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SHIFTING CULTIVATION IN SARAWAK - A REVIEW

by

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SHIFTING CULTIVATION IN SARAWAK

Preface

In the latter half of 1978 a Workshop was held in Kuching to discuss the many problems associated with the widespread practice of shifting cultivation in Sarawak. It had become apparent that the problem of shifting cultivation was becoming very acute in Sarawak and concern was felt at the lack of any concerted attempts to remedy the situation. In particular, it appeared that there might be high prevalences of malnutrition amongst the shifting cultivators and that their activities were seriously threatening the forest resource, one of Sarawak's principal export earners.

Since it was felt that Government Departments and Agencies acting in isolation could not adequately tackle the problem of shifting cultivation, it was seen as essential that an open and frank discussion be held on the subject so that the true scope of the problem could be defined and solutions of both long and short-term nature discussed.

The Workshop was attended by the State Planning Unit, Department of Agriculture, Department of Forestry, Department of Medical and Health Services, Sarawak Land Consolidation and Rehabilitation Authority (SALCRA), Department of Land and Survey and the Museum Department.

The conclusions of the Workshop were presented in a Report entitled "Shifting Cultivation in Sarawak".

Since that time (1978), however, it has become clear that not only does the Report need updating but it could be very usefully expanded to include much more detail about the practice of shifting cultivation, its extent, trends etc. In this way it is hoped to present a far more comprehensive account of shifting cultivation and most importantly draw together much of the very valuable information and research results that currently are dispersed amongst many different Departments and individuals.

In taking a more detailed look at shifting cultivation in Sarawak it has become very apparent that different groups, individuals and vested interests view the practice in a widely divergent manner. Unfortunately many of the popular opinions held about the practice are completely incorrect and it is hoped that this publication will at least lay to rest some of the more common misconceptions.

Whilst this report will attempt to view the practice in as sensitive a manner as possible, it will not attempt to draw any detailed conclusions about future action. Rather it attempts to bring together as much of the relevant material as possible so that those who must make the decisions can do so in the light of more up-to-date information.

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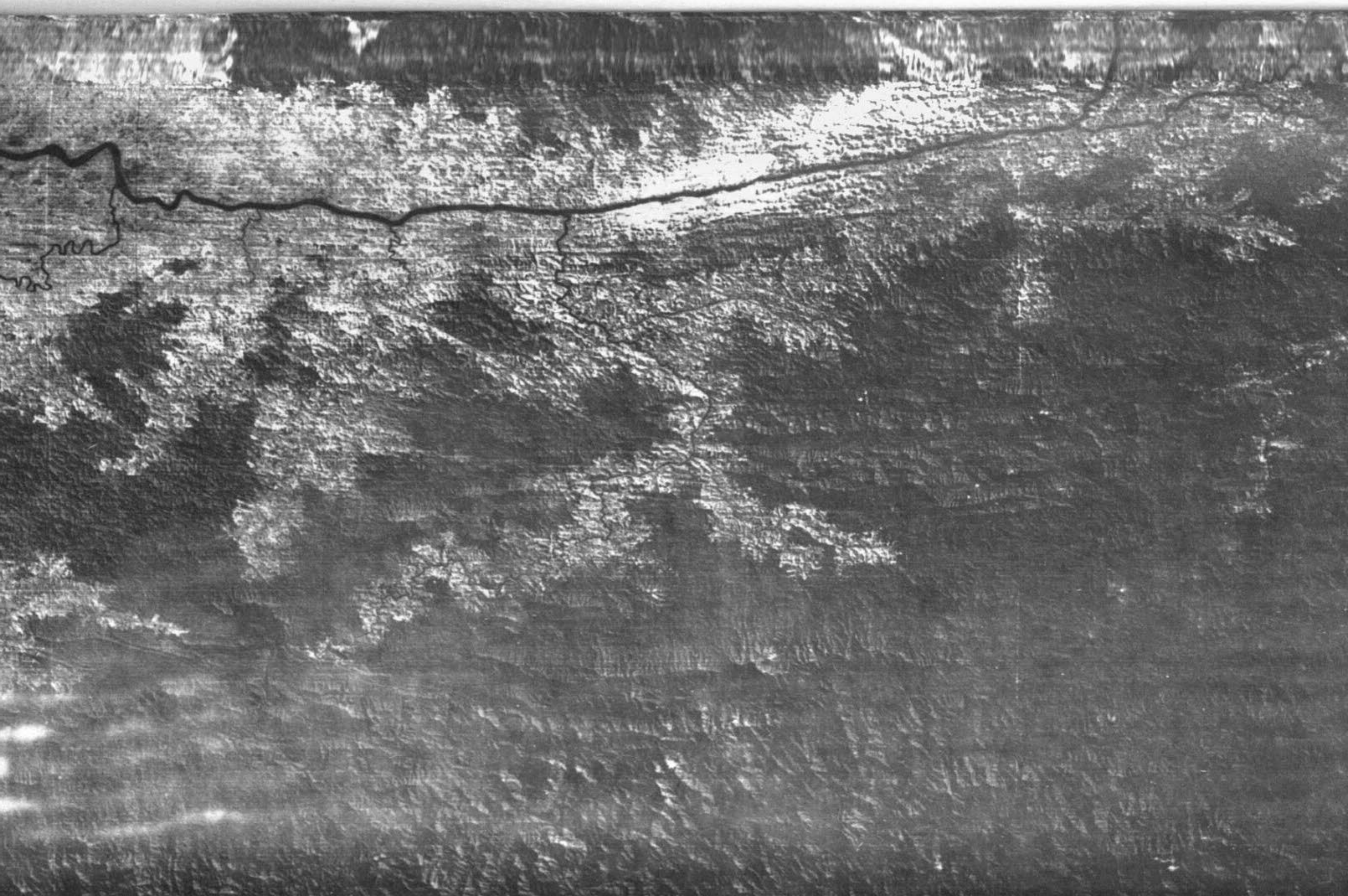

Area under Shifting Cultivation in the Mid-Rajang Valley,
(from Landsat Imagery)

Worldwide and Southeast Asia

Shifting cultivation is practised in Africa, South America, Oceania and Southeast Asia by people of widely varying origins and cultures and on a wide variety of soils with many different types of vegetation (Hauck, 1974). At present about 36 million square kilometres of land or 30% of the world's exploitable soils are under some form of shifting cultivation and they provide the bulk of the food for 250 million people or 8% of the world's population.

In Southeast Asia the most recent estimate for the region as a whole was carried out by Spencer (1966), and Table 1 gives details of the area included in his survey. Spencer (1966) points out that these represent only an arbitrary estimate and have been gathered from a wide number of sources.

The annual area cropped may be about 168,350 square kilometres but the area required to support this activity is six times more at 1,068,779 square kilometres. Spencer (1966) estimates that of the approximately 925 million people living in the Southeast Asia region, 50 million (6-7%) live by shifting cultivation and 675 million (72%) by permanent agriculture on settled farms. The balance of 200 million is made up of urban populations fed by the permanent farmers and where necessary, imports. The 675 million permanent farmers have at their disposal 225-235 million hectares of land which is generally of the highest quality available. The 50 million shifting cultivators, however, have a total land resource of about 100-110 million hectares, most of which is extremely marginal in potential and often located in very remote and hilly areas.

Other estimates within the region have been reported from time to time. At a conference held in 1979 (ASEAN, 1979) 'Country Statements' given by various delegates placed the number of shifting cultivàtor households in Indonesia and the Philippines at 1 million each. These both would appear to be something of an underestimate. For Thailand it was reported that of the total land area of 519,953 km^2, the area forested in 1961, 273,629 km^2 had been reduced by 26% to 200,749 km^2 (in the space of only 10 years) by 1972.

Whilst it is a very widespread system in Southeast Asia, it dominates only in Borneo and the hills of Thailand, Burma, Laos, Vietnam, Kampuchea and Southern China.

The regional imbalance in land distribution between

TABLE 1

FAMILIES AND LAND AREAS UTILIZED IN SHIFTING CULTIVATION (IN THOUSANDS/HA)

Area	Number of families	Land cleared annually	Land still harvesting	Fallow land	Total
Pakistan	750	1,052	202	6,839	8,093
India	3,100	4,856	809	16,592	22,257
Nepal/Bhutan	200	304	40	1,679	2,023
Ceylon	40	40	10	192	242
Burma	700	1,153	304	7,466	8,923
Thailand	400	405	81	3,561	4,047
Loas	350	263	40	2,934	3,237
Cambodia	2	4	1	15	20
South Vietnam	35	34	8	221	263
North Vietnam	50	40	12	271	323
China	1,200	1,821	202	8,094	10,117
Formosa	85	121	20	668	809
Philippines	400	728	202	3,925	4,855
Indonesia	3,800	5,261	1,619	27,518	34,398
British Borneo	175	304	243	1,679	2,226
New Guinea	500	647	405	4,006	5,058
TOTAL:	11,787	17,033	4,198	85,660	106,891

Source: Spencer (1966).

the shifting cultivator and the permanent agriculturalist is seen by Spencer (1966) as posing real problems for the area and he makes the following very relevant and cogent statement about the situation:-

> "There is a real rationale behind the urge to replace shifting cultivation with a system of land use which will prove more productive of human support, square mile for square mile; this would ease the burden upon the too densely settled lands that can no longer support their dependants. But a campaign that merely aims at producing growth, can be only a short term palliative, postponing for perhaps a century the problem of over population in all parts of the Orient. The Orient is filling up, and the shifting cultivation lands provide, in themselves no permanent solution. An effort to prohibit the practice of shifting cultivation among those now carrying on this system, concurrently and effectively teaching them some other means of livelihood, will create a large population element of cultural misfits. To force shifting cultivators to become permanent farmers, as has been done in the past, without teaching them all the practices of permanent farming and sedentary social and economic living, can result only in the ruination of large areas of crop land, and in depressing the level of living of still more millions of people."

Definition and Classification

There is a great deal of controversy over what is an adequate definition for shifting cultivation and whether the phrase "shifting cultivation" should be used to describe the farming practice itself. Other methods of description such as 'swidden', 'ladang', 'milpa', 'chitemene', 'caingin' and many others have been used by various authors and in connection with the system in different geographical locations. 'Shifting cultivation', however, will be adhered to throughout this Technical Paper, not only because it has always been used in Sarawak but also because it seems such an appropriate and descriptive title for the system as a whole.

A universally acceptable definition of the system has also proved most elusive and at times it seems that some authors have spent a disproportionate amount of time arguing over the niceties of definitions rather than addressing themselves to the problems and challenges that the system presents. One of the briefest definitions was proposed by Conklin (1957):

> "any agricultural system in which fields are cleared by firing and are cropped discontinuously"

However, the best and most descriptive is that given by Watters (1971) but which is at least probably partly attributable to Pelzer (1958).

> "One of the great systems of agriculture in the world, shifting cultivation can perhaps best be defined as a form of agriculture marked by the rotation of fields rather than crops, by short periods of cropping (one to three years) alternating with generally longer periods of fallow (up to twenty years but often only four to eight) and characterised by clearing by slash-and-burn and the almost exclusive use of human energy, employing the machete, digging stick or hoe, with the plough only rarely being used".

Many authors, but particularly Conklin (1957), Watters (1971), Pelzer (1958) and Spencer (1966) have attempted classifications of shifting cultivation which can accomodate most known systems and embrace all the myriad of variations, many of them very minor, which are to be found within the total practice of shifting cultivation. Conklin (1957) distinguishes between two major types of shifting cultivation:-

A. **Partial systems**

i) Supplementary swidden farming - where a permanent field cultivator devotes part of his time to the cultivation of a swidden.

ii) Incipient swidden farming - where a cultivator, usually from a crowded permanent-field agricultural region moves to an upland area and devotes all his efforts to the swidden in or near where he makes his home (i.e. homesteader, squatter or resettler).

B. **Integral system**

i) Pioneer swidden farming - where significant portions of climax vegetation are cleared each year.

ii) Established swidden farming - where tree crops are plentiful and relatively little or no climax vegetation is cleared annually.

Watters (1971) also identified two major types which he called:

1) Traditional Shifting Cultivation, and,

2) Shifting Cultivation Imposed by Necessity.

He describes the former type in the following terms:-

> "a community whose members are linked by habit and custom dating from time immemorial. These tribes have always practised shifting cultivation, using methods and techniques peculiar to them and inextricably woven into the very fabric of their family and tribal institutions, frequently also into their beliefs and religious practices".

This type of shifting cultivator is generally regarded as being in tune and equilibrium with nature from which he often takes signs as to when he can return to an area and take another crop. He almost always interplants his staple crop with a large variety of other crops. Since the habits and systems employed by this type of cultivator have been developed over perhaps thousands of years, it is often found to be a remarkably sophisticated agronomic system and is far more efficient than superficial appearances would suggest. However, it is as we shall see in due course, a system that is very vulnerable to external and hitherto unknown pressures such as competition for land resources (timber, estate agriculture, mining etc) and the insidious internal pressure of population increase. In its traditional form it appears to be a very fragile system and one where the equilibrium and balance can be relatively easily disrupted. It is worth noting at this point that virtually all of the shifting cultivators of Sarawak fall within this 'integral' group.

Fortunately, shifting cultivation imposed by necessity has so far not become a feature of Sarawak agriculture. Land hunger is frequently the catalyst for this type of shifting cultivation and one of its most disturbing side effects is the long term damage that can result to the land. It is often undertaken by people who are inexperienced in farming and who do not realise the potentials and limitations of the soils upon which they impose their farming systems. They will commence operations in a similar way to the traditional shifting cultivator and slash-and-burn an area of primary or well grown secondary jungle. Thereafter, however, their activities diverge very markedly from those shifting cultivators who have reached some sort of equilibrium with their environment. Very often they will cultivate their plots continuously until after a few years the influences of low soil fertility and increased erosion depress yields so drastically that the land must be abandoned and new areas sought. Furthermore, this type of farming (if indeed it can be called farming) can degrade land so seriously that it will never be able to regenerate to its former vegetational climax. Low quality grassland dominated by fire-loving species such as Imperata <u>cylindrica</u> is very often the end result of this process.

These then are the two broad categories of shifting cultivation but such apparent simplicity hides a whole mass of variations and gradations between the two types.

Shifting Cultivation: Thailand

In order to describe the shifting cultivation system in Southeast Asia as it pertains to the above two broad categories and to give some comparison for when the shifting cultivators of Sarawak are considered, I have here set down some detail on the shifting cultivation activities of two groups in Thailand, the Karen and the Hmong opium farmers. The Karen exemplify (along with the shifting cultivators of Sarawak) the traditional type of shifting cultivation which has been established for generations whilst the Hmong opium farmers conduct shifting cultivation of the very exploitive and damaging kind which frequently results in the long term degradation of land resources.

The Karen Farmers

It has been estimated by United Nations Survey (1967) that there are about 100,000 Karen (and Lua) farmers in the very hilly areas of Thailand conducting a traditional type of shifting cultivation in which one year of cropping with rice is followed by a long fallow period varying from 6-18 years. Very comprehensive accounts of Karen farming are to be found in Kunstader, Chapman and Sabhasri (1978) and in two excellent and detailed papers by Nakano (1978 & 1980).

The Lua and Karen hill farmers have always been conservative farmers and have made every attempt to act in concert with their environment. The technology that they use for their shifting cultivation of hill rice is almost identical to that of the Sarawak shifting cultivators but it appears that their 'approach' to shifting cultivation may be even more sophisticated and balanced.

Great care is taken over the selection of the sites for slashing and burning and the soil must not be 'tasteless' or infertile. Clearing of the fields commences in January with only large trees being left standing. In order to minimise erosion care is generally taken to avoid clearing ridge tops and along the banks of watercourses.

After a drying period of about six weeks and before heavy rains occur, the brush is burned and here again care is taken to construct fire breaks and prevent fire escapes.

After the burn, long poles are placed along the contour to reduce the effects of sheet erosion and assist in the formation of mini-terraces from the ash. Other wood and debris remaining is either burned in situ or chopped up and taken back to the village for firewood.

Unless the field is located very close to the village, a small hut will be built for protection from the elements and for overnight stops when harvest time approaches and the padi must be guarded from pests and predators.

Planting of the padi usually takes place in April before the main rains begin and too much of the ash and topsoil has been removed by erosion. Planting is effected using an iron pointed dibbling stick to make holes into which groups of women and children throw a few seeds.

In common with many other shifting cultivators, several different varieties of rice are normally planted in order to meet different needs, glutinous, non-glutinous, fast, medium and slow maturing varieties. A large number of other annual and some perennial crops are also planted at various times within the field (or next to it) and these may include Sorghum (Sorghum vulgare), Chili pepper (Capsicum frutescens), Beans and Soya beans (Dolichos lablab, Dolichos sp., Phaseolus sp., Psophocarpus tetragonolobus, Glycine max), Mustard Greens (Brassica sp.) Root and Tuber crops (Colocasia antiquorum) Sweet Potatoes (Ipomea batatas), Yams (Dioscorea alata) Manioc (Manihot esculenta), Tobacco (Nicotiana tabacum), Squashes, Melons, Cucumbers, Gourds (Luffa acutangula, Lagenaria leucantha, Cucurbita pepo, Trichosanthes sp.) Garlic and Onions (Allium sativum, A. porrum) Coriander (Foeniculum vulgare) Lemon Grass (Cymbopogon citratus) Mint (Mentha arvensis), Job's Tears (Coix lachryma - jobi) Millet (Setaria ilalica) and Sesame (Sesamum indicum).

Weeding is the task that is undoubtedly the most onerous for shifting cultivators and yet it is considered by most researchers to be absolutely essential to maintaining or increasing yields. The Lua and Karen farmers of Thailand consider that three complete weedings are the minimum necessary to secure a reasonable yield from their fields. Kunstader (1978) reports that all farmers were aware of the importance of weeding and describes an interesting case where an outbreak of measles in Pa Pae village prevented any weeding being done and the resultant harvest was the worst that anyone could remember.

Nakano (1978) states that Karen hill farmers are seldom short of food because they are not totally dependant on shifting cultivation for their food supply. Most of them also have irrigated rice terraces from which they produce substantial quantities of rice. At the village surveyed by Nakano (Mae Tho Yang), the 1973 yield was estimated at 66 metric tons from the shifting cultivation areas and 48 metric tons or 42% of the total from irrigated wet padi areas. However, the majority of the work in preparing and planting the irrigated fields occurs during the weeding season for the shifting cultivation areas and so weeding provides an additional constraint on food production.

Harvest starts in late September or early October when the monsoon rains are beginning to lessen in intensity. All of the padi is harvested by hand using a short sickle-shaped cutting knife. Next year's seed is normally taken from a part of the field where the crop looks particularly healthy and this is usually harvested last to ensure that the grain is fully mature.

After the harvest the shifting cultivation fields are abandoned to forest fallow but they continue to be visited for the gathering of firewood, wild products that appear during regrowth and any products which were deliberately planted by the farmers. The use of the term 'abandon' is, as Spencer (1966) has pointed out, rather inaccurate when talking about traditional shifting cultivation. In fact the fields are not abandoned at all but merely 'temporarily fallowed' as part of a definite and tried and tested system of land use.

The yields of rice from the shifting cultivation fields in villages in Thailand have been estimated by both Kunstader (1978) and Nakano (1980) and have been reported to be 1,000 kg/ha and 1,160 kg/ha respectively. Kunstader (1978) reports that not surprisingly the range of yield can be enormous and of the 34 Karen fields he measured in 1967 the range of yield was from 76 to 5,456 kg/ha. Great variability in yield is most definitely an important feature of shifting cultivation and is also one of the reasons why research results from the system can be so confusing. However, it must be remembered that yield variability may become even greater and therefore more damaging if insensitive and ill-informed attempts are made to change or 'improve' the system.

The estimates given for land use per worker by Kunstader (1978) and Nakano (1980) also agree very closely and could quite confidently be taken as 0.7 ha (1.72 acres) of swidden per worker. Kunstader (1978) further estimates that if one assumes that the shifting cycle is 10 years (9 yrs fallow, 1 yr crop) and the population and proportion of land use between swidden and irrigated rice remains constant, then the average annual land use including the 10-year fallow cycle will be 13.99 ha (34.57 acres) per family for the Lua and 16.08 ha (39.73 acres) per family for the Karen.

In his study of the Karen from Mae Tho Yang Village in early 1973, Nakano (1978) produced some interesting data on rice requirements and on the labour inputs to shifting cultivation. He estimated the total labour requirement as 1,009 man-hours per hectare per year made up as shown in Table 2.

Once again it is quite clear from these data that weeding is by far the most labour-demanding job in shifting cultivation and in this case takes up 55% of the total labour input. It would appear that attempts at increasing

TABLE 2

LABOUR REQUIREMENT FOR SHIFTING CULTIVATION AT MAE THO YANG VILLAGE

Activity	Man-hours	%
Slashing, felling, burning	56	5.5
Sowing	45	4.4
First weeding	137	13.5
Second weeding	417	41.3
Harvesting	354	35.0
TOTAL:	1,009	100.0

Source: Nakano (1978).

the efficiency of the system of shifting cultivation will have to place great emphasis on this problem of weed growth and the labour demands that are made for control. As previously mentioned, a further problem with weeding is the fact that, for the Karen and Lua at least, the peak labour demand for this activity occurs at a time when they desperately require labour for preparing their irrigated fields.

Nakano (1980) also reviewed the labour requirement data from other parts of Southeast Asia. The results given by Walker (1976) agree fairly closely with those of Nakano himself and give the labour input at 178 man-days per hectare (Nakano's 1009 man-hours is equivalent to 168 man-days). Conklin's (1957) work with the Hanunoo in Mindoro, Philippines suggested much higher labour inputs than either Nakano's or Walker's estimates. Freeman's (1970) estimate for the Iban of Sarawak at 125-165 man-days per hectare is very similar to that of the Lua and Karen shifting cultivators of Thailand.

Nakano (1980) used expenditure of work energy to calulate his figures for rice requirements and he concluded that a male adult, on average, requires 0.85 kg of husked rice daily (equivalent to 1.15 kg unhusked rice). From this he concluded that the average per capita consumption at his survey village was 300 kg (661 lbs) of husked rice per annum.

The Hmong Farmers of Thailand

The shifting cultivation activities of these farmers are very well described by Keen (1978) and as he notes,

> "The Hmong of western Tak are rapidly destroying the forest on which their economy depends and are compelled to move their villages every few years. They could certainly not be described as being in harmony with their environment."

These people grow hill rice, maize and opium poppies in swiddens and they invariably clear primary forest for their fields. But since they will often cultivate these swiddens for several years and deliberately attempt to encourage the formation and perpetuation of Imperata grassland by setting frequent fires, there are very few opportunities for the forest to re-establish itself. Keen (1978) reports that whilst the Hmong (in his survey area) cultivated the rice and maize swiddens for only two and three years respectively, some villages claimed to have cultivated the same poppy field continuously for fifteen years! Whilst the rice and maize fields might be expected to regenerate fairly quickly to some form of secondary jungle, it is hard to see how the poppy (opium) swiddens will recover for may be hundreds of years to come. Also the establishment of Imperata grassland tends to perpetuate the situation and establishes a new ecological equilibrium through the influence of annual fires.

Not only is the Hmong system of shifting cultivation very destructive to the virgin forest and its secondary successions, but it is also symptomatic of a total life style and economic organisation that is exploitive in concept and therefore in the long run only temporary. As Keen (1978) puts it,

> "their economic organisation is not comprised of mutually supporting sectors making a balanced whole and capable of expansion according to need".

This then has been a very brief and in places simplistic description of two types of shifting cultivation in Thailand that highlight the two broad categories of shifting cultivation - the traditional, well-balanced system that is largely in equilibrium with the environment and the more exploitive and destructive system that is far too frequently taken to exemplify all types of shifting cultivation. This has in many quarters given rise to the common misconception that all shifting cultivators are undesirable creatures who destroy the environment which supports them and who 'use up' the capital of the land and the vegetation that it supports.

In addition, the above description somewhat conceals the enormous range of types of shifting cultivation and the many gradations of practice that exist even within the same cultural groups and in very similar ecological zones.

