authors used the term shifting cultivation as a general term including many varieties of natural fallow cultivation systems. Conklin (1957) favours the use of the term swidden farming. Spencer (1966) and the latest MAB/UNESCO (1985) publication on swidden cultivation in Asia list numerous terms related to shifting cultivation in different regions and languages particularly in South and Southeast Asia. In Melanesia, it is simply called "gardening" and the crop fields are called gardens. Since, to the knowledge of the author, a single term has not been recommended so far, the following terms which are commonly used in English speaking world will be used in the present work synonymously; "shifting cultivation", "shifting agriculture", "slash and burn agriculture", "swidden farming (or cultivation)", "traditional agriculture", "subsistence agriculture" and "gardening".

TYOLOGY

In view of the variability in the technique, it is not surprising to note that a number of workers have attempted to classify shifting cultivation differently depending upon the elements which they wish to emphasize. Some of the important ones are briefly described below.

Conklin (1957) differentiated swidden into integral and partial systems on the basis of:-

- (i) predominantly economic interest,
- (ii) more traditional, year-round, community wide, largely self contained, and ritually sanctioned way of life.

His sub-types were based on agronomic and cultural variables, such as:

- (i) principal crops

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- (ii) crop association
- (iii) crops/fallow time ratio
- (iv) dispersal of swiddeners
- (v) use of live stock
- (vi) use of principle tools and techniques
- (vii) treatment of soil
- (viii) vegetation type
- (ix) climatic conditions
- (x) edaphic factors

Brookfield and Hart (1971) classified traditional agriculture in Melanesia into low and high intensity systems with two sub-classes within each. The classification was based on 48 attributes, such as, basic subsistence foods, population density, environmental attributes (location, elevation, terrain, rainfall, soil biota), traditional crops (5 wild food sources and 5 cultivated crops), 14 different cultivation methods, three cultivated frequencies and five crop segregation patterns.

Ruthenberg (1971) divided shifting cultivation on the basis of six attributes:

- (1) Vegetation types
- (2) Migration
- (3) Rotation
- (4) Method of clearance
- (5) Types of crops
- (6) Types of tools

Waters (1971) differentiated two main categories, viz.; (1) traditional shifting cultivation, and (2) that imposed by necessity which approximately correspond to (1) normal and (2) accelerated systems in FAO (1974) classification. Greenland's (1974) main basis of classification was land cultivation:

Phase I *Simple shifting cultivation*: dwellings and cultivated areas shift together.

Phase II *Recurrent cultivation*: cultivated areas shift more frequently than dwellings, may be complex, several field types.

Phase III *Recurrent cultivation with continuously cultivated plots*: always complex, several field

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types.

Phase IV *Continuous cultivation*: may involve alternate husbandry with planted and cultivated pastures of fallow crops.

Phase II and III can be sub-divided according to the intensity of land-use, on the basis of Allen's (Allen 1965) land use factor, which is expressed as $L = \frac{C+F}{C}$

where L = land use factor

C = length of cropping period

F = length of fallow period

The FAO/SIDA (1974) symposium differentiated swidden farming into (1) continuous and (2) non-continuous cultivation, the first referring to where some form of continuous management is practised. The non-continuous were sub-divided into natural fallow, and if the homes of the cultivators are also moved, into shifting cultivation.

Anthony (1975) divided swiddeners into three categories mainly on the basis of historical backgrounds of the practitioners:

(1) *Pioneers*:

In North Thailand, some swiddeners cultivate opium poppy as a cash crop in addition to their subsistence hill paddy. They are relatively mobile, and at least under ideal conditions, clear substantial portions of climax forest each year, hence the designation "pioneer".

(2) *Established swiddener*:

These people clear relatively little or no climax vegetation. They live at lower elevation preferring to farm the gentle slopes and plateau land. Unlike the pioneers, these established swiddeners generally farm for long periods within one definite territory.

(3) *Incipient swiddeners*:

Those who have taken this form of agriculture more recently.

Kunstadter (1978) mainly based the classification on the relationship between cultivation and fallow period and differentiated swidden farming into four main classes:

(i) Short cultivation with short fallow.

(ii) Short cultivation with long fallow or forest fallow.

(iii) Long cultivation with very long fallow or abandonment of the site.

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- (iv) Permanent field tree crops with use of forest for swidden rice and fuel.