Tropical Forest

In many descriptions of shifting cultivation it is not unusual for the climax vegetation within which the system is practised to be ignored, i.e. the tropical forest itself. Therefore we will now turn our attention to a consideration of the tropical forest and those features and interactions which bear particularly upon shifting cultivation and its future.

A good deal of research has been done on tropical forests and several excellent books have been produced. One such is that by Longman and Jenik (1974) and the following section draws heavily upon their very concise and clear descriptions.

Many scientists and concerned individuals have over several years expressed serious concern over the progressive destruction of tropical forests and this has obvious repercussions for the shifting cultivator. A statement by Myers (1981) serves to exemplify the depth and strength of feeling that exists concerning the exploitation and destruction of tropical forests,

> "The scenario (the progressive destruction of tropical forests) will represent a biological debacle to surpass virtually any other that has occurred since life's first emergence on the planet some 3.6 thousand million years ago. Not only will it mean the end of the greatest concentration of species on Earth, and of the most integrally diverse ecosystems on Earth, but also a basic shift in our planet's most dynamic evolutionary process. On a planetary time scale, it will all happen in a twinkling of a geologic eye".

Whilst making this very emotive statement Myers (1981) also acknowledges the fact that for many years the traditional and integral shifting cultivator did not seriously threaten this pool of diversity. He is concerned now about the recent increases in the partial types of shifting cultivation and the trends that are becoming evident amongst the traditional type because of pressures of population and land which they have not previously experienced.

Tropical forests have always appeared to the ill-informed as having an enormous potential for agricultural development. Whilst many tropical forests are very rich and productive, the sad fact is that many agriculturalists and particularly those from temperate areas have often used totally inappropriate techniques to exploit forested areas in the tropics and sub-tropics.

On a world basis the biomass of tropical forest represents one half of all living matter. Furthermore it can produce from 10-50 tons of dry matter per hectare per year and this is more than nearly any other source. Table 3 gives details of this.

Tropical forest is a quite outstanding example of a complex ecosystem and nowhere in the world is the diversity and the interdependence of plants and animals more obvious. What Myers (1981) calls the TMFs or Tropical Moist Forests contain 40-50% of the planetary spectrum of 5-10 million species and yet we are still more ignorant about the TMF ecological zone than any other. Myers (1981) estimates that still only about one sixth of its species have been identified and most of these in only preliminary terms. The flora of tropical forests is so rich probably because it has had time for complete specialisation and has not undergone the climatic changes of temperate areas. Tropical forests create many ecological niches for new species to fill. In Southeast Asia for example, it is usual to find more than 100 species of trees per hectare and the number of woody species may be as high as 400 per hectare. With the widespread incidence of selective logging, however, the occurrence of the so called 'depleted forest' is becoming very widespread.

Tropical climate has been classified into five separate types: rainy, monsoon, wet-and-dry, tropical semi-arid and arid. Tropical forests occur in the first two types but the true ombrophilous forest occurs only in the first type where the rain is more or less evenly distributed over the whole year.

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TABLE 3

NET PRIMARY PRODUCTION AND BIOMASS ESTIMATED FOR DIFFERENT TYPES OF VEGETATION

		Net Primary Production		Biomass	
	Area (10 ha)	Per unit area (dry tonnes/ ha/yr)	On a world basis (10 dry tonnes/ yr)	Per unit area (dry tonnes/ ha)	On a world basis (10 dry tonnes)
Tropical forest	20	20(10-50)	40.0	450(60- 800)	900
Savanna	15	7(2-20)	10.5	40(2- 150)	60
Temperate forest	18	13(6-30)	23.4	300(60-2000)	540
Boreal coniferous forest	12	8(4-20)	9.6	200(60- 400)	140
Tundra and alpine grassland	8	1.4(0.1-4)	1.1	6(1- 30)	5
Steppe and temperate grassland	9	5(1.5-15)	4.5	15(2- 50)	14
Agricultural land	14	6.5(1-40)	9.1	10(4- 120)	13

Source: Whitaker's Almanack (1970).

Generally speaking, the soils under tropical moist forest are very poor in nutrients and this approaches the extreme in the tropical podzols which support only a very specialised type of forest (called Kerangas in Sarawak). The prevailing soils are ferralitic, sometimes called latosols or laterites but now more properly referred to as Ultisols and Oxisols. These represent the soil climax of the humid tropics under freely drained conditions. They have deeply weathered profiles where the feldspathic materials are decomposed slowly but completely leaving behind simple clay minerals such as kaolinite. There are very few undecomposed minerals rich in nutrients left within reach of plant roots. Cation exchange capacity is very low except in the thin humus layer at the surface. The C/N ratio is often high (over 10) and in high rainfall regions, the pH can become as low as 4.

Nye and Greenland (1960) in their classic publication "The Soil Under Shifting Cultivation" show that the amounts of all exchangeable nutrients except phosphorus is considerably greater in the mature fallow vegetation (or virgin forest) then it is in the top 30cm of soil. This is in definite contrast to the situation in temperate areas where the soil plays a far more fundamental role in storage of nutrients. This is diagrammatically shown in Figure 1.

The nutrient relationships within a tropical forest, the movements between soil and vegetation and the changes that occur during shifting cultivation phases are extremely complex and will be considered in detail later on. However, suffice it to say that in a virgin tropical forest the equilibrium attained ensures the minimum nutrient losses from the overall system. Nutrients lost from plant residues etc are quickly trapped and re-incorporated into the biomass. The soil tends to be only an almost passive spectator in the process, acting mainly to transmit the nutrients back to the plants. In order to ensure that as few nutrients as possible leach out of the system through the soils, the plants of tropical forest develop a vast web of feeding roots which are confined principally to the upper 5 cm of topsoil. These trap the nutrients before they can leach to deeper and inaccessible levels. However, it is incorrect to assume that trees in tropical forests are only shallow rooted and in fact tap roots and sinkers may go down to as deep as 2 or 3 metres. This may be important for the so-called 'nutrient pump' action of forest fallows.

It is clear from the above that tropical moist forest is a biome (ecological zone) of unparalleled richness and productivity but unfortunately these attributes cannot

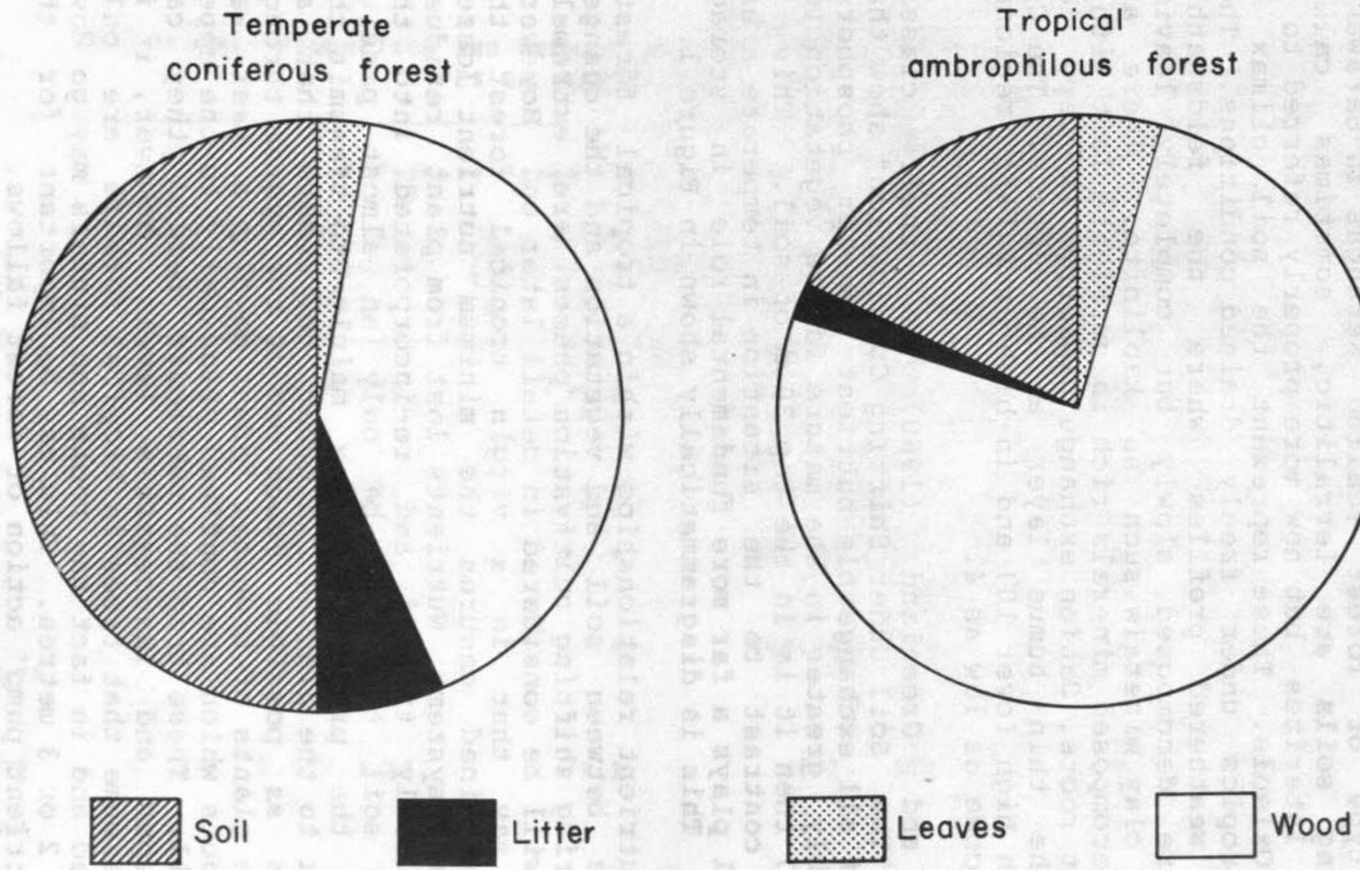

FIG. 1 NUTRIENT STORAGE IN TEMPERATE AND TROPICAL FOREST

be transferred to agricultural methods as we know them. To agriculturally exploit the forest means that in some way the first step must be to destroy it either temporarily (as in traditional shifting cultivation) or permanently (as in more intensive, permanent types of agriculture). The production of a carbohydrate (or protein) supply from a tropical forest is nearly always preceded by the cutting and burning of that forest. Therefore, the very system that can be so productive is being destroyed by agriculture because we do not have the systems or know-how to exploit that productivity. If human beings only needed green leaf matter for food then tropical moist forests with their huge dry matter production would be vigorously protected wherever they occurred and would be feeding billions of people!

Tropical Soils

The relationship between the soil and shifting cultivation is undoubtedly of the utmost importance and over the past four decades many researchers have devoted considerable time and effort to a study of this inter-relationship. What all workers seem to agree, however, is that extrapolation of results from one area or environment to another is often at best very crude and at worst totally misleading. In the past, some very considerable errors of judgement have been made merely because it was assumed that the very complex nutrient relationships within the shifting system are always the same wherever they may be found. In microcosm, this is the same attitude that prevailed half a century ago in connection with farming tropical areas. It was assumed that tropical farming was basically the same as temperature and the same principles could be extended and transferred from one (temperate) to the other (tropical). The list of catastrophes resulting from this incorrect assumption is very long and even today still seems to be getting longer!

Most of the work devoted to a consideration of soils and nutrient cycling has been done on the African continent and it is only relatively recent that other parts of the world have commenced their own detailed studies. The publication by Nye and Greenland (1960), remains one of the classic works in this field and the following section will constantly refer to their work.

The work that has been done on the soils under shifting cultivation has concentrated on those types of soils now called Oxisols and Ultisols which form the most abundant soils of the humid tropics and which together cover almost two-thirds of this ecological region (Sanchez, 1981). Table 4 gives further details of this distribution of soil types in the humid tropics.

Oxisols are deep, generally well drained red or yellowish soils with excellent granular structure and little contrast between the horizon layers (Sanchez, 1981). These soils are low in nutrients and are acid. They are also referred to in other classification systems as Ferralsols, Latosols and incorrectly as Lateritic soils. In Asia they are a far less important group than the Ultisols. These soils are very similar to the Oxisols but they have a marked increase of clay content with depth and this is the feature that sets them apart from the Oxisols. The Ultisols have slightly less favourable physical characteristics than the Oxisols but their chemical status might be marginally better though still very poor in a general sense. They often occupy steep slopes on which shifting cultivatior is prevalent and so are more prone to erosion. Ultisols are also known as Acrisols and were formerly referred to as Red Yellow Podzolics. They are the most abundant soils of upland humid tropical Asia and undoubtedly form the bulk of those soils under which shifting cultivation prevails. Indeed, in Sarawak the old name for the Ultisols, i.e. Red Yellow Podzolics has almost become synonymous with a description of those areas under shifting cultivation for hill rice.

Sanchez (1981) describes the main constraints of these soils (Oxisols and Ultisols) as follows:- high soil acidity, aluminium toxicity, deficiency of phosphorus, potassium, calcium, magnesium, sulphur, zinc and other micronutrients, and low effective cation exchange capacity which indicates a high leaching potential. An important limitation of the Oxisols and Ultisols with clayey topsoils is that they exhibit a high capacity to fix phosphorus, but this constraint is less important if the topsoils are sandy or loamy. Sanchez (1981) further points out that the organic matter contents of these Oxisols and Ultisols are higher than people expect and would probably be adequate for satisfactory crop growth if other conditions were favourable.

These soils are, as one would expect, very deeply weathered (~~15 metres or more~~) and only the most resistant minerals remain, the rest having been decomposed over time. The organic matter is concentrated in the top few centimetres and is responsible for the majority of the exchange capacity of the soil and therefore stores most of the nutrient cations.

TABLE 4

GEOGRAPHICAL DISTRIBUTION OF SOILS OF THE HUMID TROPICS BASED ON DOMINANT SOIL IN FAO MAPS AT A SCALE OF 1:5 MILLION

Soil	Humid Tropics Total	Humid Tropical America	Humid Tropical Africa	Humid Tropical Asia
	------------- in million hectares	---------------		
Oxisols	525	332	179	14
Ultisols	413	213	69	131
Inceptisols:				
Aquepts	120	42	55	23
Andepts	12	2	1	9
Tropepts	94	17	19	58
Total	226	61	75	90
Entisols:				
Fluvents	50	6	10	34
Psamments	90	6	67	17
Lithic	72	19	14	39
Total	212	31	91	90
Alfisols	53	18	20	15
Histosols	27	-	4	23
Spodosols	19	10	3	6
Mollisols	7	-	-	7
Vertisols	5	1	2	2
Aridisols	2	-	1	1
TOTAL	1,489	666	444	379

Source: Sanchez (1981).

In describing the various features of the system and the change that takes place during the cycle of fallow, burning and cropping, the method used by Nye and Greenland (1960) will be followed, i.e. the statics and dynamic features of the fallow vegetation and soil and then the changes that take place during the cropping period.

Nutrient Contents of Fallows and Soils

The work conducted by Greenland at Kade, Ghana in a Moist Evergreen - Forest Zone (1625mm rainfall per annum) and others in Africa led to the conclusion that the quantities of all exchangeable nutrients, except phosphorus, in the top 30cm of soil are considerably less than that stored in the mature-forest standing vegetation. As Nye and Greenland (1960) point out, it is quite natural that the standing vegetation will play a very essential role in the storage and accumulation of soluble nutrients in areas where the high rainfall is tending to remove them. Table 5 gives some extracts from Nye and Greenland (1960).

In Table 5, it should be noted that the soil from Kade, Ghana was much richer in calcium and magnesium than a typical Oxisol or Ultisol and therefore these levels are slightly confusing. Normally, the amounts of these two elements stored in the vegetation will be much higher than those stored in the soil and this is shown by the results from Yangambi, Zaire. It is this higher level of calcium and magnesium that accounts for the increase in pH after burning and the release of quite large quantities of calcium and magnesium to the soil.

The rate of storage of nutrients is not constant over time but is very rapid in the early stages of forest growth and then slows down somewhat. This is due to the fact that the bulk of the leaves and twigs, which are richest in nutrients, are formed very early on in the fallow and later additions to storage take place in the form of wood and roots (Table 6).

Nye and Greenland (1960) point out that the above figures may be significantly altered if the cultivation period is too long since this may seriously deplete fertility and completely destroy the many stumps, roots and viable seeds that normally cause such rapid regeneration of the fallow.

Removal of nutrients from the vegetation takes place

TABLE 5

NUTRIENTS STORED IN THE FALLOW VEGETATION AND SOILS

Location	Annual rainfall (mm)	Type of fallow	Nutrients stored in the vegetation and litter (kg/ha)					Nutrients stored in the first 30cm of soil (kg/ha)				
			N	P	K	Ca	Mg	N	P	K	Ca	Mg
Kade (Ghana)	1625	40 yr old mature secondary forest	1832	126	819	2526	346	4596	12	650	2578	370
Yangambi (Zaire)	1825	18 yr old secondary forest	559	73	40		562)	2242-3363	19	359	100	53
Yangambi (Zaire)	1825	5 yrs old secondary forest	391	24	344		293)	-	-	-	-	-

Source: Nye and Greenland (1960).

TABLE 6

MEAN ANNUAL INCREASE IN VEGETATION STORAGE (KG/HA)

	N	P	K	Ca	Mg	Forest
Over first 5 years	114	6.3	91	84		Yangambi
Over first 18 years	39	5.9	34	46		Yamgambi
*Over first 40 years	40	2.8	17	54	7	Kabe
Over first 4 years (excluding roots)	47	3.4	35	44	10	Coastal thicket, Pokoase (Nye, 1958)

*Storage in two very large trees, already standing when the forest regenerated, has been excluded.

Source: Nye and Greenland (1960).

via rain wash, burning, root excretions and most importantly, leaf and litter fall. For moist tropical forest the dry matter contributed by leaf fall is much higher than for temperate forests and Table 7 gives some examples from various parts of the world.

The litter fall figures are probably fairly accurate for young fallow but in older regrowths some allowance must be made for the loss of large branches and stems. It is normally accepted that the annual timber fall is equal to the annual production of wood and Weck (1956) gives an average value of 11,200 kg of dry wood per hectare. For most of those examples given in Table 7 this would approximately double the quantity of material being passed from the vegetation to the soil. Charreau (1972) gave some estimates of the addition of organic matter to the soil under various types of cover and these are given in Table 8.

The addition of nutrients via rain wash is of greater importance than one would imagine and Nye and Greenland (1960) showed that remarkably large quantities of potassium and phosphorus but only small quantities of nitrogen, calcium and magnesium are washed out of the leaves (Table 9).

In describing the rate of mineralisation of the litter, Nye and Greenland (1960) point out that under tropical forest conditions this is normally extremely rapid. Using data obtained from Jenny et al. (1948) they estimated that once the litter had attained its equilibrium level, 3.25% was decomposed in one week or in one year 1.7 times as much as is found on the forest floor at any one time. They also point out that the maximum level of litter on the forest floor will be reached very quickly indeed, between one and three years. Of course this would not hold true for areas where exploitive and unbalanced shifting cultivation was conducted, so considerably reducing the environment's ability to rapidly regenerate good secondary forest.

There is very little data available on the quantities of nutrients that are lost through leaching. Despite the fact that tropical forests are normally termed 'closed' systems, there is no doubt that some losses do occur. So long as water is moving down through the soil profile there must be leaching losses. However, vigorously growing vegetation will reduce leaching losses by:-

1) transpiring water and therefore reducing percolation

2) absorbing anions, especially nitrate from the soil

TABLE 7

RATE OF LITTER PRODUCTION (PER ANNUM)

Vegetation	Place	Litter Fall (kg/ha)	Nutrients in Litter (kg/ha) N	P	K	Ca	Mg
Forest (Musanga dominant)	Congo	14,571 (dry matter)	140	4.5	104	124	43
Mixed Forest	Congo	12,330 (dry matter)	224	6.7	48	105	52
Mixed High Forest	Ghana	10,536 (oven dry)	200	7.3	68	206	45
Rain Forest	Colombia	7,846 (oven dry)					
Rain Forest	Colombia	10,200 (oven dry)					
Rain Forest (sub-tropical mixed spp.)	Queensland	6,725 (oven dry-leaf only)	108	5.6	37	75	
Temperate Hardwoods	New York	3,026 (dry matter)	19	3.4	16	74	10

TABLE 8

RESTITUTION OF ORGANIC MATTER BY VARIOUS TYPES OF VEGETATIVE COVERS TO SOILS AND ORGANIC MATTER CONTENT OF SOILS DURING FALLOW

Locality	Rainfall (mm)	Vegetation	Vegetative material returned (to soil (t/ha/year))			Soil Organic matter content (t/ha)
			Aerial part of plant	Roots	Total	
Senegal (Bambey)	650	Crops	0.0	1.5	1.5	11.5
		Herbaceous fallow	0.0	1.0	1.0	13.5
		<u>*Acacia albida*</u>	4.2	2.1	6.3	22.6
Senegal (Sefa)	1300	Crops	0.0	2.0	2.0	21.4
		Thin forest	5.0	2.5	7.5	33.8
Zaire	1830	Forest	10.0	5.0	15.0	93.0

Source: Charreau (1972).

TABLE 9

NUTRIENT CYCLE IN HIGH FOREST AT KADE, GHANA

	Wt. of material (oven dry)	Nutrient elements (kg/ha/annum)				
		N	P	K	Ca	Mg
Rainfall in open- (1854mm in 12 months)		15	0.5	18	12	11
Rainfall under forest - (1575mm in same period)	P + Throughfall	27	4.1	238	41	29
Rain wash from leaves	Throughfall	12	3.7	220	29	18
Timber fall	11,209	36	2.9	6	82	8
Litter fall (on 12 months' records)	10,536	200	7.3	68	206	45
Total addition to soil surface		248	13.9	294	317	71

Source: Nye and Greenland (1960).

3) repressing nitrification and therefore reducing the concentration of anions.

Whilst the majority of the feeding roots of tropical forest trees occur in the top 30 cm or so of soil, the importance of nutrient pumping from the subsoil must not be ignored. An important observation demonstrating the significance of this process is the fact that, as Nye and Greenland (1960) have pointed out, the concentration of relatively immobile nutrients such as phosphorus and calcium in tropical forest soils are nearly always greater in the topsoil than the subsoil.

Losses and gains to the system also occur through leaching beyond the rooting zone, erosion, volatilisation, additions in rainfall, dust and fixation of atmospheric nitrogen. However, the addition and losses of nutrients by these processes are extremely small compared to the rate of cycling.

Not all system so closed.

Influence of the Fallow

For the shifting cultivator, the soil changes and improvements that occur during the fallow period are obviously of the greatest importance and significance. It is the fallow period which basically supports the whole shifting cultivation process and so we must examine it in some detail. Young and Wright (1978) list the need for the fallow (rest) period as follows:-

1) To restore plant nutrient status

2) To improve organic matter status and soil structure

3) To control weeds

4) To control pest and diseases

5) To control erosion

6) To augment soil structure

Probably the single most important constituent in the restorative process of the fallow is the soil organic matter. The soil humus is derived from the added organic matter from leaves, twigs, branches etc., and it is the humus which plays an essential role in holding exchangeable cations, stores important quantities of phosphorus and sulphur and most important of all, is the sole reservoir of nitrogen.

Very little quantitative data exists to show the increases in humus level although the rate of organic matter addition will obviously be a good guide. From Table 8, it is quite clear that the returns to the soil under mature forest are very high and this feature is also repeated during regrowth stages where addition may be as high as 6 to 8 tons per hectare per annum (Mouttapa, 1974). Obviously the rate of addition will depend upon the type of vegetation concerned but as we have already seen, tropical moist forest has the potential to make large scale additions over a short period provided its capacity for regeneration was not too seriously impaired by the cropping period. This is borne out by the work of Bartholomew et al. (1953) where they found that the leafy part of the vegetation was already as great after five years as after 18 years of fallow growth.

Of the fresh organic matter added to the soil in the form of litter fall etc, only about 10-20% will be converted to soil humus, the rest being lost through oxidation, leaching and erosion. From various experiments conducted in Ghana using applied mulchs, the indications are that the rate of retention of carbon is in the region of 10%.

The relationship between organic matter addition and conversion to humus and the subsequent levels of soil humus is a complex one, and as Nye and Greenland (1960) point out can only be judged according to those potential levels that can be reached beneath a particular vegetation type and on a particular soil.