Macewan (1978) classified the subsistence agriculture system as practiced in Papua New Guinea into six main types (Table 1).

Table 1. Subsistence Agriculture Systems in PNG (Macewan, 1978)

System	Length of fallow (years)	R Value	Comments
Forest fallow	20	5	Woody vegetation, low intensity.
Bush fallow	10-20	5-10	Softwood, wetter lowlands, low intensity.
Grass fallow	5-20	10-20	Grasses, dry lowlands and highlands, moderate intensity.
Short fallow/permanent cultivation	5	20-90	Intensive cultivation, highland valleys.
Sago harvesting	Variable	Variable	Swampy lowlands, low intensity, silviculture practised.
Perennial cropping	0	90-100	Perennial banana, moderate intensity.

The classification by Macewan is based on the relationship between crop cultivation and fallowing within the total length of one cycle of land utilization. The symbol "R" represents the intensity of cropping and is defined as the number of years of cultivation multiplied by 100 and divided by the length of cycle of land utilization. With reduced fallow period, the cropping intensity or "R" value increases. For example, one year cropping with 19 year fallow will give a "R" value of $\frac{1 \times 100}{19+1} = 5$, whereas permanent cultivation would result it "R" value of 100 or more (Ruthenberg, 1975). According to him, the value of "R" should be below 33 for an area to be classified as shifting cultivation.

Mahapatra (1979) classified shifting cultivators on the basis of dependence on swidden:

- (1) Exclusive dependence:
- (2) Major dependence:
- (3) Contingent dependence:
- (4) Marginal dependence:

Each of these major types is further divided into (i) community-wise, and (ii) individual-wise.

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Grandstaff (1980) divided the swiddeners into partial or integrated swiddeners. According to him, hill tribes of northern Thailand belong to integral swiddeners because: (i) they have long history of swiddening; (ii) for the majority, swiddening is the main occupation and pre-occupation; (iii) in most villages, even those who own terraces still swidden regularly; and (iv) the attachment to and importance of swiddening is reflected in their beliefs, values, social organization, educational system, etc. However, by his own accounts, the classification did not fit properly even in northern Thailand.

ENVIRONMENTAL IMPACTS

It is interesting to note that most of the shifting cultivators are unaware of any damage to the environment due to swidden farming. In the absence of any other viable alternative in their ecological setting they regard swiddening as the appropriate mode of food production, though in the process they destroy the valuable timber species and their regeneration, cause soil erosion and depletion of soil fertility. However, they do not perceive this as destruction of the resources or degradation of the environment.

According to one estimate, in humid tropics, a population density of 22–50 persons/km² can be supported by swidden farming without significant adverse environmental affects. Wherever the equilibrium between swiddeners and the environment is disturbed, however, mainly due to population pressure, the usual response is to shorten the fallow and to increase the frequency and period of cultivation. The balanced alternation of crops and fallow period is thus disturbed.

The main environmental impacts are described below.

Changes in vegetation structure

The first and the most prominent change on the site when the new piece of land is converted into a field is the removal of existing (primary or secondary) vegetation which in most cases is only partial. According to Donis (1975) and Denevan (1975) shifting cultivation “favours light demanding species, among them several species of economic importance, it makes the structure of stand less complex, but many forests are changed adversely and transformed into degraded secondary scrub without any production potential and turns vast area into savannas where annual burning causes intense erosion”. When the fallow period is shortened, a stage is reached when woody plants are not able to get a foot-hold to form a close canopy and the grasses

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become established. Repeated burning further inhibits the growth of woody plants. The nucleus of a deforested area is formed which extends with time.

Floristic studies in primary and secondary forests and gardens in Papua New Guinea indicate that following garden abandonment, regeneration to a floristically mixed secondary forest was rapid due to favourable climatic conditions. However, with intensive use and short fallow there was a succession to a forest dominated by *Miscanthus* sp. and *Imperata cylindrica*. Burning of these degraded forests resulted in the rapid establishment of *Imperata* grasslands (Manner, 1976). A rough estimate in PNG is that about 3.5 to 4 million ha of forest have been converted into anthropogenic grasslands in the wake of bush fallow gardening (Srivastava, 1985). The areas of alang-alang (*Imperata*) dominated lands in Indonesia are estimated at 16 million ha with an annual increase of 150,000 ha (Soerjani, 1970). Some figures for destruction of forests have been given in the earlier section. Retrogression of forest to grassland results in decrease in the live biomass, as indicated below (Manner, 1976).