The attainment of an equilibrium is very important in this regard. Since humus itself is being lost through mineralisation, the additions to it in the course of the fallow will be dependant upon how much it has been depleted in the cropping period. If soil humus was only reduced to 50% of normal levels during the cropping, then additions to it will be slow during the fallow. However, if the humus was seriously depleted during the cropping period, then humus content will rapidly increase in the first few years of the fallow.

It has been shown by a number of experiments conducted over the past few years that the C/N ratio varies very little between virgin, cropped and fallow land. Consequently, quite accurate calculations of the changes in soil nitrogen can be undertaken. During the burn, the nitrogen stored and accumulated in the vegetation will be lost and so the crop must rely almost totally on nitrogen that has been accumulated in the soil during the fallow. Nye and Greenland (1960) estimated that the gains per annum in the forest zone are about 40 kg/ha and that a ten year fallow would therefore accumulate about 400 kg/ha of N. The source of this nitrogen that is accumulated during the fallow is still in some doubt. The quite large proportion of leguminous species in tropical forest may be important but it is not known whether in fact symbiotic fixation is taking place. Nye and Greenland (1960) point out that free living non-symbiotic bacteria such as Azotobacter spp., Beigerinckia spp. and Clostridia spp. which are widely distributed in the tropics must play an essential role in nitrogen fixation. They further point out that conditions for nitrogen fixation are ideal in forest areas since temperature and moisture are high and there is abundant carbonaceous material to provide energy for bacterial activity. It is highly significant that several fertilizer experiments conducted in the moist evergreen zone have shown that plant growth does not appear to be limited by nitrogen. Bartholomew et al. (1953) have pointed out that the relatively low yields obtained under shifting cultivation in the tropics do not remove more than about 15 kg/ha of N and therefore this nutrient is not likely to be limiting under traditional conditions. However, if much higher yields are required then nitrogen may definitely become limiting and fertiliser may have to be applied. Several workers have also pointed out the potential of using blue-green algae as nitrogen fixers in a wide variety of soils.

Since phosphorus has been considered to be such a limiting factor on tropical soils, a great deal of attention has been focussed on the complexity of its relationships within the soil and vegetation (Ahn, 1974). Phosphorus is very immobile in the soil and many tropical soils have the ability to fix it in various ways (in acid soils usually as aluminium and iron phosphates). Its importance to the crop is beyond question and Ahn (1974) reported on the average yield increases resulting from a large number of trials conducted in West Africa and South America (Table 10).

Nye and Greenland (1960) point out that the fallow period makes an important contribution to the increase of phosphorus and amounts to 12-35 kg/ha in the soil organic matter. The amount accumulated in the vegetation will be higher at 35-45 kg/ha.

Table 10

YIELD INCREASES FROM PHOSPHORUS TRIALS

		Yield Increase (kg/ha)
West Africa	Maize (794 trials)	173
	Yams (53 trials)	895
South America	Maize (196 trials)	401
	Potato(53 trials)	2,762

Potassium appears to be less of a limiting factor than phosphorus probably because many soil parent materials contain adequate potassium. However, Ahn (1974) has pointed out that responses to potassium appear to be more frequent in the forested zone than savanna and therefore there are times when it might be limiting in that environment.

In general, during the fallow period in a forested zone, far more nutrients are accumulated in the standing vegetation than in the soil. However, Nye and Greenland (1960) point out that there is a most significant transfer of nutrients from the subsoil to the topsoil during the fallow which will reinstate some of the losses occurring during the cropping period. Provided the fallow period is of long enough duration, the condition of the soil will return to what it was before the cropping period. However, as we shall be considering later on there is very little known about what does constitute a 'sufficiently long' fallow period. It is apparent that the addition of organic matter to the soil during the fallow period is of paramount importance and anything which promotes this will aid in the recovery of the soil subsequent to burning and cropping.

Young and Wright (1979) proposed the use of cultivation factors to set the limit at which a steady state of productivity could be obtained. They produced data for humus and nitrogen which is given in Tables 11 and 12.

The cultivation factor used by Young and Wright (1979) is not the same as the 'land-use factor' of Allan (1965) but is derived from:-

TABLE 11

GAINS AND LOSSES OF SOIL HUMUS CARBON IN RAIN FOREST AND SAVANNA ENVIRONMENTS

Environment (in warm tropics)	Loss during cultivation kg/ha/yr	Gain during fallow kg/ha/yr	Year of fallow to restore loss in 3 years cultivation	Cultivation factor R%
A. Soil carbon at 75 percent of natural equilibrium level				
Rain forest	1730	280- 700	7.5-19	14-29
Savanna (burnt annually)	1930	75- 190	30-70	4- 9
Savanna (no burn)	1930	190- 470	12-30	10-25
B. Soil carbon at 50 percent of natural equilibrium level				
Rain forest	1170	560-1400	2.5- 6	33-55
Savanna (burnt annually)	1280	150- 380	10-26	10-23
Savanna (no burn)	1280	370- 940	4-10	23-43

Source: Young & Wright (1979).

TABLE 12

GAINS AND LOSSES OF SOIL NITROGEN IN RAIN FOREST AND SAVANNA ENVIRONMENTS

Environment (in warm tropics)	Loss during cultivation kg/ha/yr			Gain during fallow kg/ha/yr			Cultivation factor R%		
	High	Low	Typical	High	Low	Typical	Worst	Best	Typical
Rain forest zone	400	100	200	125	70	100	15	55	33
Savanna zone	200	50	100	80	25	50	11	62	33

Source: Young and Wright (1979).

$$R = \frac{C}{C + F \text{ (or L)}} \times 100$$

where C = years of cultivation
F = years of fallow
L = years of ley or other non arable use

In their study and questionaire survey of the rest requirements of tropical and subtropical soils under annual crops, Young and Wright (1979) maintain that for Africa and Asia, the maximum acceptable cultivation factor is R=25 or 1 year cultivation in every 4. An interesting result from their survey was that the most frequently quoted reason for abandonment of shifting cultivation plots in the Asian zone was the problem of weed growth.

Young and Wright (1979) conclude that if shifting cultivation systems can be transformed from a low level of inputs (traditional farming methods, no fertilisers) to an intermediate one (improved management, moderate use of fertilizers etc), then very considerable reduction in the rest period requirement is possible. Furthermore, such improvements will be greatest on the intrinsically least fertile soil types and it is on these that shifting cultivation is most frequently practised.

Unlikely

Clearing and Burning

In the forest zone it is absolutely essential that the area is burned after slashing in order to remove the large quantity of dead vegetation, kill as many weeds as possible and release the very substantial quantity of nutrients that are stored in the vegetation

Nye and Greenland (1960) list three effects of the burn (as related directly to the soil):-

1) Large quantities of nutrient ions derived from the fallow vegetation are spread onto the surface of the soil in the form of carbonates, phosphates and silicates. Nearly all the nitrogen and sulphur is, however, lost to the atmosphere.

2) The immediate soil surface is heated which affects

the microbiological population and the physical and chemical properties of the soil.

3) The changes in pH and nutrient availability brought about by the burn may radically change the type of microflora present in the soil.

At Kade, Ghana, Nye and Greenland (1960) reported that the burn of a 40-year old forest added approximately 112 kg/ha N, 25 kg/ha P, 750 kg/ha K, 1,580 kg/ha Ca and 190 kg/ha Mg. After burning a 17-year old secondary forest in Yurimaguas, Peru, Seubert et al. (1977) showed that on average, the ash contributed the equivalent of 145 kg/ha of urea, 67 kg/ha of simple superphosphate, 50 kg/ha of muriate of potash, 0.25 ton/ha of dolomitic limestone and significant quantities of micronutrients such as zinc, copper, manganese and iron. Table 13 gives these and other results from the Amazon region (Sanchez, 1981).

As Nye and Greenland (1960) point out, one of the most important affects of burning, particularly on very acid forest soils is to significantly raise the pH.

A practical example of the fertiliser value of ash derived from a burn, compared to jungle areas cleared using a bulldozer has been reported by Sanchez (1981) from Jambi Province, Indonesia. Transmigration settlers tried to burn debris on their assigned fields, all of which had been cleared using a bulldozer. The hill rice growing on burned areas was clearly more healthy than that on bulldozed but unburned sections.

Whilst burning can result in large losses from the litter layer, there does not appear to be any loss of humified organic matter from the soil itself and this has particular implications for maintaining soil fertility.

Nye and Greenland (1960) have pointed out a number of secondary effects of burning, most of which are beneficial. In addition to creating a weed-free seed bed (at least temporarily), it may also render the top one or two centimeters of soil more friable. It has been known for centuries that heating a soil can have a beneficial effect on subsequent crop growth. There are a number of reasons for this, e.g. killing of weed seeds increased supply of nutrients, increased rate of nitrogen mineralisation and changes in the numbers and composition of soil microflora.

TABLE 13

SUMMARY OF CHANGES IN TOPSOIL CHEMICAL PROPERTIES BEFORE AND SHORTLY AFTER BURNING TROPICAL FORESTS IN ULTISOLS AND OXISOLS OF THE AMAZON

Soil Property	Timing	Yurimaguas (2 sites) I	Yurimaguas (2 sites) II	Manaus (7 sites)	Belem (60 sites)	Barrolandia (1 site)
Months after burning:		1	3	0.5	12	1
pH (in H_2O)	Before	4.0	4.0	3.8	4.8	4.6
	After	4.5	4.8	4.5	4.9	5.2
Exch. Ca + Mg (me/100g)	Before	0.41	1.46	0.35	1.03	1.40
	After	0.88	4.08	1.25	1.97	4.40
Exch. K (me/100g)	Before	0.10	0.33	0.07	0.12	0.07
	After	0.32	0.24	0.22	0.12	0.16
Exch. Al (me/100g)	Before	2.27	2.15	1.73	1.62	0.75
	After	1.70	0.65	0.70	0.90	0.28
Al saturation %	Before	81	52	80	58	34
	After	59	12	32	30	5
Avail. P (ppm) (Olsen in Peru, NC in Brazil)	Before	5	15	-	6.3	1.5
	After	16	23	-	7.5	8.5

Source: Sanchez (1981).

Decline of Fertility under Cropping

Nye and Greenland (1960) have summarised the reasons for the decline in yield of crops as follows:-

1) Multiplication of pests and diseases

2) Increase of weeds

3) Erosion of the topsoil

4) Deterioration in the physical condition of the soil

5) Deterioration in the nutrient status of the soil

6) Changes in the numbers and composition of soil fauna and flora.

1) **Pests and Diseases.** Because of the long fallow that occurs under traditional shifting cultivation systems the ecological balance of predator-prey relationships are well maintained. There is little opportunity for a buildup of pests and diseases and so complete and widespread crop failures are rare. Other factors which keep pests and diseases to tolerable levels would be the fact that most shifting cultivation plots are widely scattered and monoculture is very seldom practised.

2) **Weeding.** The difficulties posed by weeds under shifting cultivation practice have been very adequately summed up by Moody (1974):-

> "The luxuriant growth of weeds is one of the major problems of tropical agriculture. The depressive effect of weeds can be so great as to destroy the crop completely. The majority of tropical farmers who use the hoe to control weeds are forced to abandon the land when they can no longer control weeds or when clearing a new piece of land will give greater returns than extra weedings on the old piece. The fallow suppresses the weeds that were a problem and is a cheap and efficient means of weed control".

There is no doubt that nowadays most researchers regard the influence of weeds and weed competition as being probably the single most important influence for encouraging the cultivator to move to another site. There is increasing evidence to indicate that decreased soil nutrient status is not as important as previously thought in relation to the shifting habit and that the influence of weed growth is a fundamental contributory factor.

Nye and Greenland (1960) observe that where semi-perennial crops are grown, weeds may not be the reason for the shifting habit. In contrast to this, there is little doubt that the weed problem is enormous in the forest regions of Southeast Asia. Conklin (1957) has estimated that a Hununoo farmer (Philippino) spends 600 man-hours per hectare on weeding land cleared from 20-year old secondary jungle. Nakano (1980) also gave figures of 550 man-hours per hectare for the Karen hill farmers of Thailand. One of the principal reasons for weeds being a particular problem in Southeast Asia is the aggressiveness of Imperata cyclindrica (Asian form).

Release of the cultivated area to fallow is one of the cheapest and most effective forms of weed control (Moody 1974). The regrowth of secondary jungle will very rapidly shade out and eradicate weeds, particularly grasses, that would have made the continuation of cropping impossible or completely uneconomic.

3). **Erosion.** It is often claimed that shifting cultivation always results in catastrophic soil erosion. Whilst there have been instances of very serious land degradation in shifting cultivation areas, this has usually been the result of the activities of exploitive and new farmers rather than the traditional kind.

In tropical forest the kinetic energy of the rain is absorbed by the various vegetational canopies and by the mass of litter and organic matter covering the soil surface. The open structure of the soil under virgin forest or fallow allows high infiltration and so there is very little surface run-off. Even under very high rainfall conditions where surface run-off does occur, it normally runs clear because of the filtering action of the litter etc. As Nye and Greenland (1960) put it:-

"the considerable depths of soil developed on steep slopes under rainfalls exceeding

> 2500 mm per annum in tropical mountain regions is itself a testimony to the efficacy of the forest in countering erosion".

Even immediately after burning when the soil would be at its most vulnerable to erosion, the damaging effects of intense rainfall will still be slight, provided an adequate fallow period has been maintained. The presence on the soil surface of large quantities of unburned logs, surface protruding roots, branches etc. helps to keep the influence of raindrop impact and run-off to a minimum. The very rapid growth of the crop and weeds after burning soon confers a very high degree of protection to the soil. Experiments conducted by Hatch (1979) have conclusively shown that erosion is not a serious problem for areas under shifting cultivation in Sarawak provided the forest fallow period is kept long enough. Furthermore, the erosion under secondary jungle has been shown to be less than under primary, presumably because of the greater density of low growing vegetation that is to be found in secondary jungle.

4). **Physical Conditions of the Soil.** When the soil is exposed to much increased insolation then the humus and litter content will decline rapidly. As Ahn (1974) has pointed out, decreases in the amount of humus in the soil are often associated with:-

a) loss of crumb structure in the topsoil.

b) lower total porosity and macroporosity.

c) poorer aeration.

d) poorer rainfall acceptance.

e) increased likelihood of run-off and erosion.

f) lower cation exchange capacity.

g) possible changes in exchangeable bases, degree of saturation and soil pH.

h) lower release of nutrients due to lower amounts of humus mineralised.

Nye and Greenland (1960) point out that many soils have an inherent constitution that is often referred to as 'good heart' by the temperate farmer. If a soil has good inherent structure and constitution then it may be used far more intensively, with the correct inputs, than a soil of poor constitution. However, the physical condition of both soils will greatly benefit from fallow periods (particularly forest fallow). An important point made by Nye and Greenland (1960) is that traditional shifting cultivation methods tend to preserve at least part of the structural improvements conferred by the fallow. If the soil is cultivated with hoe or plough, however, the improvement resulting from the fallow rapidly disappears.

5). **The Nutrient Status of the Soil.** This aspect of shifting cultivation has probably received the greatest attention over the past few years, both with a view to understanding far more about the nutrient cycling within a shifting cultivation system and to try and find ways of increasing yields from the process. As Nye and Greenland (1960) point out, the evidence that has been gathered derives from two different but complementary approaches - fertiliser trials and soil analysis.

For fertiliser trials on forest soils, Nye and Greenland (1960) report that responses to nitrogen are very small if the preceding fallow has been long (10 years or more). However, responses may be high if the land has been more intensively cropped. Responses to phosphates seem to be quite variable and seemingly dependant more on the inherent qualities of the soil than on the length of fallow. Therefore there have been cases where good responses have been obtained from application of phosphate fertilisers on long fallow land whereas there have been negligible responses on short fallow land. Responses to potash and lime seem to be small or moderate, once again depending upon the soil type and length of fallow.

As Nye and Greenland (1960) point out, one of the great disadvantages of using evidence of soil analysis for adducing the nutrient cycling dynamics is the fact that they are in fact measurements of 'capacity', and not 'potential'. However, several researchers have used the soil analysis technique to gain some insight into what is happening to the soil during shifting cultivation.

The changes that occur to the organic matter and humus are of prime importance since these materials play such a fundamental part in the storage and cycling of soil nutrients.

Many older accounts contained quite alarming figures for the rate of loss of humus during the cropping period, but Nye and Greenland (1960) observe that these now seem erroneous and probably arose from incorrect assumptions as to the rate of production of litter from a virgin forest. Many early estimates put this at over 250 tons per hectare per annum whereas it has now been calculated to be more realistically in the region of 10 tons per hectare per annum.

Nevertheless, during the cropping period there are changes in the humus contents of the soils but they are definitely not as drastic as previously thought. In the early stages of cropping, the fall in humus level will be rapid but the rate of decline will become progressively slower. Indeed, several writers have pointed out that a higher rate of humus decomposition is even desirable since it releases additional nitrogen for the crops. Ahn (1974) has described the dynamics of the system in the following terms:

> "Fundamentally the changes in humus levels may be thought of as being an adjustment from one set of conditions (soil under natural vegetation, either original or fallow which has its natural humus 'equilibrium level') to another, different set of conditions provoked by clearing of the land, cultivation and increased exposure to sun and rain, which have a humus 'equilibrium level' which is considerably lower than the previous one".

In fact, Ahn (1974) has strongly questioned the great concern that is always shown for drops in humus levels during cultivation and proposes that a more positive approach should be adopted towards 'learning to manage with lower humus levels than usual'.

Sanchez (1981) reports that during the first year of cropping in Yurimaguas, Peru, there was a 30% fall in the organic carbon content of the soil but thereafter this reached an equilibrium of only 4% per annum. He also points out, like Ahn (1974), that the very high initial decomposition rate resulted in very large increases in available nitrogen during the first cropping year.

Nye and Greenland (1960) report that several studies of traditional shifting cultivation areas have shown that humus levels remain fairly high and it is only on savanna areas frequently subjected to burning that very low humus levels are reached.

The changes with respect to nitrogen are still not well researched but it is clear that under acid, forest soils the activity of nitrifiers increases after the burn as a result of increases in the soil pH. A further very important point highlighted by Nye and Greenland (1960) is the fact that in almost all tropical soils, nitrification proceeds far more rapidly during the first rains after a dry season or even a quite short dry period. Nitrate levels will increase quite rapidly but will not be maintained for long because of rapid leaching, uptake by weeds and high activity of denitrifying bacteria. Hence early planting of the crop is most essential so that this 'flush' of nitrogen may be exploited to the full by the crop. Of course early planting confers many other advantages such as increased availability of phosphorus, less weed competition etc.

Both Ahn (1974), and Nye and Greenland (1960) point out that the levels of phosphorus are so low that they are not really worth measuring. In addition, the relationship between total phosphorus and that which is available to the plant is rather complex and not very well understood. However, there is no doubt that the burn does once again produce a 'flush' of phosphorus that is available to the crop at a time when root development is of paramount importance. Table 13 demonstrates the increased amounts of phosphorus available after the burn. Nye and Greenland (1960) also observe that a small quantity (about 10 kg/ha/annum) of phosphorus will be made available to the plant during the cropping period as a result of humus mineralisation.

The changes that occur in the levels of the other soil nutrients have not been well researched but there are some data available which are of interest. Sanchez (1976) reports that calcium and magnesium levels can be doubled or tripled during the burn but this can vary markedly according to site. Potassium also increases significantly with the burn but quickly diminishes due to rapid leaching. Nye and Greenland (1960), whilst acknowledging that nutrient levels will definitely decline during cropping, do not consider this to be serious provided cropping does not last more tnan two or three years.

The losses of nutrients that occur via crop removal, erosion and leaching are now considered but once again quantitative data are quite scarce.

In their study of the Lua shifting cultivation system in Thailand, Zinke, Sabhasri and Kunstadter (1978) estimated that with a yield of about 1,000 kg/ha of hill rice, the crop was extracting 2 kg/ha phosphorus, 0.3 kg/ha calcium, 0.8 kg/ha potassium and 7.2 kg/ha nitrogen. In their calculations on the nutrients in the ash, they found that the two figures balanced, apart from the calcium which was in surplus. It would seem, however, that these figures are a trifle low and further investigation must be conducted on nutrient removal by the crop under hill rice cultivation.

Erosion losses of nutrients will not normally be very high except where prolonged cultivation on steep slopes has promoted sheet erosion. Under tropical moist forest conditions with traditionally long fallows, there is little danger of large losses of nutrients through erosion, or of erosion itself taking place to any significant extent.

Losses of nutrients through leaching are conventionally thought to be very high under high tropical rainfall regimes but Nye and Greenland (1960) have pointed out that this may be somewhat exaggerated since leaching in the acid and very acid tropical forest soils is far more dependant upon the existence of anions, particularly nitrate, in the soil solution. Losses of phosphates through leaching are negligible and the decline of phosphorus is due to both uptake by crops and fixation into unavailable forms.

An important aspect of the nutrient cycling process is to what extent continuous shifting cultivation even of a traditional type with long fallows, depletes the soil of nutrients and slowly leads to a rundown of integrity and fertility of the soil. A popularly held view as expressed by the F.A.O in 1958 (quoted by Nye and Greenland) is that:-

> "at each turn of the cycle the soil becomes more depleted of nutrients and its productivity is less and more short-lived".

Nye and Greenland (1960) note that the level of nitrogen is probably maintained at satisfactory levels by long forest fallows and the litter production potential of secondary forest is only marginally affected by continuous shifting cultivation. With the other nutrients, however, and particularly phosphorus and potassium, losses here must be made up from the subsoil pool of non-exchangeable nutrients. Over long periods of time a part of this non-exchangeable pool will be released to the exchangeable pool but very little is known about the degree to which this takes place.

Nye and Greenland (1960) give as an example of quantities of nutrients present in the soil, the near-average values of total phosphorus and potassium among forest soils in Ghana. One hectare to a depth of about 1.5 metres will contain 1,800 kg phosphorus and 5,400 kg potassium. If this is compared with the relatively small quantities that are removed during the cropping period, it would appear that provided the non-exchangeable nutrients eventually enter the exchangeable equilibrium, nutrients should not be limiting.

Summary

1. The bulk of the soils in the humid tropical region and on which, therefore, shifting cultivation predominates are the Oxisols and Ultisols.They are highly weathered, acidic soils which are low in nutrients.

2. The rate of mineralisation of litter under tropical forest is extremely rapid and may approach double (annually) the amount of litter that is found on the forest floor at any one time.

3. Under the fallow the vegetation of tropical forest stores more nutrients than the soil.

4. The buildup of organic matter and therefore humus under the fallow can be extremely rapid.

5. Leaching losses will undoubtedly occur in the fallow but these are not as high as is normally thought and will be very dependant upon the presence and movement of the nitrate ion.

6. The 'pumping' of nutrients such as potassium and phosphorus from subsoil to the topsoil by roots of the fallow vegetation is possibly most important to maintaining the fertility of soils used for shifting cultivation.

7. Since nearly all the nitrogen stored in the vegetation is lost during the burn, the cropping period must rely upon soil nitrogen accumulated during the fallow. This has been estimated to be about 40 kg/ha/yr. The source of this addition would appear to be symbiotic bacteria but the role of free living bacteria is still not clear.

8. The burn does not appear to significantly affect the humus levels.

9. During the burn nearly all of the nitrogen and sulphur are lost. Quite large quantities of other nutrients are deposited on the soil in the form of ash. The pH is raised and the heat of the burn will influence the type and quantity of microflora present.

10. In general, the burn appears to have only beneficial effects and these will also extend to cultural aspects such as killing weeds and weed seeds.

11. During the cropping period the humus level reaches a new equilibrium level that is much lower than that under the fallow but is nevertheless stable.

12. Nitrification proceeds most rapidly during the first rains after a dry period and so early planting of the crop is most important.

13. The quantities of nutrients removed by the crop are not generally large and sufficient nutrients will normally be supplied by the burn.

14. Fertiliser experiments which have been conducted using nitrogen have shown in general that this nutrient is not limiting under shifting cultivation methods.

15. Fertilizer responses to nitrogen on long fallowed soils are normally very low and will only increase on short fallowed soils.