	<i>Metric tons/ha</i>
Primary forests	261
5 year old sec. forest	22
12 year old sec. forest	82.5
Year 1—Garden	7.5
Year 2—Garden	7.6
Year 3—Garden	15.3
Grasslands	5.4

Increase in soil erosion

Over vast areas, shifting cultivation is carried out on hill slopes. There is considerable controversy concerning the effects of shifting cultivation on soil erosion. While one school of thought maintains that shifting cultivation results in the continuous (but possibly slow) degradation of the soil through accelerated erosion, the other claims that shifting habit itself is an agronomic response designed to minimize soil erosion (Lal, 1973). Soil erosion trials in Sarawak on steep land (50 degrees slope) have shown that under traditionally practised shifting cultivation (i.e. with long bush/fallow periods), soil erosion is of little importance either in respect of continuous soil degradation or to shift the fields. These two closely linked factors are more correlated to low levels of nutrients and the problem of weed competition. However, in

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long settled and more densely populated areas, the problem of soil erosion under shifting cultivation has become quite serious. Both gully and sheet erosion have been observed in hill paddy areas where the fallow period is short or totally abandoned. On some very steeply dissected areas regularly used for hill paddy serious land slips and slumping have occurred (Hatch, 1981). In Bangladesh, it is estimated that 84 million tons of soil is lost annually resulting in serious decline of the potential productivity of land. The same is true in the highlands of PNG with high population densities (Bleeker 1983).

The unfavourable impacts of swidden cultivation have long been felt by lowland farmers in West Kalimantan (Gintings and Wiriadinata, 1973). Swidden on steep slopes in mountain regions result in the accumulation of acid silt and sand which made lowland rice fields infertile. In the 1930s, Chinese farmers in the villages of Lohabang and Pasai reacted strongly to swidders in the mountains. In central Kalimantan, Satjapradja (1972) reported that swidden cultivation (and even worse logging) caused siltation in rivers which flooded farmlands. Yield of rice was reduced. Heavy and rapid siltation in Lake Limboto and floods in North Sulawesi were reported by Gintings (1973) due to shifting cultivation in the catchment areas.

In 1952, the area of Lake Limboto was 5,000 ha with a maximum depth of 24m. The lake has now decreased to 3,500 ha with a depth of only 8m. The flooding in the area was so serious that the local government issued order in 1971 to move the farmers from the steep mountains down to the lowlands.

Changes in soil properties

The effects of shifting cultivation on soil properties are rather well established and have been reviewed by a number of authors (Nye and Greenland 1960, 1964; Sanches 1972; Greenland 1974). The conversion of forests to garden by shifting cultivation is, particularly in areas with high rainfall, accompanied by decreases in soil organic carbon, total nitrogen, cation exchange capacity, C:N ratio, and increases in bulk density, total base content and base saturation (Manner 1976; Wood 1979). Available phosphorus showed a marked decline with cultivation.

Bleeker (1982) reports soil analyses results taken from primary forest, gardens and grasslands both in wetter as well as drier places in the Highlands of PNG. In almost all characters examined, forest soils had higher content.

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Removal of rainforest vegetation followed by cultivation, thus, leads to decline in soil fertility. Tables in Anon (1978 74-75) clearly show these trends in chemical soil properties. Furthermore soil profiles in grassland are often truncated or have very shallow top soil or are waterlogged.

Wildlife

With removal of vegetation cover, changes in kind and number of wildlife can be expected. Where long fallow systems prevail, full recovery on disturbed sites is potentially rapid. However, regular hunting by shifting cultivators to supplement their diet, particularly in densely populated areas results in modification of wildlife. On the other hand where forest survives around swiddens, certain species are encouraged due to availability of crops which is tolerated by the shifting cultivators for hunting. With short fallow cropping systems were cropping is replaced by permanent pasture or savanna, the effect on wildlife is devastating (Anon, 1978).

Hydrology

Where vegetation removal for shifting cultivation is complete, particularly on steep slopes under high population pressure, hydrology is significantly modified. The run-off is more rapid resulting in shorter but higher and more destructive flood levels. Soils dry out more rapidly affecting vegetation and crops and lower water gables cause lower stream levels during the dry season (Hatch 1980, 1982; Anon, 1978).

Table 2. Comparative Streamflow and Sediment Yield from Burned and Unburned Grassland Watersheds

Watershed Treatment	Monthly Mean Sediment Yield
Burned	402.79 (kg/ha)
Unburned	278.18

Table 3. Hydrology of Different Landuse

Treatment	Surface Runoff	Sediment Yield
Overgrazed Pine	152.77 (mm/yr)	51.352 (ton/ha/yr)
Benguet Pine Plantation	50.69	11.342

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Climate

Data on the effect of shifting cultivation on climate is rare. Micro-climates are obviously changed. Haze from swidden fires may cover vast areas reducing solar radiation reaching the ground. Extensive clearing must affect evapotranspiration too (Anon, 1978).

ALTERNATIVES TO AND CONTROL OF SHIFTING CULTIVATION

Two facts of shifting cultivation have been well-established:

1. Shifting cultivation provides a bare minimum level of subsistence for the people who practise it though under certain socio-economic and climate-edaphic situations, this may be the only way of life.
2. With increase in population and reduction in fallow period in most of the areas in Asia-Pacific where the practice is still common, shifting cultivation has resulted in the spread of inert anthropogenic grasslands, destruction and degradation of invaluable forest resource and increase in soil erosion which in turn has adversely affected a number of hydrological processes.

In other words, swidden is a way of life which characterizes low quality of life with progressively degrading quality of the environment and destruction and deterioration of natural resources (forest, soil, water).

In spite of these facts, there is no evidence that shifting cultivation is reducing (in terms of area or number of people) and will just "go away" as general development takes place. Very conscious and determined efforts have been made to seek alternatives to the process with varying success. These alternatives can be broadly discussed under two heads: (1) Legislative and punitive approach, and (2) Improvement of shifting cultivation system with a view to ultimately convert swiddening into sedentary type of agriculture. The latter can further be divided into two heads, (1) *In situ* improvement of swidden farming, and (ii) Improvement through regrouping or resettlement of swiddeners.

Improvement of shifting cultivation systems

In-situ improvement

Considerable efforts have been directed to intensify and systematize shifting cultivation

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practices with a view to increase productivity and raise the level of living standard of the swiddeners on the one hand and minimize the ill-effects (malnutrition, destruction of natural regeneration, expansion of grassland, soil erosion, etc.) on the other.

Carefully managed crop fallow system

A classical example is the "corridor system" tried by the Belgians in the Congo. Under this system, the forest was divided into 100m strips, oriented east to west to maximize sunlight penetration. Every year alternate corridors were cleared, leaving forest fallow on either side of the cleared strips. The number of corridors in a management unit was the sum of the number of years in crops and the number of years in fallow. No such techniques have been tried in the Asia-Pacific region though even in Congo, the system fell into dis-use because it required overly sophisticated methods (Weinstock, 1984).

Introduction of new crop varieties

In traditional agroforestry systems, continuous attempts have been made to introduce new crop species and varieties, besides the main staple crop, which may be hill paddy as in Malaysia, Indonesia and Thailand, taro or sweet potato as in PNG. It has three objectives, viz.; (i) to supplement the yield; (ii) to add varieties to the diet; and (iii) to guard against the failure of the main crop through unfavourable climate, insect pest or diseases. In recent years, it has also resulted in earning some cash. The example of Wancho (in India) cultivating millet, maize, arum, tapioca, local oar, chilli, ginger and Thai swiddeners growing corn, millets peppers, opium, potatoes, yams, vegetables, etc. besides rice shows this trend.

In Papua New Guinea, according to Powell (1976), as many as 251 plant species (cultivated, semi-domesticated and wild) are used as food (Table 4). Besides, in almost all the countries, traditional communities depending upon shifting cultivation supplement their diet which is invariably carbohydrate rich with hunting and fishing. In some countries, (India, Malaysia, Thailand) attempts have been made to introduce horticulture extensively on the field normally marked for shifting cultivation. Under these schemes, pineapple, orange and banana are being successfully grown in many localities. Problems of transport and marketing have, however, appeared as the main hurdle in the growth of horticulture.