16. Phosphorus is probably a more limiting element than nitrogen since not only is it present in quite small quantities but it is also prone to fixation into non-available forms.

17. Responses to phosphorus are very variable and are dependant upon the ability of the soil to fix phosphorus in unavailable forms.

18. Potassium and other nutrients may become limiting but in general, levels appear to be adequate for shifting cultivation techniques.

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17. Responses to phosphorus are very variable and are dependant upon the ability of the soil to fix phosphorus in unavailable forms.

18. Potassium and other nutrients may become limiting but in general, levels appear to be adequate for shifting cultivation techniques.

19. During the cropping period the build-up of pests and diseases will not be too serious under traditional shifting cultivation but this does not mean that serious attacks will not occur on a fairly regular basis.

20. The build-up of weeds during the cropping phase is an absolutely fundamental aspect of the whole system and its influence must not be underestimated either in terms of the immediate damage they do to a growing crop or the longer term motivation they provide to the shifting cultivators for moving to another plot of land. The labour input aspects of weeding are also of great importance since this can affect a farmer's ability to intensify or diversify his farming methods.

21. In Southeast Asia, _Imperata cylindrica_ is a parti- cularly aggressive weed.

22. Under traditional shifting cultivation methods, even on very steep land, erosion does not appear to be a problem in humid tropical forest areas.

23. The importance of the deterioration of the physical condition of the soil that takes place during the cropping period is not clear but it may not be as important as previously considered particularly on soils with inherent 'good heart'.

24. Whether or not continuous shifting cultivation over many years or centuries will lead to a permanent reduction in a soil's ability to maintain fertility is not known, although it will depend a great deal upon the equilibrium between the non exchangeable and exchangeable pool of nutrients.

Conclusion

To make any hard and fast statement about shifting cultivation and the highly complex series of changes that are taking place in the soil is dangerous in the extreme. However, one thing is very clear and bears repeating - traditional shifting cultivation is _not_ as destructive to the soil either in the short or long term as has frequently been asserted. It can and has maintained yields from naturally very poor soils over long periods of time and as stated by Nye and Greenland (1960):

> "the system is the best that could have been derived; for as we have shown, the labour of clearing, planting and weeding in relation to size of harvest is low".

Were the world and its population a static thing, there is every likelihood that shifting cultivation would not be of any great concern to us. Unfortunately, however, the shifting cultivators are being pressured by outside influences such as timber exploitation and internal pressures such as natural population increase. These influences in their turn are placing great pressure upon the environment, cycles and natural systems that have for centuries quite happily supported the shifting method of agriculture. It is this which is of the greatest concern. As many writers have pointed out, it is not necessarily true that the potential of poor tropical soils cannot be improved but rather that the trauma and difficulties of transition from an extensive shifting agricultural system to a far more intensive and settled one can cause real damage not only to those having to undertake the change, but also to the environment and soils concerned.

SHIFTING CULTIVATION IN SARAWAK

So far we have reviewed some of the data that are available throughout the world on shifting cultivation in humid tropical forest areas. However, this review has been by no mean exhaustive and the reader is referred to the very many excellent works listed under References.

It is now appropriate that we should turn our attention to the situation with regard to shifting cultivation as it pertains to Sarawak. In this section, we have attempted to draw together the work and research that has been conducted on shifting cultivation in Sarawak over the past twenty years or so as well as to give us much information as possible on the present state of the practice.

Climate and Topography

Sarawak has an area of approximately 12,325,000 hectares and it lies in the tropical monsoon belt between latitude 0° 50' and 5° north and longitude 109° 30' and 115° 40' east. The climate is characterised by heavy rainfall, varying from 3,048 - 5,588 mm per annum, uniform temperature (mean of 26°C) and high relative humidity (D.I.D. 1978). Table 14 gives the average annual rainfall for Sarawak from 1963 to 1978. In addition, rainfall intensity can be very high indeed and commonly exceeds 100mm per hour. The seasons are not really very clearly defined but between the months of October and February, the Northeast Monsoon (Landas) brings greater than average rainfall. Just prior to the onset of the monsoon, there is normally a dry spell of several weeks, normally two to three but sometimes more, and it is at this time that the shifting cultivators cut their plots and allow the vegetation to dry. The subsequent burning, ideally timed to occur just before the first heavy monsoon rain, invariably covers Sarawak in a pall of hazy smoke which is only dispersed by the rains. The onset of the monsoon is not generally uniform throughout the State and is somewhat earlier in the north-east. Drought conditions in the true sense of the word never pertain in Sarawak since no prolonged dry spell occurs. However, several researchers have recognised the fact that damaging moisture deficit conditions may arise on rare occasions. These dry periods are completely unpredictable and can do significant damage to purely rain-fed crops such as the hill padi grown by Sarawak shifting cultivators.

TABLE 14

SUMMARY OF AVERAGE ANNUAL RAINFALL IN MILLIMETRE (By Thiessen Method)

Year	Amount
1963 - 1964+	3386
1964 - 1965+	3586
1965 - 1966+	3665
1966 - 1967+	3993
1967	3853
1968	3584
1969	3322
1970	4310
1971	4044
1972	3272
1973	3853
1974	3716
1975	4054
1976	3454
1977	3907
1978	3346

\+ Water year is used, i.e. from July to June.

Source: D.I.D. (1978).

Broadly speaking, Sarawak can be divided into six topographic zones:-

1) Coastal mangrove and nipah mudflats

2) Peat swamps

3) Recent marine beach deposits and alluvium

4) Recent riverine alluvium

5) Rolling and moderately steep low hills

6) Steep, dissected hilly and mountainous country.

The first four of the these categories occupy about 20% of the land area of the State and are not in general used for the shifting cultivation of hill padi. The rolling and moderately steep low hills have slopes varying from 15° to 30° and occupy approximately 10% of the land area in the coastal-interior transition zone and some interior valleys. The steep, dissected, hilly and mountainous country is characterised by slopes often in excess of 30° and occupies over 70% of the land area of the State. This kind of topography is found between the low hills mentioned above and the border with Indonesia (Kalimantan). Thus, it can be seen that about 80% of the land area of the State has moderate to very steep slopes and it is here that shifting cultivation for hill padi predominates. It is worth noting that a form of shifting cultivation is also practised for wet padi in Sarawak whereby some wet padi fields are not regularly cropped, even though there is no apparent cultural or management reason preventing this. In addition and to further confuse matters, there is a definite transitional zone between wet padi areas and hill padi areas where a type of padi is grown that could best be described as upland padi. Such padi is often planted on very gentle lower slopes between the permanently inundated wet fields and the dry hill padi hill slopes. In relation to the total area used for shifting cultivation, however, the extent of the 'upland padi' type is very limited.

Soils Under Shifting Cultivation

The soils under the steep to very steep terrain used for shifting cultivation show some variation but in general they are shallow and of rather low fertility, having been derived from sedimentary rather than igneous parent material. Probably the most important soil group in the interior areas of Sarawak and upon which shifting cultivation is most widely practised is the Red-Yellow Podzolics (yellow to red loamy sands to clays). Such soils are deeply weathered and rather low in plant nutrients, notably phosphate; most of the plant nutrient being held within the generally shallow humus layer. Where the terrain becomes steeper than 30° then the soils become very shallow and are skeletal in nature.

Red-Yellow Podzolics are locally defined (Tie, 1982) as mineral soils that:

a). do not have a lithic or paralithic contact or the top of a C horizon within 50 cm of the surface;

b). do not have a drainage class of 3 or less;

c). do not have sulphidic material or a sulphuric horizon within 100cm of the base of an O horizon;

d). do not have a sandy particle-size class and are not formed in recent alluvium;

e). do not have exchange complex dominated by amorphous material;

f). have a cambic or an argillic horizon not overlain by an oxic or a spodic horizon; and

g). have dominant soil colour with a hue of 2.5Y or redder and a chroma of 5 or more or value of 5 or less in the B horizon.

Correlation with Soil Taxonomy (USDA, 1975) and World Soil Map Legend (FAO, 1974) is, however, arbitrary. This is because of the uncertainty on the existence of an argillic horizon (Andriesse, 1975; Scott, in print). They may, however, find a place in the proposed kandic subgroup of the Ultisols with low activity clays and having a finer textured subsurface horizon which does not fall within the present definition of an argillic horizon. In the mean time, Red-Yellow Podzolic Soils are tentatively correlated with either Typic/Orthoxic Paleudults or Typic/Oxic Dystropepts. Aquic subgroup also occurs to a smaller extent. Under the World Soil Map Legend, they may be classified as Ferralic/Dystric Cambisols or Orthic/Ferric Acrisols.

The Red-Yellow Podzolic Soils occur on upland areas with an undulating to very steep terrain. They form the dominant soil type in the State, particularly in the low hilly regions described above. These soils are usually associated with Mixed Dipterocarp Forest.

Red-Yellow Podzolics can develop on a variety of parent materials. However, they are most commonly found on Tertiary to Mesozoic non-calcareous sedimentary rocks. Since most of the State is covered by this type of material, the associated Red-Yellow Podzolic Soils are very common and will occupy most of our attention. Four families of Red-Yellow Podzolic Soils that have developed from non-calcareous sedimentary rocks have been classified locally. They are Semongok, Merit, Bekenu and Nyalau families with very fine clayey, fine clayey, fine loamy/silty and coarse loamy/silty particle-size classes respectively. Semongok and Merit Family soils are formed from shales, mudstones or siltstone, while Nyalau soils have developed in sandstones. The parent materials of the intermediate Bekenu soils can be sandy shales, or more commonly, interbedded argillaceous rocks and sandstones.

Andriesse (1975) and Scott (in print) have separately studied the formation of Red-Yellow Podzolic Soils and recognised the following dominant processes:

a) strong leaching of easily soluble constituents;

b) removal of iron (deferritization) with limited accumulation in the B horizon (aluminium appears to be relatively immobile);

c) residual silification in the topsoil and upper subsoil;

d) lateral removal of clay in the A and E horizons (little or no evidence of either clay illuviation or clay formation in the B and destruction in the A horizons);

e) homogenisation of solum by faunal activity; and

f) surface truncation by erosion on steeper terrain

The Red-Yellow Podzolic Soils in Sarawak usually have less than 10cm of A horizon. The topsoils are brown to dark brown with a friable consistence. The structure is granular or crumbly and this is usually the part of the solum with the most well developed structure. The A horizon is also the most well rooted section.

Below the A horizon, the colour changes abruptly to brownish yellow or yellowish brown. These are the most common colours of the subsoil although redder colours are not uncommon especially in the lower subsoil. Consistence of the upper subsoil would still be friable in Bekenu, Nyalau and some Merit soils but the lower subsoil is usually firm to very firm in all the families. Structural development is usually weak and Scott (in print) concluded that this is one of the constraints in clay illuviation. However, where road cuttings and soil pits have been left to dry out, very coarse blocky to columnar structures have been observed.

Texture generally becomes heavier down the profile and contrasting texture profiles are seldom encountered in Red Yellow Podzolic Soils. The clay increase down the profile normally meets the textural requirement of an argillic horizon although argilluviation may not be the process involved. However, management-wise, this textural B horizon would still be an important factor to consider. For example, it would slow down internal drainage thereby causing imperfect drainage and more run-off and surface erosion because of less infiltration. In the case of very heavy and compact subsoil, root penetration may also be hindered.

Soil reaction is low in all Red-Yellow Podzolic Soils derived from non-calcareous sedimentary rocks. The pH (in water) ranges from 4.0 to 4.2 in the topsoils and increases slightly with depth to around 4.5 (Table 15). The pH (KCl) values (not shown) are even lower showing the considerable influence of the exchangeable aluminium. Levels of active aluminium may be high in these highly leached, acidic soils.

Organic carbon is moderate to high in the topsoils and decreases rapidly to fairly low values in the B horizons. Levels of total nitrogen are also fairly high in the topsoils but decrease sharply with depth. The organic matter is fairly well mineralised despite the low base status with carbon-nitrogen ratios of around 12 in the topsoils and below 10 in the subsoil. Nyalau family with an average C/N ratio of 19 in the topsoils is the exception here and this is indicative of the generally lower fertility level of these coarser-textured soils.

Phosphorus levels are low in all the Red-Yellow Podzolic Soils. Available phosphorus is almost zero below

Table 15

AVERAGE TRENDS FOR SELECTED CHEMICAL PARAMETERS IN THE FINE EARTH FRACTION OF THE FOUR SOIL FAMILIES

Family	Hori-zon	pH (H_2O)	C %	N %	Ca (Exch.	Mg me/100g)	K	CEC	BS %	Res P. ppm	Av.P ppm
Semongok	A1	4.0	3.41	0.29	1.29	0.62	0.25	22.1	10	231	4
(4 profiles)	B	4.6	0.50	0.08	0.17	0.16	0.17	20.5	4	145	<1
Merit	A1	4.2	2.89	0.24	0.71	0.41	0.41	14.3	15	132	4
(11 profiles)	B	4.4	0.39	0.06	0.56	0.07	0.13	8.5	11	85	1
Bekenu	A1	4.1	4.80	0.38	0.60	0.60	0.40	12.1	17	182	6
(7 profiles)	B	4.6	0.36	0.05	0.50	0.07	0.11	5.1	11	73	1
Nyalau	A1	4.1	3.75	0.20	0.50	0.40	0.30	10.6	15	128	1
(11 profiles)	B	4.6	0.19	0.02	0.34	0.10	0.10	3.0	22	63	<1

the A horizon, although up to 6 ppm may be found in the thin topsoils. Total phosphorus values are also low; even in the topsoils where organic phosphorus accounts for a large proportion of total phosphorus, the highest value is only slightly more than 200 ppm in Semongok soils. Total phosphorus in the subsoil is usually below 100 ppm. Nyalau soils again show the lowest phosphorus status among the four families.

Cation exchange capacities (CEC) are relatively high particularly in the very clayey Semongok soils. Contribution from the organic matter is particularly significant in the coarser-textured soils which show a marked difference in the CEC values between the A and B horizons. In the clay fraction, illite and vermiculite account for the relatively high CEC. On converting the values shown in Table 15 to clay basis, all these soils have CEC values of more than 16 meq/100g clay. However, some members may have values ranging from 16 to 24 meq/100g clay and these would go into the Oxic or Orthoxic subgroup of Soil Taxonomy (USDA, 1975).

Exchangeable calcium is relatively high in the topsoil of Semongok family, but in the subsoil it is very low. In this case accumulation of calcium in the A horizon is very much in evidence. Exchangeable magnesium, potassium and calcium in the other soils generally have medium values in the A horizon, while subsoil values are low. Accumulation of magnesium and potassium in the topsoil layers is also evident but is less expressed than for calcium in Semongok soils. Base saturation is very low in these soils with none of the values exceeding 25 percent. The apparently higher values in Nyalau soils have little significance because of the low CEC.

The siliceous sedimentary rocks which give rise to these soils have mostly been reworked in a number of cycles. Therefore, there are few easily-weatherable minerals in the sand and silt fraction. The clay fractions generally have a high proportion of amorphous material. Illite and vermiculite are the dominant silicate clay minerals in soils derived from shales with subordinate kaolinite and gibbsite. In soils developed over sandstones, kaolinite is usually dominant. Soils of intermediate texture developed over mixed sedimentary rocks have either illite or illite and kaolinite dominant (Scott, in print).

Therefore, all these Red-Yellow Podzolic Soils have a low to very low supply of plant nutrients. They have strong acidity, low base status and high aluminium activity.

Phosphorus status is also very low. The small amounts of plant nutrients that are available are mainly concentrated in the topsoils of 8 to 12 cm thick. In their recent study, Koopmans and Andriesse (1982) found that except for available potassium and sulphur, the vegetation has to rely more for its main nutrient supply on the amounts stored in the 0-25 cm soil layer than those found in the subsoil. Furthermore, they concluded that litter plays a very important role in recycling processes in Sarawak, indicating the importance of organic materials in maintaining soil fertility.

The immediate reason for shifting cultivators throughout the world to fallow the land and plant elsewhere is declining yield. As previously noted, this rapid decline in yield has been attributed by various researchers to declining soil fertility, increased weed competition, increased pest problems, accelerated erosion or a combination of these factors.

In Sarawak, pest damage and diseases are normally not serious in hill padi cultivation. However, some padi farms have been observed to be abandoned due to weed encroachment (Dunsmore, 1968) and it is clear that weeding is the most labour-demanding job on a hill padi farm. Increased surface erosion due to shifting cultivation is normally negligible (Andriesse, 1972; Scott, in print; Hatch, 1979).

Declining soil fertility is most obvious where the land has been overfarmed. Under Sarawak conditions where the natural fertility is originally low to very low, soil degradation could become a serious problem. In extreme cases, the soil can become so impoverished in nutrients that only sheet lallang (<u>Imperata cylindrica</u>) can grow after the farm has been abandoned. The danger of overfarming is very critical in Sarawak because the forest vegetation seems to rely more on the top 25cm than on the subsoil for its main nutrient supply (Koopmans & Andriesse, 1982). If the topsoil is too impoverished, forest regeneration would obviously be seriously effected.

The only empirical work conducted to-date in Sarawak (Andriesse, 1977) showed that there are large increases in major nutrients in the soil immediately after the burn, but these virtually drop to the initial pre-burn levels soon after cropping. Leaching and surface wash probably account for most of these losses. For phosphorus, fixation may be important. During the fallow, all major nutrient levels remain fairly constant in the topsoil. Andriesse (1977) further suggested that a forest fallow of 20 years would be sufficient to balance the losses due to leaching and surface wash, and to accumulate enough nutrients in the living vegetation for another crop of hill padi upon the burn of the felled forest.

Forest Types

Earlier on we considered in broad terms the features of Tropical Moist Forest. Now we shall describe in greater detail the forest types of Sarawak with particular reference to those in which shifting cultivation predominates.

The tropical rain forest is the product of a uniform climate characterised by high rainfall and temperature all the year round. The rain forest in Sarawak is among the richest in Southeast Asia. Primary or virgin forest used to cover about 75% of the State's total area of 12,325 sq. km, but a large proportion of this has now disappeared as a result of continuous logging, shifting cultivation, agricultural and industrial development.

Sarawak's forest may be classified into a number of different types, each distinct in structure and species composition. The main factors determining these types are edaphic and climatic. A significant proportion of Sarawak is occupied by Mangrove and Peat Swamp Forest, in neither of which shifting cultivation is normally found. However, for completeness, these forest types are also described below.

(i) **Mangrove forest**

This develops on recent alluvial deposits along sheltered shores and estuaries. It is most gregarious where extensive mud flats have developed. In Sarawak, this type of forest is concentrated in the Sarawak River Delta in the First Division, the Rejang Delta in the Sixth Division, and the Lawas-Trusan River Delta in the Fifth Division, occupying a total area of about 174 sq. km. Most parts of the forest floor are constantly inundated during daily high tides, and the mud is thus constantly water-logged, highly saline, low in oxygen content and high in sulphide content.

The forest may be further classified into a series of zones or subtypes based on factors such as the frequency of inundation, soil and water properties and the adaptive characteristics of the various species. Species of Sonneratia (Perepat and Pedada) and Avicennia (Api api) form the pioneer zone on the seaward fringe. Rhizophora (Bakau) develops behind this zone. R. apiculata (B. minyak) is the most successful of all the species in Sarawak, forming extensive and almost pure stands in all the major areas. Species of Bruguiera (Berus) develop further inland where the frequency of inundation decreases and the mud is consolidated and stiff. Other common trees on stiff mud include Xylocarpus (Nyireh), Excoecaria agallocha (Buta Buta), and Heritiera (Dungun).

The most landward zone of the mangrove forest is made up of a number of transitional species of which the most common includes the Nibong (Oncosperma tigillarium). The other common palm, the Nipah (Nypa fruticans) thrives best on heavy, consolidated mud along inland channels.

Some of the mangrove swamps in the First and Sixth Divisions have been reclaimed for cultivation of coconut, rice and a number of other crops. Shifting cultivation is not practised within this forest type.

(ii) **Peat Swamp Forest**

This is a fresh water swamp which develops on dark brown and permanently water-logged peat. This forest occurs behind the mangroves and is concentrated along the coastal and deltaic swamps of the Second, Fourth and Sixth Divisions, forming an almost continuous strip and covering an area of approximately 14,660 sq. km.

Based on floristic composition and vegetation structures, six phasic communities or subtypes are recognised. These are:

a. Mixed swamp forest on the perimeter of the swamp, characterised by the presence of Ramin (Gonystylus bancanus) and Jongkong

(Dactylocladus stenostachys);

b. Alan forest dominated by large Alan batu (Shorea albida) with uneven canopy;

c. Alan bunga forest dominated by large Alan bunga (Shorea albida) with a close and cauliflower-like canopy;

d. Padang Alan forest near the centre of the swamp with small, pole-like trees of Shorea albida;

e. Mixed community dominated by Selunsor (Tristania), Ngilas (Parastemon) and Nyatoh (Palaquium). This is a narrow transitional zone;

f. Padang Keruntum at the centre of the swamp dominated by Keruntum (Combretocarpus rotundatus) and Jongkong (Dactylocladus stenostachys).

Forests on shallow peat occurring mainly in the coastal areas of the Third and Sixth Divisions have been cleared for rice, coconut and sago cultivation. Once again shifting cultivation is not practised within this forest type.

(iii) Mixed Dipterocarp Forest

The Mixed Dipterocarp forest grows on well-drained clay loam and clay soils. It extends from about sea level to an altitude of about 1,250m, covering an area of approximately 69,930 sq. km or 56% of the total area of Sarawak. The canopy layer is dominated by trees of the family Dipterocarpaceae which comprise between 30 to 60% of the total timber volume of the forest. It is here that shifting cultivation for hill padi predominates.

Members of the Dipterocarpaceae produce a major proportion of Sarawak's timber. Some of the well known species are Meranti and Selangan Batu (Shorea spp.), Kapur (Dryobalanops spp.) and Keruing (Dipterocarpus spp.).

The forest is further classified into:

(a) **Lowland Mixed Dipterocarp forest,** which occurs from sea level to about 500m a.s.l. This is commercially the most valuable forest as about 65% of the total 183 species of Dipterocarpaceae recorded in the Mixed Dipterocarp forest are concentrated here.

The forest was licensed for large-scale timber exploitation beginning around 1968. Long before this, however, shifting cultivators throughout the State had been cutting and burning large areas of the forest. While the forest is rapidly disappearing, demand and competition for land is steadily increasing. As a result, shifting cultivators have encroached into permanent forest in recent years. In addition, there is an increase in the alienation of land for housing, industrial and infrastructural developments near the urban areas and agricultural and rural development in the rural areas. The Lowland Dipterocarp forest will surely all disappear unless concerted efforts are made to preserve it.

(b) **Hill Dipterocarp forest** occurs from above 500m to 1,250m a.s.l. Here the number of Dipterocarp species is greatly reduced to only about 35% of the total, but the number of individuals of each species increases. The trees are smaller in size especially towards the upper limit of the forest zone, but the volume remains more or less the same as that in the lowland forest.

This forest is concentrated in the high mountain ranges in interior Sarawak. Because of the difficult terrain and access, this type of forest is still comparatively free from interference by shifting cultivators or logging interests. How long this will continue, particularly where timber interests are concerned, remains to be seen.

(iv). **Kerangas Forest**

'Kerangas' is an Iban word meaning land or forest where no rice can be grown. This forest develops on podzolised sandy soils which are very poor in nutrients and low in water retaining capacity. Thus although the forest is floristically very diverse, most of the trees are small and pole-like and exhibit xerophytic characters such as thick bark and small, thick leaves. Clearly the shifting cultivator himself is aware of the limitation of this type of land and consequently it is rarely used for hill padi cultivation.

The Area Under Shifting Cultivation

Due to the remoteness of the areas where shifting cultivation is undertaken, it is extremely difficult to accurately determine the annual hectareage that is planted to hill padi or the total area that is actively within the shifting cultivation cycle. The statistics that are available would suggest that in the 1980/81 season, 75,388 hectares (0.6% of land area of State) were cleared, burned and planted with hill padi. Of this area, 66,390 hectares were harvested. Details of the estimated areas under hill padi between 1960 and 1980 are given in Table 16. Table 17 gives details of the total padi hectareage and Table 18 the wet padi hectareage.

The true extent of shifting cultivation in terms of land use is best illustrated by a recent exercise in updating the mapping of areas which are either actively within the shifting cultivation cycle or have been slashed and burned for hill padi at least once. This has shown the area involved to be 3,178,085 hectares which represents 25.7% of the total land area of the State, and must serve to highlight the magnitude of the potential problem posed by shifting cultivation and its impact upon all aspects of life in Sarawak.

A divisional breakdown of the above figure is given in Table 19 and it can be seen that the First and Second Divisions are the most seriously affected. The areas of Sarawak that are either actively within the shifting cultivation cycle or which have been slashed and burned at least once are shown in Map 1. This information was produced by taking the 1:250,000 Land Use Map (Edition 2) and correcting the areas shown as shifting cultivation using Department of Forestry vegetation type maps, air photographs and Landsat imagery. It is considered that Map 1 represents the most up-to-date information on the extent of shifting cultivation.

TABLE 16

ESTIMATED AREA UNDER HILL PADI BY DIVISION 1960/61 - 1980/81
(IN HA)

DIVISION / YEAR(SEASON)	FIRST	SECOND	THIRD	FOURTH	FIFTH	SIXTH	SEVENTH	SARAWAK TOTAL
1960/61	7,080	13,563	36,034	11,791	4,385	-	-	72,853
1961/62	6,151	13,071	34,237	12,909	4,127	-	-	70,495
1962/63	9,362	13,938	31,346	13,091	3,692	-	-	71,429
1963/64	7,830	10,427	36,553	10,433	3,763	-	-	69,006
1964/65	6,325	10,788	38,381	9,851	4,008	-	-	69,353
1965/66	4,401	12,270	35,180	9,861	4,008	-	-	65,720
1966/67	6,461	11,138	37,448	9,943	3,125	-	-	68,115
1967/68	6,038	16,362	46,820	10,198	3,025	-	-	82,443
1968/69	10,152	16,038	47,089	10,279	2,836	-	-	86,394
1969/70	8,461	15,938	38,201	11,067	2,538	-	-	76,205
1970/71 P.A.	7,533	11,858	40,411	10,934	2,511	*	*	73,267
1971/72 P.A.	10,605	12,177	48,338	12,189	2,319	*	*	85,628
1972/73 P.A.	5,408	11,921	4,658	11,330	2,592	5,157	21,435	62,501
1973/74 P.A.	4,705	10,923	5,387	12,713	1,881	8,305	22,635	66,549
H.A.	4,267	10,487	2,795	12,160	1,881	8,264	22,209	62,063
1974/75 P.A.	4,637	12,136	6,055	13,344	2,919	8,637	16,473	61,201
H.A.	4,585	11,517	5,002	12,728	2,807	8,635	15,883	61,157
1975/76 P.A.	5,448	11,385	5,286	14,285	2,835	8,678	18,033	65,950
H.A.	5,443	10,396	3,909	13,787	2,795	8,655	17,131	62,116
1976/77 P.A.	5,000	11,157	6,474	14,323	2,914	4,392	19,291	63,551
H.A.	4,903	10,092	6,223	13,771	2,873	4,120	18,481	60,463
1977/78 P.A.	6,079	11,672	7,203	14,456	2,856	5,079	19,364	66,709
H.A.	6,077	11,424	7,090	13,909	2,659	4,856	19,239	65,254
1978/79 P.A.	5,893	12,110	8,527	14,595	2,630	10,061	19,293	73,109
H.A.	5,873	11,162	7,044	13,802	2,630	8,770	19,122	68,403
1979/80 P.A.	6,203	15,032	7,200	14,838	4,553	6,706	19,676	74,208
H.A.	6,203	12,992	7,151	13,482	2,490	6,601	18,305	67,224
1980/81 P.A.	6,553	15,032	7,264	12,930	2,742	12,257	18,610	75,388
H.A.	6,501	12,992	7,159	10,886	2,458	9,937	16,460	66,393

P.A. = Planted Area
H.A. = Harvested Area
* = Included under Third Division

Source: Dept. of Agriculture Statistics 1970-1981.

TABLE 17

ESTIMATED AREA UNDER PADI BY DIVISION 1959/60 - 1980/81
(IN HA)

DIVISION / YEAR(SEASON)		FIRST	SECOND	THIRD	FOURTH	FIFTH	SIXTH	SEVENTH	SARAWAK TOTAL
1959/60		19,320	25,507	39,458	14,958	5,232	-	-	104,475
1960/61		15,835	30,999	44,543	15,107	6,767	-	-	113,251
1961/62		13,071	32,335	42,452	16,875	6,596	-	-	111,329
1962/63		18,248	32,528	40,360	17,309	6,065	-	-	114,510
1963/64		17,498	24,501	47,220	17,940	6,191	-	-	113,350
1964/65		17,987	23,609	49,581	19,228	6,893	-	-	117,298
1965/66		13,690	26,860	50,994	12,907	7,015	-	-	111,466
1966/67		14,571	23,872	47,993	19,380	6,261	-	-	112,077
1967/68		16,253	29,036	59,858	19,282	6,161	-	-	130,590
1968/69		22,600	29,326	63,748	19,749	5,953	-	-	141,376
1969/70		20,339	30,720	51,119	20,536	5,554	-	-	128,268
1970/71	P.A.	21,299	28,785	59,905	19,322	5,528	*	*	134,839
1971/72	P.A.	23,912	27,616	67,115	21,185	5,862	*	*	145,690
1972/73	P.A.	12,937	30,891	8,327	18,966	6,440	11,267	21,852	110,680
1973/74	P.A.	12,837	28,788	9,802	21,305	5,931	15,299	23,245	117,207
	H.A.	12,128	28,334	6,189	20,288	5,810	15,253	22,812	110,814
1974/75	P.A.	13,959	28,644	11,077	22,581	7,182	17,691	17,243	118,377
	H.A.	13,739	27,079	9,457	21,734	6,964	17,689	16,647	113,309
1975/76	P.A.	14,339	31,552	10,227	24,234	7,374	17,429	18,861	124,016
	H.A.	12,618	29,325	8,284	22,974	6,651	17,352	17,817	115,021
1976/77	P.A.	16,604	33,471	16,225	24,355	7,253	13,256	20,175	131,339
	H.A.	16,097	31,671	15,831	23,491	6,409	12,936	19,307	125,742
1977/78	P.A.	17,950	35,121	15,953	24,844	6,985	14,120	20,181	135,154
	H.A.	17,690	34,600	15,697	23,998	6,519	13,581	20,053	132,138
1978/79	P.A.	18,506	35,086	17,581	25,282	7,077	20,179	20,012	143,723
	H.A.	18,437	33,090	15,926	24,090	6,511	18,799	19,833	136,686
1979/80	P.A.	18,517	38,440	16,597	26,004	9,109	16,735	20,205	145,607
	H.A.	18,485	35,920	16,400	24,086	6,802	16,566	18,828	137,087
1980/81	P.A.	18,840	38,569	16,187	24,282	6,679	22,682	19,094	146,339
	H.A.	18,672	36,051	15,906	17,350	6,376	20,326	16,915	131,596

P.A. = Planted Area H.A. = Harvested Area

* Included under Third Division

Source: Dept. of Agriculture Statistics 1970-1981

TABLE 18

ESTIMATED AREA UNDER WET PADI BY DIVISION 1960/61 - 1980/81 (IN HA)

DIVISION / YEAR(SEASON)		FIRST	SECOND	THIRD	FOURTH	FIFTH	SIXTH	SEVENTH	SARAWAK TOTAL
1960/61		8,754	17,436	8,509	3,186	2,381	-	-	40,266
1961/62		6,920	19,263	8,215	3,966	2,468	-	-	40,832
1962/63		8,886	18,590	9,014	4,217	2,373	-	-	43,080
1963/64		9,667	14,073	10,667	7,506	2,428	-	-	44,341
1964/65		11,662	12,820	11,200	9,377	2,885	-	-	47,944
1965/66		9,288	14,589	15,813	3,046	3,007	-	-	45,743
1966/67		8,110	12,734	10,544	9,437	3,136	-	-	43,961
1967/68		10,215	12,674	13,038	9,083	3,136	-	-	48,146
1968/69		12,447	13,288	16,658	9,469	3,116	-	-	54,978
1969/70	P.A.	11,877	14,781	12,918	9,469	3,015	-	-	52,060
1970/71	P.A.	13,746	16,927	19,494	8,388	3,017	*	*	61,572
1971/72	P.A.	13,307	15,439	18,777	8,996	3,543	*	*	60,062
1972/73	P.A.	7,529	18,970	3,669	7,636	3,848	6,110	417	48,179
1973/74	P.A.	8,132	17,865	4,415	8,592	4,050	6,994	610	50,658
	H.A.	7,861	17,847	3,394	8,128	3,929	6,989	603	48,751
1974/75	P.A.	9,322	16,508	5,022	9,237	4,263	9,054	770	54,176
	H.A.	9,154	16,562	4,455	9,006	4,157	9,054	764	52,152
1975/76	P.A.	8,891	20,167	4,941	9,949	4,539	8,751	828	58,066
	H.A.	7,175	18,929	4,375	9,187	3,856	8,864	686	52,905
1976/77	P.A.	11,604	22,314	9,751	10,032	4,339	8,868	884	67,788
	H.A.	11,194	21,579	9,608	9,720	3,536	8,816	826	65,279
1977/78	P.A.	11,871	23,449	8,750	10,388	4,129	9,041	817	68,445
	H.A.	11,613	23,176	8,607	10,089	3,860	8,725	814	66,884
1978/79	P.A.	12,613	22,976	9,054	10,687	4,447	10,118	719	70,613
	H.A.	12,564	21,928	8,882	10,288	3,881	10,029	711	68,283
1979/80	P.A.	12,314	23,408	9,397	11,166	4,556	10,029	529	64,721
	H.A.	12,282	22,928	9,249	10,604	4,314	9,965	523	63,234
1980/82	P.A.	12,293	23,537	8,923	11,352	3,937	10,425	484	70,951
	H.A.	12,171	23,059	8,747	6,464	3,918	10,389	455	65,203

P.A. = Planted Area
H.A. = Harvested Area
* = Included under Third Division

Source: Dept. of Agriculture Statistics 1970-1981.

TABLE 19

AREA OF SHIFTING CULTIVATION BY DIVISION

Division	Total Area (ha)	Shifting Cultivation (ha)	% Shifting Cultivation
First	863,163	411,278	47.6
Second	997,584	534,511	53.5
Third	1,284,813	449,332	34.9
Fourth	3,849,128	821,802	21.3
Fifth	773,317	168,342	21.7
Sixth	664,330	263,349	39.6
Seventh	3,892,873	529,471	13.6
TOTAL:	12,325,208	3,178,085	

By using the above figures for total shifting cultivation area (3,178,085 hectares) and 1980/81 planted area (75,388 hectares), one arrives at an average forest fallow period for the State of 42 years! However, it is quite clear from the various surveys that have been conducted that the average forest fallow period for the State is far less than 42 years and is probably in the region of 10-15 years. Indeed, were the average fallow period actually 42 years, then it is likely that shifting cultivation in Sarawak would not be such a source of concern and the per hectare yields would be much higher.

If, therefore, we take the average fallow period to be 15 years then either there is a substantial proportion (amounting to some 2.04 million hectares) of the area shown on Map 1 that is not actively within the shifting cultivation cycle or the figure given for annually planted area (75,388 hectare) is wrong by a factor of nearly three and should be in the region of 200,000 hectares.

Map 1 shows the area that is either actively within the shifting cultivation cycle or which has been slashed and burned for hill padi at least once. However, due to the scale of the mapping employed, it has not been possible to separate out the considerable areas within kampung or long house holdings that are not used for shifting cultivation. This area would include very steep land (too steep even for the shifting cultivator), pepper gardens, cocoa gardens, small areas of wet padi, some rubber gardens, cemetaries, reserved land, fruit trees and the kampung area itself. In his survey at Ng. Tapih, Cramb (forthcoming) mapped the different land uses and these are given in Table 20 below.

TABLE 20

LAND USE AT NG. TAPIH

Land Use	Area (ha)	%
Rubber	166.7	27
Pepper	8.6	1.4
Forest Reserve	6.3	1
River Reserve	22.3	3.6
Settlement	1.16	0.2
Former Longhouse Sites	1.19	0.2
Hill Padi Area	406.22	66
TOTAL:	612.47	100

Source: Cramb (forthcoming).

In this case, at least 66% of the land area of the kampung is used for shifting cultivation. In fact it will probably be somewhat higher than this since it is quite normal for a proportion of the rubber gardens to be included within the hill padi cycle. It seems likely, therefore, that of the total land holding at Ng. Tapih, approximately 75% could be considered to be within the hill padi cycle whilst 25% is not used for shifting cultivation. If we extrapolate this to the Statewide figure for shifting cultivation, then the actual area involved would diminish from 3,178,085 hectares to approximately 2,383,563 hectares. If we once again use the Dept. of Agriculture estimate for 1980/81 planting of 75,388 hectares, we now arrive at an average forest fallow period of about 30 years. This still appears to be very high. If the figure for annual planting was assumed to be fairly reliable then this would mean that either the area shown on Map 1 was seriously wrong or that there has been a significant reduction in the area planted to hill padi and large areas of what appear to be shifting cultivation are no longer within the cycle. Since Map 1 is considered to be at least reasonably accurate, and there is no evidence to support a supposition that the annual area planted to hill padi has decreased greatly in recent years, it seems more likely that the error lies with the estimate of annual planting. If we assume that the figure of 2,383,563 hectares is a true reflection of the extent of shifting cultivation in the State, then once again by applying the average forest fallow period of 15 years we find that the annual planting would be in the region of 150,000 hectares or double the current Department of Agriculture estimate.

It would appear that the Department of Agriculture estimate for cleared and planted area is rather suspect. They are based upon reports from District staff who frequently do not visit the farms concerned to make confirmatory measurements. In addition, there is a strong likelihood that pressure of work prevents the staff from interviewing all farmers in their areas and the estimates are based purely upon the staff's 'guesstimates'.

A further cause of error would occur in those cases where the estimates are based upon the farmer's own estimates of their farm size. This has been highlighted by a study carried out in August 1982 in cooperation with Best (forthcoming).

An attempt was made to compare various methods of gauging the area of hill padi farms to see which method gives the figure closest to the actual area of the padi farm as determined by a detailed ground survey using a theodolite. Five separate hill padi farms were used in the survey and the three methods used to determine area were, (a) farmers estimation, (b) quantity of seed sown and (c) planimetric measurement of farms located on aerial photographs. The results of this survey are given in Table 21.

TABLE 21

HILL PADI FARM AREA SURVEY - PADAWAN

	FIELD				
	1	2	3	4	5
Actual Area (ha)	0.42	0.24	0.51	0.67	2.28
Plan Area (ha)	0.38	0.23	0.449	0.60	1.78
Average Slope of Field	26	16	29	26	39
Slope Factor %	12	4	14	12	28
Farmers Estimation(ha)	0.5	0.3	0.4	0.5	1.01
Quantity of Seed (ha)	2.48	1.45	1.65	2.07	8.29
Area from Aerial photo (ha)	1.88	1.14	1.3	1.21	2.67

The conclusions from this survey can only be tentative since the sample was small but they do show that the most consistently accurate method would be the amount of seed sown. If the figures for total quantity of seed sown as given in Table 21 are divided by the normal rate of seeding of 23kg/ha (4 gantangs/acre) then the areas are 0.6, 0.35, 0.4, 0.5 and 2.02 hectares respectively. Farmer's estimates do not appear to be very accurate and could be very much in error, particularly for larger fields. Use of aerial photos where the exact boundary of the field is not known appears to be very inaccurate. The only cases where aerial photographs could provide accurate data is when the photograph is taken reasonably soon after the burn when field boundaries, which are normally very irregular, can be clearly seen. Table 21 also gives some data on the percent differences (slope factor) between actual area and plan area caused by ground slope.

It would appear from this preliminary survey that farmer's estimates cannot be relied upon to give an accurate assessment of the area planted to hill padi each year. Use of aerial photos also appears to be very unreliable.

However, the quantity of seed sown does give a consistent approximation of hill padi farm area.

Further evidence in support of the view that the annually cleared area is larger than current statistics suggest is provided by an exercise undertaken to map the changes that have taken place in the area under shifting cultivation in some selected watersheds. This has been done by plotting the area under shifting cultivation as delineated on old 1:50,000 scale topographic maps (derived from aerial photography) and then determining subsequent changes that have taken place by using more recent satellite imagery. This has been done for the Rajang, Tatau and Kemena rivers and the results of the mapping are shown in Maps 2, 3 and 4. These watersheds were chosen because they were the only ones for which there was good, cloud-free Landsat photographs available. Shifting cultivation has increased in all three watersheds and details of this are given in Table 22.

TABLE 22

EXPANSION OF SHIFTING CULTIVATION IN THREE SELECTED WATERSHEDS

	Kemena	Tatau	Rajang North	Rajang South
Date of 1:50,000 Maps used as base	1956	1956	1958	1960
Date of Landsat	1972	1972	1973	1973
1:50,000 Area (ha)	50,017	29,920	373,298	188,141
Landsat Area (ha)	118,389	48,468	472,650	248,139
% Increase	107	62	27	32

If the boundaries of shifting cultivation have not over time been advancing then this could indicate that the annual area planted was indeed of the order of 75,000 hectares and that the total area that was or had been within the cycle (i.e. 3.1 million hectares) could not be used as a guide to the amount being cut and burned annually. In other words, a very substantial amount of the area shown in Map 1 was no longer within the shifting cultivation cycle. However, since the boundaries of shifting cultivation are apparently expanding, it would seem likely that a very substantial proportion of the area shown in Map 1 is still actively within the hill padi cycle. Were it not so, then forest fallow periods would be longer than 10-15 years and there would be no regular expansion of the shifting cultivation boundaries. Clearly since the latest date available in the study for Landsat imagery is 1973 any changes and possible major reductions in shifting cultivation in the past ten years are not shown. However, there is no reason to suppose that there have been any major shifts in hill padi cultivation over the last ten years and it is considered that those trends shown in Table 22 are still continuing and shifting cultivation is increasing by a modest amount each year.

It is interesting to note that the rate of expansion in the Kemena and Tatau areas is much higher than the Rejang. This is also supported by the reports of Cramb and Dian (1979) on the Bintulu and Selangau Extension Regions where they reported that significant areas of virgin jungle were being cleared annually for hill padi. This area of the Fourth Division does appear to be a region into which recent migration by shifting cultivators has taken place and this is reflected in the clearance of primary forest and the expansion observed in the mapping exercise. The situation in the Tatau and Kemena watersheds contrasts significantly with that in the Rejang where expansion is only very slow and probably only reflects population growth.

The Shifting Cultivators

The population of the State of Sarawak in 1980 has been estimated at 1,294,793. Table 23 gives the breakdown of this population by main racial groups for 1976. The breakdown for 1980 was not available at this time.

Of these seven racial divisions the most important with respect to shifting cultivation are the Iban, Land Dayak, and other Indigenous. The Chinese and Malay are largely confined to urban areas or practising settled, intensive agriculture for pepper, cocoa, coconut, wet padi and horticultural crops. Fishing is also an important activity for coastal Malays. Those conducting shifting cultivation are the Iban, Land Dayak, Kayan, Kenyah, Kelabit and Murut but it is the Iban and Land Dayak who have the greatest impact via this method of agriculture since their population is larger than any other indigenous group.

Sarawak is divided into seven administrative areas called Divisions and the populations and areas of these Divisions are given in Table 24.

Since the Iban and Land Dayak form the bulk of the shifting cultivation population, their distribution within Sarawak is of some importance in any consideration of shifting cultivation and with the Iban particularly, their past migrations were of great moment.

Prior to early 1500's, Sarawak was an almost totally unpopulated region of virgin forest. The scattered tribes that did exist were hunter-gatherers and had little impact upon the land. However, in the middle of the sixteenth century the Iban migrations began from the middle reaches of the Kapuas River (now in Kalimantan) (Sandin, 1967). By migrating through the low watershed between the Kapuas River systems and those of the Ai and Lupar, they had by the beginning of the nineteenth century become firmly established in the watersheds of the Lemanak, Ai, Lupar, Saribas and Layar rivers (Second Division). The Iban were shifting cultivators and Freeman's (1970) description of the later Iban migrations into the Rajang watershed could equally apply to and reflect the impact that these peoples have always had on the environment of Sarawak.

> "They were a virile and truculent people, whose whole way of life was based on the cultivation of hill rice. For them the virgin forests (of the valley of the Rajang) held the promise of those bountiful and heavy harvests which are the foremost aim of all Iban endeavour".

During the nineteenth century there occurred a second Iban migration north-eastwards so that eventually they became firmly established along the Rajang, Baleh, Oya,

TABLE 23

POPULATION OF SARAWAK BY MAIN RACIAL GROUP

Racial Group	1970 Census	1976 Estimate
Iban	302,984	315,591
Chinese	294,020	341,200
Malay	182,709	212,274
Land Dayak	82,276	96,917
Melanau	53,234	61,706
Other Indigenous	49,960	57,911
Others	9,735	11,284
TOTAL:	975,918	1,131,234

Source:- 1970 Population and Housing Census of Malaysia - March 1972.

TABLE 24

DIVISIONS OF SARAWAK, POPULATION AND AREA

Division	Area (ha)	Population	Density (person/km^2)
First	863,163	465,339	539
Second	997,584	165,349	165
Third	1,284,813	221,822	172
Fourth	3,849,128	210,759	54
Fifth	773,317	45,961	59
Sixth	664,330	118,062	177
Seventh	3,892,873	67,461	17
TOTAL:	12,325,208	1,294,753	105

Source: 1980 Population Census

Mukah, Tatau and Kemena rivers. These migrations were by no means conducted peacefully and in their pioneering drive to find virgin jungle for hill padi cultivation, the Iban continually came into conflict with other races such as the Kayan and Kenyah and eventually with a Brooke administration that was attempting, not very successfully, to curb the Iban migrations.

The Land Dayak, who orginally moved northwards from the south-west corner of Borneo (Jackson, 1968) have in comparison to the Iban, shown little tendency to undertake any major migrations. They are a comparatively peaceful and sedentary group and as noted by Geddes (1954):

> The Sadong (Land Dayaks) are not nomadic but they tend to stray a little every few generations - not far, but often far enough to need some new arrangement with their neighbours".

Hence we now have a situation where the two racial groups who traditionally conduct hill padi cultivation by the slash and burn system are located over extensive areas of Sarawak. The Land Dayak are confined almost entirely to the First Division whereas the much larger Iban population, by virtue of their past migrations can be found in all seven Divisions of the State.

The Shifting Cultivation System in Sarawak

The general features of shifting cultivation from other parts of the world but particularly from Thailand have already been described. Now we shall devote our attention to a consideration of the details of shifting cultivation as they are to be found in Sarawak. In very many ways, these features, not suprisingly, bear a very close resemblance to those of the Lua and Karen hill farmers of Thailand. All of the shifting cultivators in Sarawak are of the Integral and Traditional type where mostly only secondary jungle is cleared each year and the system is practised along traditional lines that do give every chance for a balanced system to subsist.

Whilst there are differences between the ways in which shifting cultivation is practised between the different groups in Sarawak, these are really quite minor and will be highlighted only if necessary. Differences tend to be of degree rather than fundamental and so need not be considered in any great detail.

The shifting system, as practised in Sarawak, fits well into the definition given earlier by Watters (1971), but traditionally it has tended towards the extremes, i.e. very short cropping periods and long forest fallows. Where virgin jungle is available then the land may be cropped with hill padi for two successive years but in secondary jungle only one crop (of rice) is generally taken and then the land is fallowed for a long period, usually in excess of ten years.

The Village Community

The Iban, Kayan, Kenyah and Murut have traditionally (and still do) lived in longhouse communities of a varying number of households or doors. The average number of households per longhouse would appear to be in the region of 20-30 but the range can be very large indeed, from only one or two up to several hundred. The average number of persons per household is normally taken as six but this may vary slightly from area to area. The Land Dayak, whilst also living in longhouses to some extent, have shown more of a tendency to live in separate houses within the village rather than under one longhouse roof. There is no doubt that this trend is accelerating quite rapidly amongst the Land Dayak in the First Division, and the longhouses are slowly disappearing.