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Table 4. Numbers of plant species used for subsistence purposes (Papua New Guinea)

Use	Numbers
Foods	251
Stimulants, etc.	18
Medical-cuts	23
-burns	8
-sores	52
-pains, etc.	49
-foothache, etc.	22
-fevers, etc.	25
-coughs, etc.	38
-intestinal ailments	57
-childbirth and fertility	25
Magic	115
Weapons and tools	80
Canoes and rafts	39
House building, etc.	136
Ropes	40
Cords and textiles	46
Food preparation, utensils	90
Decoration	90
Art	60
Hunting and fishing	43

Source: Powell (1976)

Improvement of cultivation techniques

Over the period of time, by experience, a number of improvements in agronomic techniques have been carried out by the swiddeners themselves, such as:

- (i) Soil fertility maintenance through planting of fallows with nitrogen fixing plants such as *Casuarina*, *Leucaena* composting and crop rotation with winged bean. (Thiagalingam and Fahmy, 1981).
- (ii) Techniques of soil tillage, such as, mounds of Enga (PNG) which facilitate drainage.
- (iii) Soil erosion control through placement of logs, planting of cover crops and building

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furrows along the slopes.

- (iv) Deep hoeing of yams to get large tubers.
- (v) Building terraces.
- (vi) Use of mixed cropping and different cultivars within each species to suit varied tastes and requirements which at the same time offer broad protection against pests and diseases.
- (vii) Silviculture management of tree food crops such as, tulip and sago.
- (viii) Progressive harvesting of certain crops assuring continuous food supplies.

In recent years, government sponsored schemes have encouraged terrace cultivation (Hatch 1981) since the traditional shifting cultivation can no longer adequately fulfill its role of subsistence farming and is causing problems of an environmental and economic nature, the viability of using reverse-sloped (dry) bench terraces for growing hill paddy on a sustainable annual basis is being tested in Sarawak. If conversion to settled hill paddy farming on terraces can be effected, then large areas of land currently within the shifting cycle would be released for more appropriate agricultural crops or forestry.

In India, in some provinces, the Department of Conservation has stepped in to build terraces under the *Jhum* (swidden cultivation) control scheme. During the period 1974-76, altogether 52 hundred thousand (Borah and Goswami, 1977). In a study, it was revealed that the total cost of resettlement over the three-year period would be about Rs. 11,000. Terraced paddy was expected to yield a minimum of 1,500kg per ha against the maximum *Jhum* yield of 600 to 700kg (Gupta and Sambrani, 1978).

However, studies indicate that these efforts have not been very successful everywhere. The main reasons for the lack of response to the scheme were (Roy Burman and Sharma, 1970):

- (i) The nature of the terrain is not suitable for wet or terrace cultivation;
- (ii) Plots are small and scattered and there is a fear of damage from wild animals;
- (iii) Difficulty in making roads linking scattered and far off plots;
- (iv) Difficulty in constructing irrigation channels from deep rivers;
- (v) Lack of sufficient funds for irrigation.

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Introduction of cash crops

One of the most important alternatives to improve or replace cultivation with semi-permanent and sedentary cultivation has been the introduction of cash crops. Wherever these projects have been backed by governments with proper extension services, subsidies and other inputs, people have accepted it. In some countries, (e.g.. Malaysia), it has resulted in substantial increase of income of the swiddeners. Ecologically, it is the most suitable alternative to shifting cultivation. As is well known, in the tropical rainforests, the bulk of nutrients are locked in the standing crop with an almost closed nutrient cycling system. Soils are inherently low in nutrients. When the forest vegetation (primary or secondary) is cleared, large quantities of nutrients are removed and a major part of those retained by the soil is lost due to leaching under the impact of frequent and heavy rains. It has been argued that because of the above process, majority of soils in the tropics are not suitable for annual crops. On the other hand, with proper agronomic techniques which have already been worked out for a number of species, the perennial crops are able to restore the fertility and nutrient cycling system. In fact, according to some experts (FAO 1982), permanent tree crops seem to provide the most satisfactory solution.

Some of the important tree cash crops which have been introduced in shifting cultivation systems are pepper (Indonesia, Sarawak), rubber (Malaysia, Indonesia), oil palm (Malaysia, Indonesia) cocoa and coconut (Malaysia, Indonesia, Philippines, PNG). In some cases, however, it has been claimed (Padoch, 1980) that crops like black pepper which demand more intensive clean weeding combined with its planting on steep, inadequately terraced slopes, have caused extreme soil erosion and gullying. The sheet erosion observed is far more severe than that produced by traditional shifting cultivation. Besides, the production of these crops depends on high inputs of pesticides and fertilizers through subsidies (sometimes imported) and higher labour input for hoeing, weeding and fertilizer application etc. Most of these crops have developed as small holdings and are strongly backed by marketing system.