The Land Holding

This is by no means a simple matter and the reader should refer to other more detailed publications to obtain some idea of the ramifications of family land ownership (e.g. Best, 1977). Not only will each household have land upon which shifting cultivation for hill rice is practised, but it will also have an area of rubber, pepper or possibly cocoa. Those households without a cash crop of some kind would be very much in the minority. Map 5 shows the details of the land use of Kg. Pain/Sait in the First Division. This map was produced by a member of the village and gives some idea of the many different types of land use to be found there. The average area of land cleared each year for hill padi is enormously variable and the extensive surveys done by Cramb and Dian (1979) showed ranges of from 0.08 - 9.31 hectares (Table 25).

From this survey the average size of hill padi farm is 1.62 hectares and if one assumes an average forest fallow period of 10 years then it is clear that each shifting cultivation household will have within its ownership or control at least 16.2 hectares of land that is used for shifting cultivation. This is likely to be something of an underestimate since it appears that many shifting cultivators can call upon land that has been under a longer fallow than 10 years. However, it may represent a more accurate picture in the long settled and more densely populated areas such as the First and Second Divisions.

The Hill Padi Cycle

The whole process of growing hill padi by shifting cultivation is surrounded by much ritual and superstition and each stage of the cycle is normally marked by rigid adherence to certain religious practices that ensures that the padi gives a bountiful harvest. To the shifting cultivator of Sarawak, in common with shifting cultivators from many other parts of the world, the growing of hill padi (or other staple) is not merely a system of providing food but is a practice that permeates nearly every aspect of his social organisation and religious belief (Hatch, 1979). This is neither the time nor place to go into great detail concerning the religious aspects of hill padi cultivation and the reader should refer to the many excellent and detailed works on this subject by writers such as Freeman (1970), Jensen (1974) and Geddes (1954).

The annual cycle of hill padi cultivation can be taken as beginning in the dry (or drier!) season months of June and July when areas of jungle (either secondary or primary) are cut down. This is an occupation very much favoured by the men of the household but the women also help particularly in the slashing of the thinner underbrush. Secondary jungle is now the type that is predominantly cleared but there is still a substantial area of primary jungle cleared every year although the total area involved is not known. Where the men of the household are not present because they are seeking or holding wage-paid

TABLE 25

AVERAGE FARM SIZES

Extension Region	% Households Hill Padi	% Households Wet Padi	Hill Padi Farm Size (hectares) Average	Range	% More Than One Farm
Serian	94	43	1.17	0.08-3.24	32
Engkilili	100	3	1.82	0.28-3.8	24
Ng. Spak	100	0	1.66		28
Debak	35	76	0.69	0.12-1.66	0
Julau	95	3	1.62		28
Dalat	73	85	1.34	0.08-3.93	21
Selangau	75	51	1.42	0.2-6.27	5
Bintulu	98	71	1.54	0.32-3.76	15
Belaga	98	5	2.31	0.4-6.07	54
Baram	100	20	2.02	0.4-7.28	
Merapok	36	71	0.93	0.32-1.34	0
Lg. Sukang	84	76	2.99	1.42-9.31	9
			1.62	0.08-9.31	

Source: Cramb & Dian (1979).

employment, then the women must do all the farm work. It is quite common in such cases for only short fallow secondary jungle to be cleared for the farm. The number of plots slashed by each household can vary from only one up to as many as three or four and in addition they might be quite widely separated. In their surveys, Cramb and Dian (1979) noted that 20% of households had more than one hill padi farm and these were located up to an hour's walk from the village.

The age of the jungle cleared (the forest fallow period) is obviously of the greatest importance since as has previously been discussed, it has very major implications for the fertility of the soil and hence the yields obtained from it. The fallow periods on the farms surveyed by Cramb and Dian (1979) are presented in Table 26 and it can be seen that once again the situation is quite variable.

The data from Table 26 show that on average about 50% of the households are farming land which has been fallowed for ten years or less whilst the other 50% are utilising land which could be considered to be in a better state of recovery. In fact, the averages from these figures, not surprisingly, tell us very little. However, by looking at the figures from Engkilili it is possible to view what may be the long term trends for a significant number (if not all) of shifting cultivators in Sarawak. Engkilili is in that part of the Second Division that has been long settled by the Iban and consequently has been most intensively farmed by shifting cultivators. Very little if any pioneer areas remain in this region. It is disturbing to note that in contrast to many other areas, 70% of the farmers are using land that has been fallowed for ten years or less and a very significant proportion (27%) are farming land that has only been fallowed for four years or less. This represents a very disturbing trend and one which must have serious implications for the long term integrity of the soils in regions such as this.

Padoch (1982) made a study of two Iban communities in the First Division (Ensabang River) and the Second Division (Engkari River). Her data on fallow periods is rather sketchy but are nevertheless reproduced in Tables 27 and 28. She points out that the Iban in the lower Engkari have been farming there for almost three hundred years and yet the land still appears to be productive. She contrasts this with the view expressed by Freeman (1970) that the Iban are "eaters of the forest" and are in the long term very destructive. The fact that the land in the Engkari region

TABLE 26

FALLOW PERIODS FROM EXTENSION REGION SURVEYS
(% Of Farms)

Extension Region	0	1-4	5-9	10-24	24+	Primary Jungle
Serian						
Engkilili	10	17	43	12	18	0
Ng. Spak	0	2.8	30.6	52.8	11.1	0
Debak	0	0	41.7	58.3	0	0
Julau	0	14	48	22	3	13
Dalat	0	56.6	21.8	13	8.7	0
Selangau	0	9.8	24.4	31.7 (10-14)	9.8 (15-19)	17.1
Bintulu	7	11.3	38	21.1	2.8	19.7
Belaga						
Baram						
Merapok						
Lg. Sukang	0	0	31 (3-9)	52 (10-19)	13 (20+)	4
AVERAGE:	21	14	35	33	8.3	6.7

Source: Cramb and Dian (1979).

TABLE 27

FALLOW PERIODS FROM NG. JELA, ENGKARI RIVER

Duration (in years) of last fallow	Number of farms 1973-4	(N=39) 1974-5
Less than 1	0.5	0
1	0	0
2	0	0
3	0	0
4	4.5	2
5	4	5.5
6	6	5.5
7	5	4
8-10	7.5	5
11-15	6	7
16+	5.5	10

Source: Padoch (1982).

TABLE 28

LAND USE ON SUNGAI PELAI (ENSABANG RIVER)

Types of land farmed	Number of households 1974-5	1975-6
Primary Forest Only	7	18
Primary for./Sec. growth	9	15*
Primary for./Swamp	16	27
Primary for./Sec. gr./Swamp	9	4
Sec. growth/Swamp	2	0
	N=43	N=64

*½ fallowed less than 1 year. Source: Padoch (1982).

is still productive even after 300 years of shifting cultivation highlights the equilibrium that this system can attain under traditional practice. Padoch's (1982) data from the Ensabang area do not truly represent an exclusively shifting cultivation community since many of the households are also farming wet land.

The data of both Cramb and Dian (1979) and Padoch (1982) do indicate that a fair proportion of virgin or primary jungle is still being cut by shifting cultivators. The mapping data previously presented from the Kemena and Tatau systems also tend to support this. The extent to which this occurs, however, is very controversial with timber interests claiming that the annual destruction of valuable and marketable timber is very large. The reasons why shifting cultivators continue to clear virgin forest are many but include high fertility of the soils, reduction of weeding, extension of land holding and acquisition of forest products for food and other uses (Padoch, 1982).

Whatever type of jungle has been cleared for the crop, the slashed area is left to dry for three to six weeks and sometimes longer depending upon weather conditions. A relevant side effect of the slashing at the beginning of the dry season is the fact that it markedly reduces evapo-transpiration water losses and therefore improves the moisture status of the shifting cultivation soils in comparison to adjoining jungle areas over this very critical period (Kunstader, Chapman & Sabhasri, 1978). Hence the crop should be in a more advantageous position to make quick germination and early growth.

The burn which ideally takes place after the cut vegetation has completely dried out but just before the first monsoon rains, is of absolutely critical importance to the following crop, its yield and ease of maintenance. A good hot and complete burn has enormous advantages for the farmer and can be listed as follows:-

1) Releases the maximum quantity of nutrients from the cut vegetation.

2) Physically cleans the area thoroughly and therefore helps planting and other management practices.

3) Kills or reduces the viability of many weeds and weed seeds.

4) Kills pests living in the field.

Even a very fierce burn will not consume many of the thicker logs and branches and these are in general just left lying randomly in the field.

If in contrast, the burn is poor because insufficient time was allowed for the vegetation to dry out or because some early rains moistened the slashed vegetation, the farmer can expect to encounter real problems with his hill padi crop. Fertility will be lower because of the reduced quantity of ash deposited on the soil surface, weed growth will be faster and more widespread, pests will be present in greater abundance and movement around the field may be severely restricted. Many farmers (after a poor initial burn) do attempt to reburn or even stack and reburn vegetation that the first burn failed to consume. However, there is no doubt that reburned fields seldom yield as well as those that have had good initial burns.

Planting immediately follows the burn and involves the whole family group. There is a definite urge to plant as quickly as possible since all farmers understand the importance of giving the padi a 'head start' on the weeds. The padi seed is placed into cone-shaped holes made by a pointed dibbling stick (tugal). Normally teams of men dibble the holes and groups of women and children follow on depositing, often with great accuracy and dexterity, a small amount of padi seed into the holes. The holes are made randomly but on average the spacing of hill padi is about 30cm. In common with other traditional shifting cultivators, those in Sarawak also plant a large variety of inter-crops. Particularly important in this regard is Zea spp. (Maize), Dioscorea spp. (Yams), and Cucumis spp. (Cucumber). Coix lachryma - jobi (Job's Tears) is often planted along field margins and Manihot spp. (Tapioca) is very frequently interplanted with the padi for harvest in the following year before the field enters the fallow cycle. Sometimes these inter-crops will be planted just before the padi and very frequently they are concentrated in areas of the field where fertility is clearly higher either through topsoil accumulation (flatter areas) or because of an accumulation of ash from a dense area of vegetation or a reburned area.

The growing of one hill padi variety in a single field is most unusual and it is generally found that at least three, and often more different varieties of padi are planted, each of which when harvested will have a particular use (food, making alcohol, feeding animals etc). Shifting cultivators in Sarawak are particularly interested in rice and will normally be extremely anxious to try out any new variety that attracts their attention. Consequently, there is a bewildering number of hill padi varieties in use throughout the State but it is very likely that many of them are in fact the same variety but with a different local name. All of the hill padi varieties are long maturing, taking about 180 days and they show only poor responses to fertiliser, particularly nitrogen. Further details on the characteristics of hill padi are given in a later section.

Weeding will commence one or two months after planting depending on the condition of the field and the diligence of the household. As has been previously highlighted, weeding is both the most onerous and most critical of the farm management operations and this applies just as much to the Sarawak shifting cultivators as it does to other groups. The predisposition of the Iban towards using virgin jungle for their hill padi has, as one of its roots, the fact that weeding requirements on such land will be quite low. Indeed, Padoch (1982) observes that whilst both her and Freeman's estimates show that slashing and felling primary forest requires up to 50 man-days per hectare, such fields do not generally require any weeding. In contrast to this, an area of young secondary growth only takes about 25 man-days per hectare to cut but will almost certainly need several weedings.

Weeding is predominantly the work of the woman and they generally do one complete round and sometimes two but rarely three. The importance of weeding is also clearly shown by the survey done by Cramb and Dian (1979) in the Nanga Spak Extension Region. Here, they found that some downriver longhouses had deliberately 'intensified' their hill padi operation by reducing farm size to about one quarter of the previous level in order to release labour to undertake increased cash crop (pepper) farming. This reduction appeared to result in an increase in the yield per unit area on the smaller downriver farms. One of the very important contributory factors towards this increased yield was the much increased time that was available for the weeding operation.

Farmers very readily appreciate the importance of the weeding operation and the trend towards use of weedicides is very clear despite the high price of these materials. In their survey, Cramb and Dian (1979) reported that on average 20% of households were using herbicides on their hill padi. The range of use varied from 0 to 50% (of households) depending on the area surveyed. Of course use of herbicides (usually Gramoxone) in hill padi farms is quite difficult and risky because of the dangers of drift. However, many hill padi farmers show great ingenuity when spraying their padi and often enclose the head of the sprayer by a tin can so that drift to the crop is minimised. Despite this precaution, scorching of the padi is quite frequently observed in hill padi fields where herbicides have been employed. Cramb (forthcoming) reports that use of herbicides still appears to be increasing.

Harvesting of the padi takes place in February/March after approximately 160 days growth. Normally, only the ears of the rice are harvested using a small cutting tool and the padi is carried back to the longhouse where it is threshed. Methods of storage vary somewhat and from race to race. The Land Dayak often store their padi in small separate buildings close to the longhouse. The Iban, however, generally store their padi in bins in the loft of the longhouse itself. It is likely that losses to pests in storage are very high and considerable effective increases in yield could be achieved if these losses could be minimised.

The yields from hill padi farms in Sarawak are a constant subject of speculation, discussion and argument and the only definite statement that can readily be made is that they vary a great deal! To place the yields and production of hill padi in context it would be as well to firstly consider the rice situation in the whole of the State. In 1980/81 the total padi production in Sarawak (both hill and wet) was 177,090 metric tons. Table 29 gives the padi production by Divisions from 1960 to 1980, whilst Tables 30 and 31 give the breakdown into hill and wet padi. This information is also displayed in graph form in Figure 2. - It can be seen that up to 1963/64, the production of both hill and wet padi was approximately the same but since then the production of wet padi has increased dramatically whilst hill padi has remained fairly constant in the region of 50,000 metric tons per annum. Table 32 gives the percentage contribution of padi production by hill padi.

Whilst padi production has steadily increased over the years, largely as a result of increases in wet padi yield, it has really only kept pace with increases in demand. The percentage of rice imported into Sarawak has really not changed significantly over the years. Table 33 gives details of this.

The figures for per hectare yields in total and for

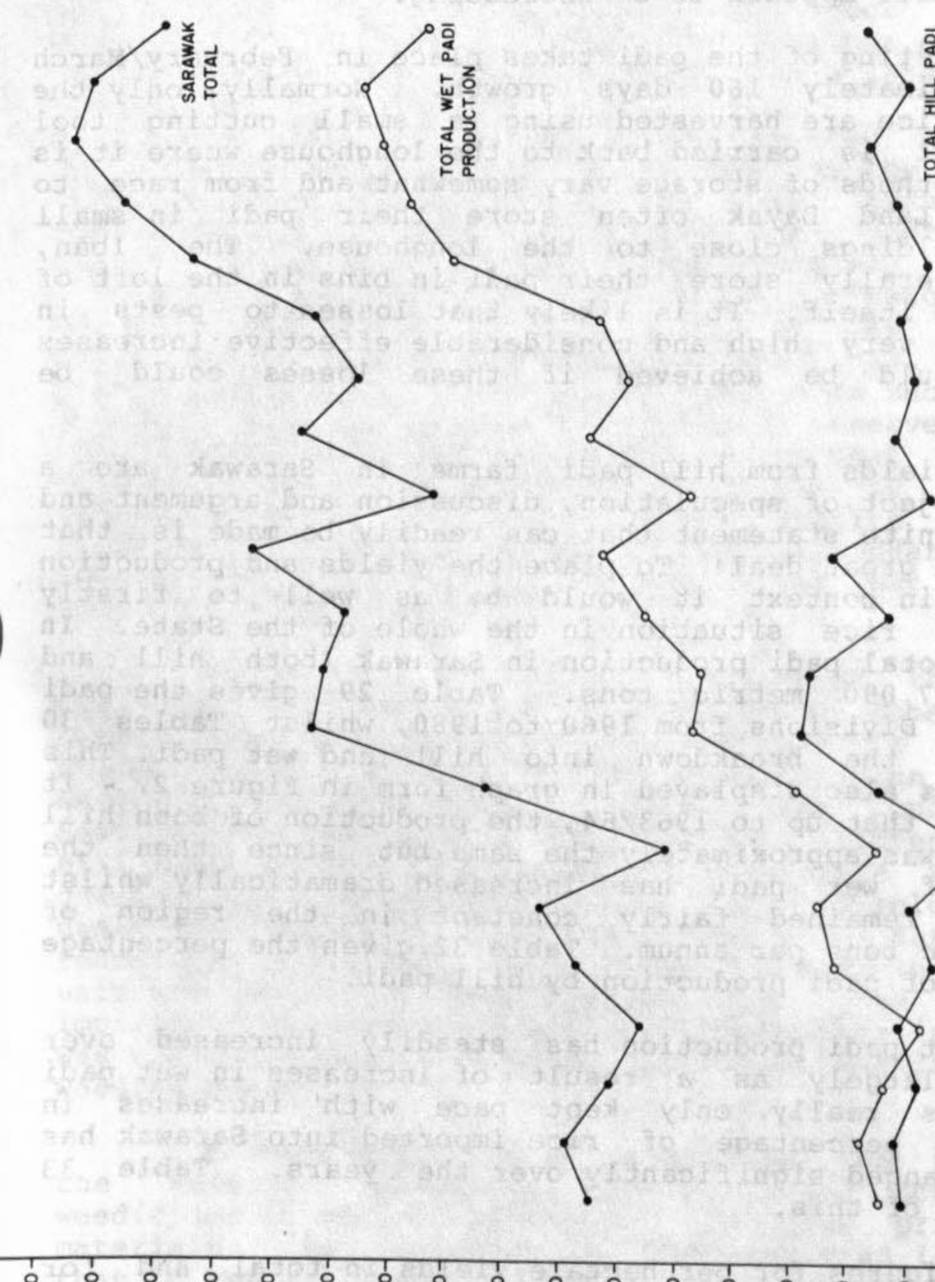


FIG. 2 WET PADI, HILL PADI AND TOTAL PADI PRODUCTION IN SARAWAK, 1960/61 TO 1980/81

TABLE 29

PRODUCTION OF PADI BY DIVISION, 1960/61 - 1980/81
(IN METRIC TON)

DIVISION / YEAR(SEASON)	FIRST	SECOND	THIRD	FOURTH	FIFTH	SIXTH	SEVENTH	SARAWAK TOTAL
1960/61	11,761	47,874	28,965	10,851	4,864	+	+	104,315
1961/62	N.A.	N.A.	N.A.	N.A.	N.A.	+	+	108,410
1962/63	11,018	43,960	39,547	7,810	4,188	+	+	100,523
1963/64	13,838	20,640	43,656	14,065	4,344	+	+	96,543
1964/65	14,720	25,794	37,840	20,743	7,079	+	+	106,176
1965/66	8,042	28,589	49,672	18,898	7,663	+	+	112,864
1966/67	14,263	25,771	21,952	20,307	8,282	+	+	90,575
1967/68	19,143	27,274	44,048	21,882	8,913	+	+	121,260
1968/69	28,950	28,747	60,346	23,783	10,138	+	+	151,964
1969/70	23,125	37,994	56,440	24,574	8,290	+	+	150,423
1970/71	28,128	39,187	47,634	23,336	8,132	+	+	146,417
1971/72	24,462	42,913	58,612	57,330	9,079	+	+	162,396
1972/73	21,073	40,176	9,175	21,178	12,507	13,574	12,271	129,954
1973/74	22,828	48,718	7,192	28,183	11,609	19,932	14,920	153,382
1974/75	20,400	30,672	9,683	33,621	13,532	24,271	12,033	144,212
1975/76	17,186	39,660	8,827	36,888	10,866	23,973	13,673	151,073
1976/77	23,180	49,513	22,471	35,609	10,927	16,828	13,662	172,190
1977/78	26,098	51,518	21,597	39,793	12,583	18,471	14,048	184,106
1978/79	29,730	49,324	21,557	40,885	10,699	25,672	14,610	192,477
1979/80	29,224	53,303	24,410	39,028	11,482	20,422	12,202	190,071
1980/81	27,602	53,874	23,401	21,911	12,395	26,015	11,892	177,090

\+ Under Third Division
N.A. Not available

Source: Dept. of Agriculture Statistics 1970-1981.

TABLE 32

PERCENTAGE PRODUCTION OF HILL PADI, 1960/61 - 1980/81

Year (Season)	Total Wet Padi Production (M.T.)	Total Hill Padi Production (M.T.)	Sarawak Total (M.T.)	% of Hill Padi Production
1960/61	53,948	50,366	104,315	48.28
1961/62	56,696	51,714	108,410	47.70
1962/63	53,172	47,348	100,523	47.10
1963/64	46,581	49,962	96,543	51.75
1964/65	61,940	44,235	106,176	41.66
1965/66	64,551	48,312	112,864	42.81
1966/67	53,749	36,825	90,574	40.66
1967/68	67,884	53,371	121,260	44.01
1968/69	85,145	66,818	151,964	43.97
1969/70	84,035	66,387	150,423	44.13
1970/71	94,612	51,805	146,417	35.38
1971/72	101,224	61,172	162,396	37.67
1972/73	85,746	44,208	129,954	34.02
1973/74	103,299	50,083	153,382	32.65
1974/75	97,030	47,182	144,212	32.72
1975/76	101,276	49,797	151,073	32.96
1976/77	127,370	44,820	172,190	26.03
1977/78	134,143	49,963	184,106	27.14
1978/79	139,671	53,806	492,477	27.96
1979/80	142,517	47,554	190,071	25.02
1980/81	131,526	54,564	177,090	30.81

M.T. = Metric ton

wet and hill padi are given in Tables 34, 35 and 36. This information is also given graphically in Figure 3. It can be seen that the total yield of padi has increased from an average of 939 kg/ha in 1960/61 to 1346 kg/ha in 1981 but all of this increase in yield has been contributed by the increases in wet padi production from 1,109 kg/ha in 1960/61 to 2,617 kg/ha in 1980/81. The yield of hill padi has remained more or less constant since records were first compiled in 1960.

During their baseline surveys for the National Agricultural Extension Project, Cramb and Dian (1979) also collected data on yields and production and these are presented in Table 37.

It can be seen from Table 37 that the average yield for all the survey areas was 588 kg/ha which is about 100kg/ha less than that given by the Department of Agriculture statistics. The range of yield was very large, from zero up to 2861 kg/ha. The very high yields are nearly all derived from farms made from virgin jungle or very old secondary forest. At the other end of the scale, there were several instances of total crop losses, frequently through pest attack. Stem borers and army worm are a particular problem and Cramb and Dian (1979) reported one incidence where a padi field which had been completely re-seeded because of pest attack was destroyed again by pests and was a total loss. However, total crop losses through pest attack are not a typical feature of hill padi cultivation in Sarawak and occur on only infrequent occasions.

Of rather greater significance to the shifting cultivator than his yield is the duration that his harvest can provide him with food and whether this is long enough to carry him over to the next harvest period. Beginning in 1974, the Department of Medical and Health Services conducted a number of nutritional surveys amongst the indigenous rural population of Sarawak. Since the surveys were conducted in rural and, for the most part, remote areas, the results tend to reflect the nutritional status of the mostly hill padi-dependant shifting cultivators. Table 38 gives details of the protein-calorie malnutrition indices among the eight groups surveyed.

Anderson (1978) in his report on the nutritional surveys compared his results with that obtained from other parts of the world and concluded that the Sarawak indigenous groups were much worse off on average than some of the poorest nations. His comparison is given in Table 39.

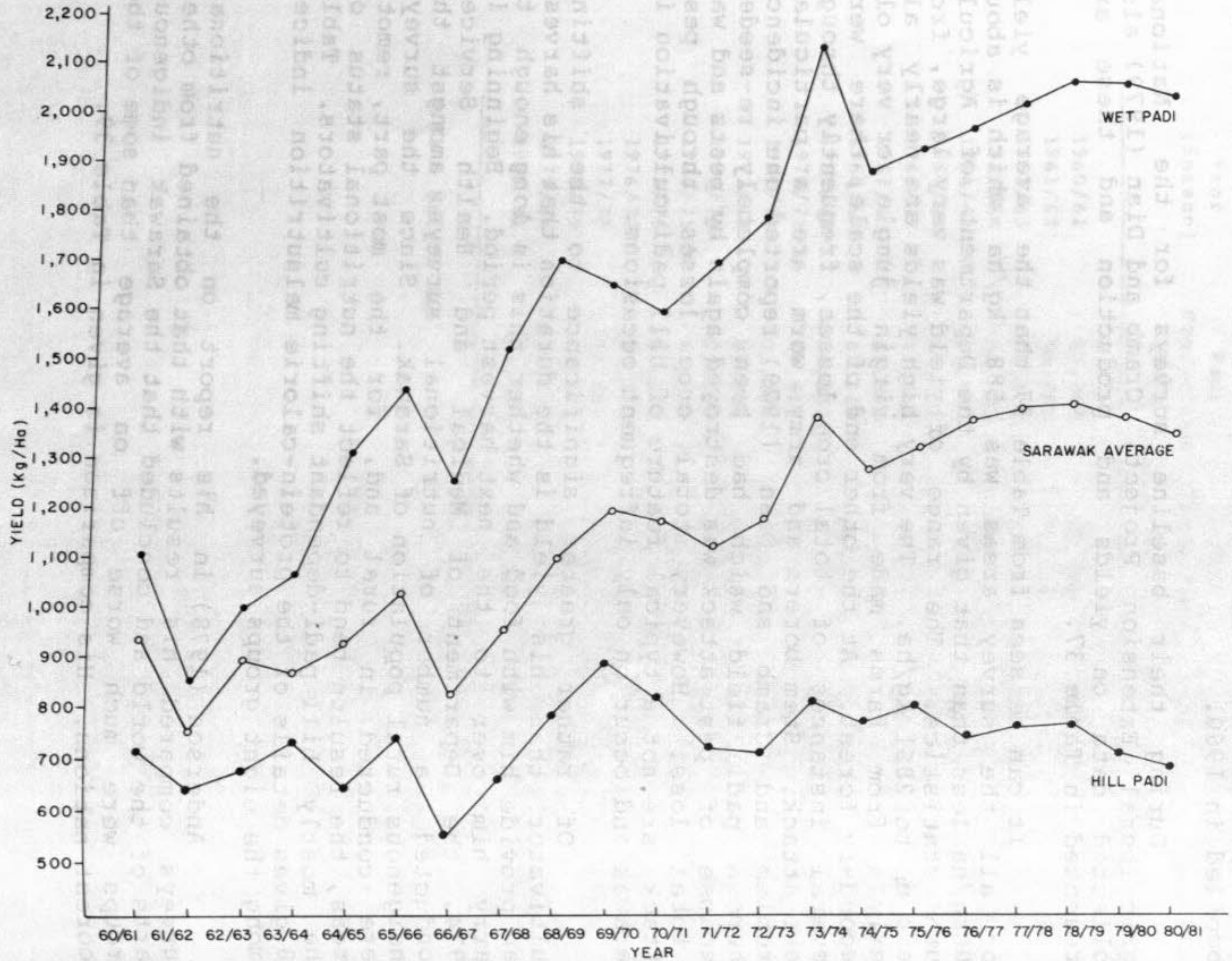


FIG. 3 HILL PADI, WET PADI AND SARAWAK AVERAGE PADI YIELD, 1960/61 TO 1980/81

TABLE 33

PRODUCTION AND IMPORTATION OF RICE IN SARAWAK, 1971-1980 (IN METRIC TON)

	Imports (rice)	Consumption (rice)	Production (rice equivalent)	% Insufficiency
1971	60,404	154887.20	94483.20	39
1972	63,962	161399.60	97437.60	40
1973	71,331	149063.40	77732.40	48
1974	98,958	190987.20	92029.20	52
1975	36,924	123451.20	86527.20	30
1976	64,000	154643.80	90643.80	41
1977	77,937	181251.00	108814.00	43
1978	55,471	165934.60	110463.60	33
1979	62,920	178162.60	115242.60	35
1980	69,183	183225.60	114042.60	38

1 tonne of padi = 0.6 tonne of rice.

Source: Hatch (1982).

TABLE 34

AVERAGE YIELD OF PADI BY DIVISION, 1960/61 - 1980/81
(IN KILOGRAMS PER HA)

DIVISION / YEAR(SEASON)	FIRST	SECOND	THIRD	FOURTH	FIFTH	SIXTH	SEVENTH	SARAWAK TOTAL
1960/61	754	1,497	694	814	790	*	*	939
1961/62	940	N.A.	688	963	801	*	*	993
1962/63	622	1,305	862	580	676	*	*	892
1963/64	778	808	969	808	772	*	*	867
1964/65	742	1,065	945	1,101	1,119	*	*	921
1965/66	880	1,091	1,125	999	1,143	*	*	1,031
1966/67	994	1,095	467	1,065	1,346	*	*	823
1967/68	1,197	958	748	1,155	1,472	*	*	946
1968/69	1,305	999	963	1,226	1,729	*	*	1,095
1969/70	1,155	1,256	1,125	1,209	1,514	*	*	1,192
1970/71	1,299	1,262	1,078	1,048	1,563	*	*	1,168
1971/72	1,023	1,554	873	1,290	1,549	*	*	1,115
1972/73	1,629	1,301	1,102	1,117	1,942	1,205	562	1,174
1973/74	1,882	1,719	1,162	1,389	1,998	1,307	654	1,384
1974/75	1,485	1,133	1,024	1,547	1,943	1,372	723	1,273
1975/76	1,362	1,352	1,066	1,606	1,634	1,382	767	1,313
1976/77	1,440	1,563	1,419	1,516	1,705	1,301	708	1,369
1977/78	1,475	1,489	1,376	1,658	1,930	1,360	700	1,393
1978/79	1,613	1,491	1,354	1,697	1,643	1,366	737	1,408
1979/80	1,581	1,484	1,488	1,620	1,688	1,233	648	1,386
1980/81	1,478	1,494	1,471	1,263	1,944	1,280	703	1,346

* = Included Under Third Division
N.A.= Not Available

Source: Dept. of Agriculture Statistics 1970-1981.

TABLE 35

AVERAGE YIELD OF WET PADI BY DIVISION, 1960/61 - 1980/81
(IN KILOGRAMS PER HA)

DIVISION / YEAR(SEASON)	FIRST	SECOND	THIRD	FOURTH	FIFTH	SIXTH	SEVENTH	SARAWAK TOTAL
1960/61	730	2,095	748	963	1,005	*	*	1,109
1961/62	1,245	N.A.	730	1,191	1,077	*	*	849
1962/63	945	1,772	898	526	162	*	*	999
1963/64	1,161	1,137	1,023	891	1,041	*	*	1,072
1964/65	1,041	1,544	1,263	248	1,610	*	*	1,316
1965/66	1,179	1,497	1,335	1,173	1,675	*	*	1,437
1966/67	1,233	1,233	197	1,287	1,898	*	*	1,244
1967/68	1,490	1.616	1,113	1,406	1,932	*	*	1,512
1968/69	1,681	1,460	1,514	1,442	2,351	*	*	1,689
1969/70	1,454	1,820	1,664	1,461	1,957	*	*	1,640
1970/71	1,621	1,617	1,691	1,076	1,940	*	*	1,583
1971/72	1,419	2,153	1,549	1,472	1,914	*	*	1,685
1972/73	2,227	1,740	1,522	1,550	2,240	1,532	1,381	1,780
1973/74	2,372	2,150	1,494	2,187	2,244	1,968	1,430	2,119
1974/75	1,859	1,551	1,406	2,303	2,243	2,039	1,421	1,861
1975/76	1,793	1,817	1,391	2,368	1,851	2,085	1,328	1,914
1976/77	1,756	2,022	1,931	2,302	1,938	1,711	1,460	1,951
1977/78	1,813	1,957	1,957	2,478	2,230	1,844	1,457	2,006
1978/79	1,969	1,963	1,915	2,443	1,954	2,110	1,394	2,045
1979/80	1,995	2,009	2,088	2,461	2,020	1,731	1,128	2,040
1980/81	1,878	2,023	2,068	1,901	2,467	2,060	1,277	2,017

* = Included under Third Division
N.A.= Not Available

Source: Dept. of Agriculture Statistics 1970-1981.

TABLE 36

AVERAGE YIELD OF HILL PADI BY DIVISION, 1960/61 - 1980/81
(IN KILOGRAMS PER HA)

DIVISION / YEAR(SEASON)	FIRST	SECOND	THIRD	FOURTH	FIFTH	SIXTH	SEVENTH	SARAWAK TOTAL
1960/61	783	898	640	664	580	*	*	713
1961/62	640	N.A	652	736	532	*	*	640
1962/63	305	826	832	640	609	*	*	676
1963/64	395	478	915	730	503	*	*	736
1964/65	442	593	634	898	634	*	*	646
1965/66	586	593	922	832	616	*	*	748
1966/67	700	940	305	855	790	*	*	550
1967/68	699	442	645	927	992	*	*	658
1968/69	837	609	766	1,023	1,053	*	*	784
1969/70	763	763	940	999	987	*	*	886
1970/71	713	755	783	1,027	1,100	*	*	819
1971/72	526	794	611	1,156	991	*	*	714
1972/73	797	602	771	825	1,499	817	546	707
1973/74	981	986	759	856	1,485	748	633	807
1974/75	739	567	683	1,012	1,499	673	689	771
1975/76	794	507	701	1,098	1,334	674	745	802
1976/77	718	582	630	961	1,419	424	674	741
1977/78	829	539	671	1,064	1,494	491	668	766
1978/79	849	563	645	1,141	1,184	514	712	772
1979/80	761	557	713	960	1,113	481	634	707
1980/81	729	557	742	884	1,111	464	687	68

* = Included under Third Division
N.A. = Not Available

Source: Dept. of Agriculture Statistics 1970-1981.

TABLE 37

PRODUCTION AND YIELD OF HILL PADI

Extension Region	Yield (kg) Average	Range	Production (kg) Average	Range
Serian	477	N.A.	482	0-1737
Engkilili	250	0-1979	280	0-1206
Ng. Spak	714	12-2503	579	39-1158
Debak	954	207-1789	519	58-1312
Julau	536	17-1579	712	29-3015
Dalat	566	118-1191	772	10-4052
Selangau	714	118-2085	856	68-5789
Bintulu	447	0-2861	603	0-5306
Belaga	595		1061	39-6030
Baram				
Merapok	536	59-1430	458	72-1206
Lg. Sukang	667		1833	253-4703
	588		741	
		0-2861		0-6030

Source: Cramb and Dian (1979).

TABLE 38

PROTEIN-CALORIE MALNUTRITION AMONG 4,106 SARAWAK CHILDREN UNDER 9 YEARS OLD BY % WHO STANDARD WEIGHT FOR AGE

	Children	Severe 60% or less	Moderate 61-80%	Mod. & Severe 80% or less
Penan	130	7.7	84.6	92.3
Melanau	485	6.6	67.6	74.2
Mukah Iban	562	11.0	71.5	82.5
Lemanak Iban	505	13.5	76.5	89.7
Sut & Mujong Iban	502	9.6	76.5	86.1
Land Dayak	696	8.3	76.9	85.2
Malay	516	8.7	75.2	83.9
Kayan & Kenyah	710	3.1	63.5	66.6
TOTAL:	4,106	8.4	72.6	81.0

Source: Anderson (1978).

TABLE 39

CHILD MALNUTRITION IN DEVELOPING AREAS BY GOMEZ WEIGHT CATEGORIES

	Severe 60% or less	Moderate 61-75% St. Wt.	Mod. + Severe 75% or less
Latin America	1.6	18.9	20.5
Africa	4.4	26.5	30.9
Asia	3.?	31.2	34.4
Total (173,000)	2.4	22.8	25.2
Sarawak (4,106)	8.4	55.1	63.5

Source: Anderson (1978).

TABLE 40

MONTHS OF RICE CROP SELF-SUFFICIENCY

	Kayan & Kenyah	Iban Sut	Iban Mujong	Iban Lemanak	Iban Mukah	ANP Land Dayak
Harvest(s)	1977/78	1976/77		1976	1974	1977
Months	7.4	3.7	5.8	3.5	6.8	2.8

Source: Anderson (1978).

Anderson (1978) observed that an important point about malnutrition amongst Sarawak shifting cultivators is that it is mainly chronic and the result of a general and continuing food insufficiency rather than periodic famine interspersed with adequacy. Generally, birth weights of children concerned appear to be relatively good and good weight gains are made in the first six months of life. Thereafter, however, as food intake falls below requirements, weight gains become very far from satisfactory.

Anderson (1978) further reported that for mainly rice-dependant people, the per capita yearly requirement of milled rice for all needs (including saving seed, feeding animals, losses in storage etc.) is approximately 255 kg. This figure is somewhat higher than that given by Freeman (1970) at 164 kg and Nakano (1980) at 180 kg.

In addition to the purely nutritional survey, Anderson also reported on how long the rice crop lasted for his survey groups and these results are given in Table 40.

These results certainly seem to provide evidence of serious rice shortages in the communities surveyed by Anderson. The lowest figure of 2.8 comes from a Land Dayak area where the government has instituted an Applied Nutrition Project (ANP).

Cramb and Dian (1979) in their surveys also collected data on the ability of the padi crop to meet the needs of their annual requirements and these data are presented in Table 41. From this Table, it is quite clear that very many households do not have sufficient padi to meet their annual requirements. Cramb and Dian's (1979) data are for the total padi crop and therefore include wet padi supplies if available. Since wet padi yields are in general higher than hill padi, one would expect many of the households to be even worse off if they were totally dependant upon hill padi.

This situation is very clearly shown by comparing a number of the different areas surveyed. The Engkilili data for example could be taken to represent the type of situation with respect to shifting cultivation in Sarawak that is giving increasing cause for concern. The people in this region have very little wet padi land available to them (only 3% of the surveyed households had wet padi) and they are virtually totally dependant upon hill padi for their rice. In addition, they are farming an area of long settlement where there is little opportunity to farm virgin

TABLE 41

SELF-SUFFICIENCY IN RICE

Extension Region	No. of Years of Previous 5 in which Households was Self-Sufficient in Padi %						Harvest as % of Requirement	% Buying Padi
	0	1	2	3	4	5		
Serian							<50	24
Engkilili	58	14	9	5	5	9	<20	76
Ng. Spak	48.3	0	10.3	24.1	6.9	10.3	39	69
Debak	44.1	8.8	14.7	8.8	11.8	11.8	-	62
Julau	43	6	12	12	15	12	40	60
Dalat	38.5	11.5	26.9	3.9	3.9	15.4	-	77
Selangau	51	11.8	15.7	3.9	7.8	9.8	62	75
Bintulu	47.5	20.3	8.5	6.8	10.2	6.8	50	71
Belaga							-	32
Baram							-	12
Merapok	10.7	7.1	7.1	14.3	10.7	50	76	0
Lg. Sukang	4	4	4	4	32	52	-	0
	38.3	9.2	12	9.2	11.5	19.6	48	46.5

Source: Cramb and Dian (1979).

or old secondary jungle. It is clear from Cramb and Dian's (1979) survey that shifting cultivation in this area has reached a very critical state and is no longer capable of supplying the farmers with anything like their rice requirements. In fact, a similar though less critical situation exists in the other survey areas where wet padi and virgin jungle are not available. The situation at Merapok and Long Sukang is in marked contrast to that at Engkilili and in these two survey areas self-sufficiency (and even rice surplus) is the rule rather than the exception. This is mainly due to the larger area of wet padi land available to the farmers and also to a much reduced population density, thus allowing for longer fallow periods.

A further indication of the obvious inability of shifting cultivation for hill padi to meet the food requirements of many farming families is the degree to which people are purchasing padi from local traders. Figures for this are also given in Table 41 and it is clear once again that areas such as Engkilili, Ng. Spak, Serian, Julau, Selangau and Bintulu need a regular supply of imported rice. The contrast with places like Merapok and Long Sukang, which purchased no rice during Cramb and Dian's (1979) survey, is once again evident. Purchasing rice from local traders is not the only method employed to obtain extra rice. Lending of rice and exchange for labour are also quite common methods of making good a padi shortage.

One of the great natural 'fallbacks' for the shifting cultivators of Sarawak where food is concerned is their ability to exploit wild jungle plants such as sago when times are hard. Hunting for animals (e.g. rusa and barking deer, plandok, wild boar, monkeys, squirrels etc.) and fishing provide important sources of food. Despite the fact that populations of wild animals and fish have been seriously reduced over the years, they can, in concert with wild plants, see the shifting cultivator over the period just before harvest when he may have run out of rice. It is this availability of jungle produce that acts as a 'buffer' for shifting cultivators and which rather confuses and distorts the survey results of nutritionists.

Much has been said about malnutrition amongst shifting cultivators over the past few years and it is really quite impossible to determine where the true story lies. Anderson (1978) was of the opinion that his surveys demonstrated that most of the shifting cultivators of Sarawak, totalling up to almost 500,000 people, were suffering from serious malnutrition. This seems to be unlikely, however, since his surveys were conducted in notoriously poor areas. There are those who advance the contrary opinion that malnutrition is of no significance whatsoever. This also seems to be an inaccurate and overly optimistic position to take, particularly in view of the survey data provided by both Cramb and Dian (1979) and Anderson (1978). Best (1982) has also drawn attention to the large rice deficits occurring in some kampongs. It is clear that further studies must be undertaken to determine the nutritional status of the shifting cultivator and to what degree malnutrition has become evident.

Destruction of Forest Resources

This is an aspect of the shifting cultivation problem in Sarawak that has received probably the greatest amount of attention since it is one that affects the potentially huge profits which could be made out of timber. Generally, the group that is most vociferously critical of shifting cultivation is the timber industry. Demands for an immediate cessation of shifting cultivation are very frequently heard from this group and yet they are totally unable to suggest either improvements or alternatives to the system. In addition, interests such as these totally ignore the fact that shifting cultivation is, for may be half the total population of Sarawak, the principal means of obtaining food. It is also an unfortunate truth that logging interests in Sarawak have themselves not shown any great respect for the environment and tend to be only exploitive in nature. The destruction and damage wrought by timber extraction is in many places quite inexcusable and is only tolerated because of the wish to make fast and large profits. To give one example, there is little doubt in this writers' mind that the soil erosion created by timber extraction is far in excess of that created by shifting cultivation. Burgess (1971) in his study of West Malaysian logging operations points out that in a logged area, 10% of the trees are felled for timber, 55% are destroyed or damaged in the extraction process and only 35% remain undamaged. He also draws attention to the serious soil erosion caused by logging operations. Damage on a similar scale also occurs in the Sarawak rain forest and this has been described by Marn and Jonkers (1981).

Despite this, there is no doubt that the forests of Sarawak are one of its most valuable resources.

Table 42 gives details of the value of principal exports of Sarawak from 1972-81 and it can be seen that at the current time, the forest sector of the economy accounts for 20% of Sarawak's export earnings (M$897 million). It should be noted in this context that 67% of export earnings come from petroleum and its products whilst the agricultural sector accounts for only 5% and this is largely from non-food items such as pepper and rubber.

It has been noted by De Backer (1981) that if the forests are saved and managed properly, then from the mid-eighties onwards, the 4.7 million hectares of operable forest will be providing 85,000 jobs, over M$400 million in wages, M$1.1 billion of products, and some M$200 million in State and Federal revenues. The potentially renewable nature of the forest resource is also of great importance since it could provide income in perpetuity, in contrast to non-renewable resources such as oil and gas which are currently 'fuelling' the national economy.

Since approximately 25% of the land area of the State has been subjected to hill padi cultivation at sometime, it is clear that shifting cultivation does pose a potential threat to the forest industry in Sarawak. However, the degree of threat is once again an important issue and it is unclear as to how much actual damage is now occurring. It has been provisionally estimated by the Forest Department that the mature forest being destroyed annually for shifting cultivation in Sarawak would be of the order of 35,000 hectares. This figure has been derived from an estimated annual area of forest cleared for hill padi of approximately 100,000 hectares, 20-30% of which is mature rather than secondary forest.

Based upon the above estimates, the Forest Department has calculated that the net revenue loss per year to the economy of the State from shifting cultivation would amount to some M$300 million. 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. In terms of timber royalties to the State and Federal Governments, the annual loss through shifting cultivation is, at present, of the order of M$14 million. Therefore, it is claimed that for every log exported, one log in equivalent is burned through the activities of the shifting cultivator.

One particularly disturbing trend in shifting cultivation has been the invasion of permanent forest areas. This very frequently occurs because timber extraction opens

TABLE 42

VALUE OF PRINCIPAL EXPORTS OF SARAWAK, 1972-1981
(Value in M$)

Item / Year	Agricultural Products $'000	%	Timber $'000	%	Petrolium & Products $'000	%	Other Goods $'000	%	Total $'000
1972	83,070	14	134,457	22	321,113	53	68,479	11	607,119
1973	159,232	19	210,848	25	392,200	47	72,181	9	834,461
1974	176,852	13	165,888	12	953,659	67	89,502	6	1,385,901
1975	158,585	11	125,913	9	1,025,319	74	77,578	6	1,387,395
1976	226,160	10	359,050	16	1,532,241	69	104,650	5	2,222,101
1977	226,519	12	343,585	16	1,423,191	66	120,522	6	2,153,817
1978	276,466	14	399,505	21	1,068,098	56	164,518	9	1,908,587
1979	313,694	10	911,743	30	1,624,440	53	235,995	7	3,085,872
1980	300,455	7	920,447	23	2,515,216	62	305,305	8	4,041,423
1981	219,593	5	897,157	20	3,015,783	67	382,200	8	4,514,733

1981 Figures are preliminary

a - Includes sawn logs and sawn timber.

b - Excludes bunker and full supplies to ships and air-craft.

Source: Dept. of Agriculture Statistics 1981.

up the areas for easy access and the shifting cultivators just follow on after the timber has been taken out. In some permanent forest areas, this situation has become particularly acute with total excision being the only course left open to the Forest Department.

Table 43 gives details of hill forest reserves in Sarawak and the extent to which they have been invaded by shifting cultivators. It can be seen that of the total of some 2.3 million hectares, almost 64,000 hectares (7.6%) have been destroyed or damaged by the activities of shifting cultivators. As can be clearly seen, the seriousness of destruction varies from zero or very low in many reserves up to nearly 40% in places like Balai Ringin and Bukit Subis. Map 6 shows the Balai Ringin, Sabal Forest Reserve and the extent to which it has suffered from the activities of shifting cultivators.

There is no doubt that shifting cultivation does have a detrimental affect upon the timber industry but this writer would seriously doubt some of the figures that have been advanced for destruction of forest by shifting cultivators. That the loss is serious, particularly in Forest Reserve areas, is beyond doubt, but whether it approaches the order of 35,000 hectares per annum is rather in question and more detailed surveys are necessary to verify this claim.

Moreover, it must be appreciated that shifting cultivators do not cut down virgin jungle or invade permanent forest areas because they obtain some special pleasure from burning commercially valuable timber. They do it for one principal reason and one only - to grow food. The fact that they continue to invade forest reserves does not mean that they are irresponsible people but is rather an expression of their need for suitable land on which to grow rice. Unless strenuous attempts are made to find alternatives for such people, then it is likely that the forest reserves will come under even more pressure and rapidly dwindle in extent.