An interesting example of change in land-use pattern brought about by the introduction of cash crops is in Papua New Guinea where majority of the people follow shifting cultivation. Most of the food gardens in Enga, Milne Bay, Madang and Morobe Provinces were converted into coffee plantations. The same was true for cocoa in Milne Bay and East Sepik Provinces. In the case of pure coconut or mixed coconut and cocoa plantations, the trend was the same—food gardens and big bush (areas with 20-year fallow) were preferred (Srivastava, 1985).

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Thus, over the years, due to general improvement in living standards and increase in communication facilities and urbanization (such as Malaysia, Papua New Guinea) gardening practices have undergone a change from subsistence to cash/subsistence and to cash cropping resulting in reduction of crop diversity. In the long term these changes may have further social implications in terms of nutrition, health and proper use of additional income.

Forestry oriented programmes

The most obvious impact of shifting cultivation in majority of the countries has been deforestation and deterioration of forest crop quality. It is not surprising therefore that the foresters in every country have been most vocal in their criticism of swidden farming and have tried to control and even completely ban these practices by legislative and punitive measures. Lately, as mentioned earlier, instead of imposing a blanket ban, the Forest Departments have come up with many projects which seek active support of swiddeners in growing trees along with food and/or cash crops. Examples of this approach are taungya plantations in India, Burma, Sri Lanka, Thailand, Commercial Tree Farming projects in the Philippines and other agroforestry systems developed in the last one or two decades in many countries (Indonesia, Thailand, Papua New Guinea).

In the taungya system which was started about 100 years back in Burma, the cultivators are permitted to clear and burn the compartment (forest plot) and then plant rows of commercially valuable trees under the supervision of the forest officers. The line to line spacing is such that the farmer uses spaces between the rows to cultivate food crops. Within a span of three or four years, the new forest plantation gets established and the cultivator is asked to move to another compartment and repeat the process there. The system has been very successful in some areas in India and large scale plantations of high value timber species have been established. A number of projects of this nature have been promoted in South and Southeast Asia countries mainly with a view to settle the swiddeners (MAB/UNESCO, 1985).

In author's opinion, the most important drawback of the agroforestry approach, particularly when a cash crop (such as cocoa or oil palm) is combined with forest trees (such as *Eucalyptus deglupta* in PNG), has been that less and less importance is given to the forest crop and ultimately only the cash crop remains on the ground. However, it appears that the approach appeals to the landowners who have shown greater involvement in such projects.

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A noble and successful agroforestry system has been developed by traditional agriculturists of PNG in the Highlands (between 1,400 to 2,000m). Sweet potato is the staple food of both the people and their most important animal, pigs. Numerous other species are grown as food crops, often in mixed vegetable garden which are gradually converted into the recently developed food crop-coffee-casuarina system and ultimately into coffee/casuarina stands. *Casuarina oligodon* is a fast growing species that provides shade and timber for fencing, house construction and firewood. Its timber is easy to split and burns well. It helps, being a nitrogen fixer, to restore soil fertility. The system provides food, cash from coffee and some marketed food, and timber for construction and fuel. According to Bourke (1985), returns on labour inputs would compare very favourable with alternate systems. Because the canopy is maintained continuously by a sequence of faster and slower growing species, the requirements for weeding are minimized. Other agroforestry systems are gaining the favour of shifting cultivators in almost all the countries in the region and notable success has been attained in the Philippines and in Indonesia (Soedarwono, 1978; MAB/UNESCO 1985). Another agroforestry system has been described by Weinstock (1984) in Indonesia where the communities exploit rattan to supplement their income.

In some countries, cattle have been introduced into agroforestry systems (Davidson, 1982) to supplement beef production with varying success. Majority have failed because (i) motivation was not being sustained by local people; (ii) cattle was not part of their culture; (iii) failure of government officers to maintain interest; (iv) marketing/transport problems; (v) maintenance problems (fencing etc.); and (vi) poor business sense of landowners (Srivastava, 1985).

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