Soil Erosion and Degradation

Much has been written and talked about concerning soil erosion and shifting cultivation particularly in the African context. Lal (1974) points out that there is considerable controversy as to whether shifting cultivation

TABLE 43
HILL FOREST RESERVES

Forest Reserve	Total Area in Hectares	Area of Shifting Cultivation (ha)	% of Shifting Cultivation in Forest Reserve
1. Datu P.F.	1,214.03	0	0
2. Gunong Pueh F.R.	25,005.06	511.58	2.04
3. Gunong Gading F.R.	6,025.00	571.00	10
4. Pasir Jangkar P.F.	1,618.71	90.72	5.60
5. Sampadi F.R.	34,438.00	3,222.00	9
6. Tanjong Embang F.R.	117.36	0	0
16. Balai Ringin F.R.	21,551.00	9,996.00	46
17. Sabal F.R.	7,832.00	1,719.00	22
18. Krangan P.F.	1,416.00	35.00	3
19. Gunong Apeng F.R.	1,999.00	471.00	24
*28. Silantek P.F.	1,848.00	545.00	29
53. Mukah Hill P.F.	98,619.64	7,126.82	7.23
62. Lanjak Entimah P.F.	193,031.44	4,052.31	2.09
63. Pelagus P.F.	7,162.67	448.58	6.26
65. Balleh P.F.	847,841.04	1,091.20	0.12
66. Mujong Merirai P.F.	160,576.26	869.43	0.54
68. Taman P.F.	38,993.97	1,464.17	3.75
70. Anap P.F.	143,563.59	1,287.77	0.89
71. Kakus-Pandan P.F.	145,188.37	927.39	0.64
72. Similajau F.R.	123,460.81	2,298.32	1.86
73. Labang F.R.	25,174.62	1,388.57	5.51
74. Kebulu P.F.	40,030.76	2,426.85	6.06
*76. Tatau P.F.	27,254.54	564.50	2.01
78. Niah-Jelalong P.F.	57,342.88	234.37	0.41
83. Sujan F.R.	43,648.58	3,185.39	7.29
85. Sawai P.F.	30,043.30	70.56	0.23
86. Niah F.R.	19,473.00	1,190.00	6
87. Bukit Subis P.F.	3,315.79	1,204.60	36.33
89. Bok Tisam P.F.	30,071.63	5,413.16	18.00
90. Lemiting P.F.	85,718.91	9,800.64	11.43
91. Batu Belah P.F.	9,088.26	965.20	10.62
96. Marudi F.R.	6,976.32	524.18	7.51
98. Telang Usan P.F.	86,889.24	2,862.82	3.29
103. Bakas F.R.	1,918.58	0	0
*106. Terentang F.R.	6,420.22	0	0
*108. Kayangeran F.R.	5,704.18	297.32	5.21
109. Belansat F.R.	169.96	0	0
TOTAL/AVERAGE	23,343.09	63,924.59	7.6

* Swamp Forest

Source: Dept. of Forestry

is the cause or effect of accelerated soil erosion. Whilst 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 the shifting habit is itself an agronomic response designed to minimise soil erosion. It has been reported by Virgo and Ysselmuiden (1979) that shifting cultivation for hill padi on steep lands (in Thailand) leads to such high losses of soil and nutrient that even long forest fallow cannot sustain this type of agriculture. This seems to be something of an over simplification and rather ignores the fact that shifting cultivation has been carried out in Southeast Asia on steep and inhospitable terrain for many hundreds and perhaps even thousands of years. From the many observations made by this author and several erosion trials conducted in various parts of the State, it is clear that under traditional conditions, the practice of shifting cultivation does not lead to serious soil erosion and may in fact even reduce the natural rate of soil erosion. The results of erosion trials on hill padi carried out at the Agricultural Research Centre at Semongok and a nearby kampong (Kg. Benuk) are shown in Table 44.

Table 44 also shows the soil erosion occurring under a variety of other conditions in order to demonstrate the very serious rates of soil erosion that can occur under Sarawak's very high and intense rainfall regime.

It is clear from the results presented in this Table that the rate of soil erosion under shifting cultivation gives no cause for alarm. However, it has been observed in certain parts of the State that the forest fallow periods have dropped to such low levels that sheet erosion is becoming evident on certain hill slopes. This does give some cause for concern. In addition, it seems that there may be a greater incidence of landslips in shifting cultivation fields but this is only a subjective impression and no empirical evidence can be presented to support it.

Whilst soil erosion does not appear to be serious under traditional shifting cultivation, there are very little data available on the changes in water yield and storage that occur in catchments subject to extensive shifting cultivation. Once again a subjective opinion only gained from conversations with those living downstream of widely shifting cultivated areas seems to indicate that the incidence of flashfloods has increased over the years. If this is true, then the impact of shifting cultivation carried out in remote areas on downstream agricultural areas, towns, development areas etc cannot be ignored.

TABLE 44

SOIL LOSS AND RUN-OFF DATA FROM TRIAL PLOTS AT SEMONGOK AND KAMPONG BENUK

	1978		1979		1980		1982		
	Soil Loss tons/ha	% Run-off	Soil Loss tons/ha	% Run-off	Soil Loss tons/ha	% Run-off	Soil Loss tons/ha	% Run-off	Comments
Primary Forest	0.1389	0.33	0.0615	0.47	Terminated June 1980		Recommend March 1981		
Secondary Jungle/ Hill Padi	0.2528	4.29	0.0391	2.67	0.043	2.72	0.0222	2.68	Slash & burned in August 1980 & planted with hill padi
Hill Padi *	-	-	0.1776	2.54	-	-	-	-	Results for September 1979 to August 1980
Hill Padi Terraces	1.4342	19.72	0.2923	17.09	0.5257	18.31	0.2465	10.65	
Traditional Pepper	52,3131	14.32	54.9579	15.59	139.1203	17.68	78.88	16.55	
Pepper Terraces	11.5479**	26.75	0.6765	14.14	1.3521	16.1	0.5771	6.16	

* Kg. Benuk

** Very high 1978 figure due to high soil losses immediately after terrace construction

However, this author would tend to support the view that flash flooding caused by the activities of the shifting cultivator, whilst occurring in one or two watersheds, is not at present widespread.

One agent of erosion that is frequently ignored or which receives little attention is that of timber extraction. It must be said that many of the logging operations in Sarawak are not carried out in a very responsible manner (from a soil erosion point of view) and it is obvious to even the casual observer that very serious erosion is caused during the construction of the logging roads, landing sites and camp sites. In addition the most popular method of retrieving the logs is by sending bulldozers into the jungle to tow them out and the skid paths also promote increased erosion. Aerial logging which has not yet been widely introduced into Sarawak causes much less erosion.

Land Tenure and Ownership

Prior to 1958, all land titles in Sarawak were issued at the discretion of the Rajah. In practice, this did not really affect shifting cultivation since it was (and still is) conducted in such remote areas. Since the population of Sarawak is so low, the competition for land has never really been very intense (except perhaps in the urban areas) and therefore there has not been the necessity to issue titles to all users of land. Very little of the shifting cultivation land has title issued on it but nevertheless, it is governed by a fairly strict 'adat' or customary right handed down and administered by the people themselves. Very basically, this customary right declares that the land belongs to the person who first clears it from primary jungle. In fact the situation is slightly more complicated than this. Further details can be obtained from Richards (1961).

In Sarawak, land is classified into basically four different types, these are: Interior Area Land, Native Area Land, Reserved Land and Mixed Zone Land. The areas under these different categories are given in Table 45 and are shown on Map 7.

Native Customary Rights are not, as some people assume a 'type of land' but rather a 'bundle of rights' that can be exercised by the natives of Sarawak. Native Customary Rights may be created under Section 5 of the Land

TABLE 45

LAND CLASSIFICATION OF SARAWAK (Km^2)

Division	Mixed Zone	Native Area	Forest Reserve	Interior Area
1	1,387.10	525.80	1,908.08	5,081.06
2	4,219.37	2,393.55	1,098.39	2,560.84
3	1,890.34	651.62	3,456.46	6,188.83
4	982.26	3,187.10	9,733.89	25,040.35
5	396.76	983.86	861.29	5,548.17
6	841.93	1,459.67	1,367.75	3,051.77
7	146.78	-	1,118.47	37,669.04
	9,864.54	9,201.60	19,544.33	85,840.06

Code as follows (Porter, 1967):-

1) Felling of virgin jungle and the occupation of the land cleared.

2) Planting of fruit trees.

3) Occupation or cultivation of land.

4) Use of land for burial ground or shrine.

5) Use of land for rights of way.

6) Any other lawful method.

Hence Native Customary Rights can be established over any land in the four categories described except Reserved Land. The different categories of land can be defined simply as follows:-

1) Native Area Land - land where only natives can acquire rights of ownership.

2) Reserved Land - come under the jurisdiction of the Land and Survey Department and can also include Forest Reserves.

3) Mixed Zone - land to which any Malaysian can acquire rights.

4) Interior Area Land - Unclassified land not falling within the other three categories.

The Land Code of 1958 consolidated all the laws made by previous Orders (by the Rajahs) and established a detailed framework for land administration in all parts of the State. Since 1958, there have been no substantial amendments to the Land Code.

Native Customary Right Land has no title until one applies for a Grant in Perpetuity (Freehold). After the 1958 Land Code until 1963, title could not be issued for Native Customary Rights Land but a 99-year lease could be given for payment of a rent of M$3/acre/year. The 1963 amendment to the Land Code abolished the rental payment but still only leases could be issued. With the 1974 amendment, a Grant in Perpetuity could be issued on land held under

Native Customary Right. Native Customary Right can be extinguished under Section 5 of the Land Code with payment of compensation.

Some Statutory Bodies such as Sarawak Land Consolidation and Rehabilitation Authority (SALCRA), Sarawak Land Development Board (SLDB), and the Land Custody Development Authority (LCDA) can purchase land, but in practice usually just declare areas to be "development areas". This is frequently done on shifting cultivation land and the owners must co-operate but do not have to give up ownership of their land. Very often the ownership boundaries may be re-adjusted or rationalised during the course of the development scheme.

Table 46 gives details of the issue of new titles in 1979 whilst Table 47 gives extant titles as at December 31st, 1979.

It can be seen that of the total area of Sarawak (12,325,208 hectares) only 3.5% (433,901 hectares) is held under title. Since much of this will be urban or near urban land, it is clear that very little of the shifting cultivation land has legal title attached to it.

Alternatives/Improvements to Shifting Cultivation

Unfortunately not nearly enough attention has been paid to seeking "sensitive and practical" alternatives or improvements to the system despite the dire need for such work and the numbers of people who would benefit from any advances made.

Chin (1977) points out that it will be impossible to prevent shifting cultivators from being influenced by many of the values and aspirations (both good and bad) of the modern world and therefore it is essential that efforts be made to raise their economic status and give them the advantages of education, modern medicine etc.

Past attempts at 'improving' shifting cultivation have been somewhat disasterous and particularly in Africa, there have been some rather major debacles for the temperate agriculture 'experts'. Where attempts were made to replace shifting cultivation with intensive rotational systems of

TABLE 46

NEW LAND TITLES ISSUED IN SARAWAK, 1979

Division	On First Registration			Replacement		Total	
	Pesaka	Native Sago	Payable	Pesaka	Payable	No. of Titles	Area (ha)
			1979				
First	913	1	424	585	1,805	3,728	3,086
Second	1,181	1	303	182	233	1,900	2,397
Third	153	15	199	7	646	1,020	974
Fourth	108	2	234	413	530	1,287	1,338
Fifth	168	-	24	396	180	768	788
Sixth	85	28	94	228	216	651	1,080
Seventh	131	-	13	-	18	162	363
TOTAL	2,739	47	1,291	1,811	3,628	9,516	10,025

Source: Annual Report 1979, Land & Survey Dept., Sarawak.

TABLE 47
EXTANT TITLES

Division	Post Settle-ment and Land Code	Pre-Settlement Leases	Occupation Tickets	Jubliee Occupation Tickets	Grants	Rubber Garden Registration Certificates
First	51,876	7,478	9,495	-	122	147
Second	27,118	4,298	5,697	17,063	2	-
Third	43,978	7,357	8,623	-	1,164	-
Fourth	23,746	4,285	1,570	-	-	-
Fifth	10,989	1,172	2,202	-	3	-
Sixth	27,024	5,313	5,711	-	19	-
Seventh	1,788	379	757	-	31	-
TOTAL	186,519	30,282	34,055	17,063	1,341	147

Table 47 (cont'd)

Division	Coconut Garden Regis-tration Certificates	Squatters Licences	Total Number of Titles	Total Area (hectares)
First	13	41	69,172	103,336
Second	-	.	54,178	54,785
Third	-	-	61,122	123,197
Fourth	-	-	29,601	51,412
Fifth	-	-	14,366	27,253
Sixth	-	-	38,067	68,129
Seventh	-	-	2,955	5,789
TOTAL	13	41	269,461	433,901

Source: Annual Report 1979, Land & Survey Dept., Sarawak.

cropping with very short and planted fallows (usually of leguminous cover crops), it was found that crop yields declined rapidly and erosion increased markedly. The temperate approach to improvement of shifting cultivation areas completely failed to take cognizance of the special problems of tropical areas such as the potentially disasterous erosion rates, the rapid depletion of nutrients and organic matter and the rapid buildup of weeds, pests and diseases. Whilst it is true that modern methods of agriculture can now allow us to 'force' a temperate system upon tropical areas and perhaps sustain it indefinitely, it is prohibitively expensive to accomplish and far beyond the means of the normal subsistence farmer. The great beauty of shifting cultivation is that all those cultural effects (soil conservation, control of weeds, restitution of fertility, reduction of pests and diseases) are achieved with virtually no capital input whatsoever and in a manner that is harmonious with nature rather than contradicting it.

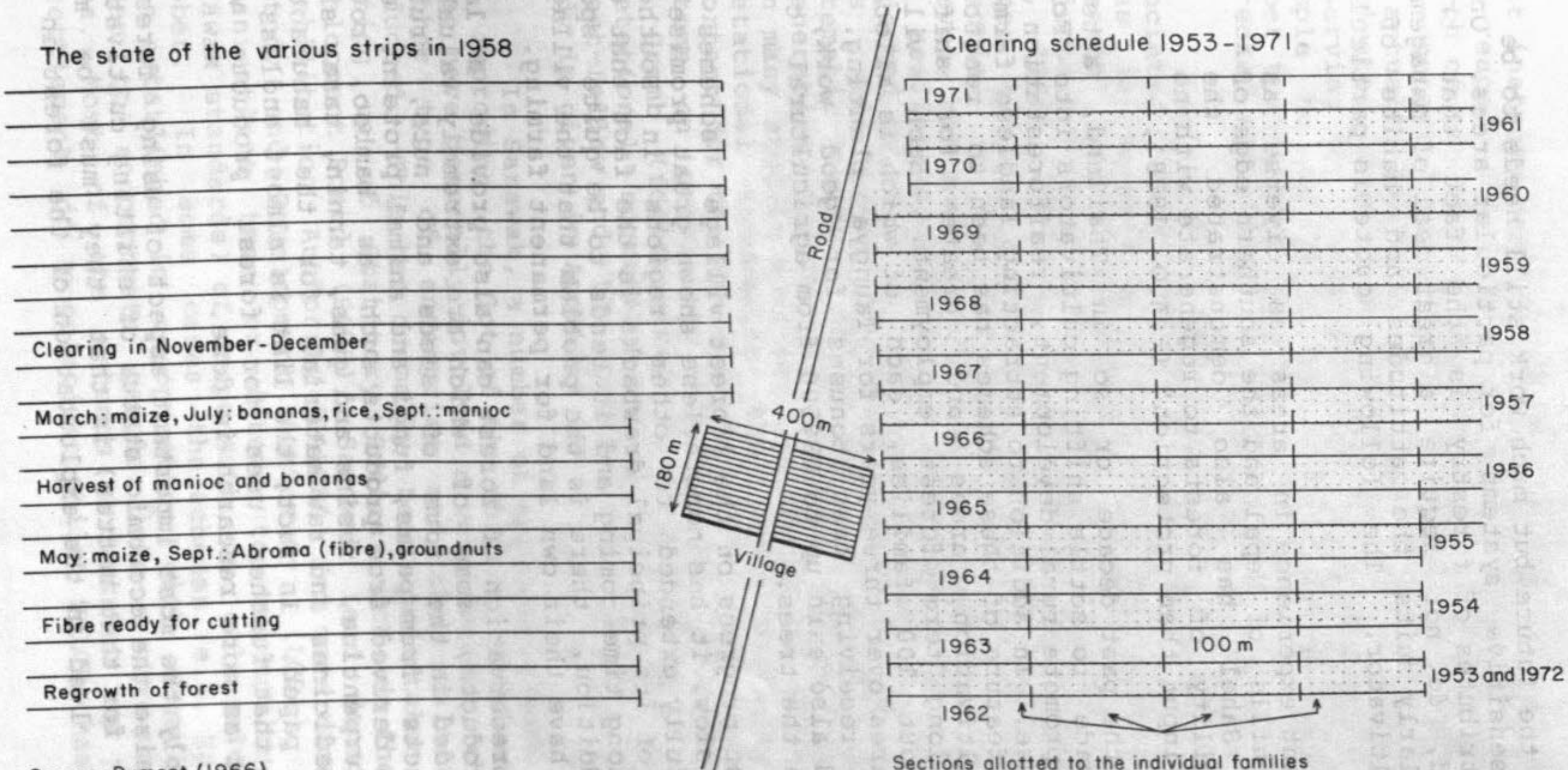
An attempt to modify shifting cultivation using the couloir or corridor system was attempted in 1960 in the then Belgium Congo (Ruthenberg, 1980). Families were allotted strips of jungle that were cleared on a planned basis in order to maintain the fallow period. An example of the rotation is shown in Figure 4.

Other similar systems have been developed elsewhere to take account of local climates, soils and social organisations but none of them have really met with the success first hoped for. The corridor system of the Belgium Congo was introduced to 200,000 shifting cultivators on nearly two million hectares of land and yet in present day Zaire, the system can no longer be found. It did not appear to accomodate the strong desire on the part of the shifting cultivator to move about in a more random manner.

A system of some importance for Southeast Asia has been the Taungya system. The word is of Burmese origin (Enabor, 1974) and means hill (taung) cultivation (ya). This system consists of intercropping a forest plantation with agricultural crops in the initial years, until the canopy of the forest closes (F.A.O. 1978). It started in Burma in 1856 and has since been adopted in various forms in other countries. Critics of the system point out that it arose out of a colonial system of land administration that was seeking ways to reafforest areas for commercial timber. The shifting cultivators were merely hired labour.

There is no doubt that forestry will provide very many shifting cultivators with a rational and logical source

FIG.4 CORRIDOR SYSTEM IN BELGIAN CONGO



Source: Dumont (1966).

of income in the future but much work still needs to be done to devise sensitive systems for particular areas. One of the great attributes of forestry is the fact that trees, once planted, do not require a great deal of management. This particularly suits the attitudes and habits of the shifting cultivator. The following quote is particularly noteworthy:

> "Recent experience in areas as diverse as the hills of Nepal and the southern edge of the Sahel has also demonstrated the capability of forests to regenerate with no more input than protection" (F.A.O. 1978).

Over the past decade or so in Thailand, attempts have been made to settle shifting cultivators into 'Forest Villages' to promote rural development, reafforestation and sound land-use. In addition to attracting landless farmers, an important feature of these schemes has been to reafforest shifting cultivation areas and create for shifting cultivators long term forest employment. Each village comprises about 100 families, each of which is allocated about 5 hectares over three years for Taungya planting. In addition to receiving cash bonuses for good work, the farmers could also earn up to US$500 from agricultural crops grown between the trees.

Whilst progress on the 'forest village' schemes has been quite slow, it has nonetheless shown great promise and might be usefully extended to other regions in Southeast Asia. One of its principal drawbacks is the fact that cash income is a long time coming and it tends to be quite sporadic. In addition, there is the problem that the villagers often do not have their own land for permanent farming.

The preservation of forest can also provide a large range of products, some of which are extremely valuable. Food is provided in the form of seeds and nuts, fruits, edible products from palms, fungi and animal protein. Cash income may be derived from products such as bamboo, rotan, rosin and turpentine, resins and gums, tannin, tasar silk, um arabic, medicines and raw material for the manufacture hand-made paper. In fact, the list is almost endless and certain that further uses for forest products will evident as more research is done.

ssibly the most important aspect of using forestry raise the economic status of shifting cultivators for that matter) is that they must be more lved in the exploitation of the forest in the first instance and the potentially very high rewards that are reaped from this activity. Too often today we see the wealth of the forest passing into the hands of the few well-connected individuals and virtually none going to those who actually live and work in the forest. The shifting cultivator cannot be expected to take any interest in preserving (or sensibly exploiting) the forest when the example he is given is that of the totally exploitative timber tycoons who take what they want and leave behind them a wrecked and ruined environment.

Lee (1981) has reviewed some of the problems associated with reafforestation of shifting cultivation areas in Sarawak and has outlined possible areas for research and development. In addition, reafforestation projects have been carried out on a pilot scale (Lee and Lai, 1982) although the initial work had been done on a rather ad hoc basis with no attempt to evaluate site potential or to match species with site. Site evaluation, however, has been carried out in selected areas earmarked for reafforestation in the permanent forests which had been subjected to shifting cultivation (Butt, forthcoming) and this will place the reafforestation scheme on a more systematic basis. If a better understanding of the regenerative ability of tropical forest is to be gained, then many studies must be undertaken on nutrient cycling, vegetational succession etc. This may prove particularly important for the establishment of plantations or Taungya systems on previously shifting cultivated areas. Chai, Lee and Cramb (forthcoming) have undertaken some work on vegetational succession in 3, 6, 9, 12 and 15 year old forest-fallow and the preliminary species list for this study is given in Appendix 1.

In Sarawak, a number of approaches have been adopted for improving the lot of the shifting cultivator. To date, these have generally involved a very drastic change towards another type of enterprise and the scale at which it is conducted. This has normally been undertaken through the setting up of Statutory Bodies such as the Sarawak Land Development Board (SLDB), Sarawak Land Consolidation and Rehabilitation Authority (SALCRA) and more recently the Land Custody and Development Authority (LCDA). All these organisations have or intend to set up large estates (by Sarawak standards) of crops such as oil palm, cocoa, and rubber. In some cases the schemes (e.g. Ng. Sekuau) have been established in co-operation with security forces in order to concentrate people into a more easily protected area. Most of the schemes undertaken by SLDB involved resettlement of populations whilst SALCRA have concentrated on <u>in situ</u> development in mainly shifting cultivation areas in the First and Second Divisions. SALCRA's approach is most typical of the kind of assistance that is given to the shifting cultivator.

When SALCRA undertakes a scheme, the Minister responsible will declare a given area a 'development area' and within this boundary the owners (scheme participants) are required to give their co-operation but they do not relinquish ownership rights over the land. The 'development area' is then treated in effect as an 'estate' with the scheme participants acting as the hired labour. This situation continues until the crop comes into full bearing at which time the owners of the land then farm as smallholders, delivering their crop to the processing plant. At this time, some rationalisation of ownership boundaries or land exchange may take place. It should be pointed out that as yet SALCRA have not reached this last and most critical stage of any of their oil palm or cocoa schemes and it remains to be seen how in practice it will work.

Tables 48 and 49 give details of SLDB and SALCRA schemes that have been implemented or are in process at the present time. It can be seen that SLDB have spent over M$18.5 million for the benefit of 3,460 households (settlers) on 25,000 hectares whilst SALCRA have spent M$80.5 million for the benefit of 2,050 households on 7,857 hectares.

The people involved in such schemes are shifting cultivators and whilst they do apparently drastically reduce the amount of land they plant to hill padi every year, most families continue to plant a small area of padi for use in making alcohol, preserving seed, or maintaining their stock of 'padi pun'. Indeed, some families do continue to shifting cultivate quite large areas of land despite the fact that they are receiving a pay of about M$5 per day. SALCRA have attempted to diversify their approach and provide areas where padi may be grown in a settled manner but as yet this does not appear to have received the priority it deserves.

A recent SALCRA scheme of some interest has been the Kg. Mayang Mawang Tea Project which has been established in an area of shifting cultivation in the First Division. It aims to plant about 100 hectares of lowland tea and the output will be taken by a processing factory owned and run jointly by SALCRA and Tate and Lyle. During the establishment of the tea estate, the people of Kg. Mayang Mawang (and a few from other kampongs nearby) are paid at the rate of

TABLE 48

SARAWAK LAND DEVELOPMENT BOARD SCHEME LOCATIONS, AREAS AND COST

Project/Location	Area (ha)	Started	Completed	No. of Settlers	Costs
Oil Palm					
Bukit Peninjau	1,570.9	1970	1973	245	
Sungai Tangit	1,407.3	1971	1973	164	
Ladang Tiga	1,722.1	1972	1975	240	
Ladang Empat	1,005.7	1973	1978	92	Individual
Subis I	771.7	1974	1978	93	cost not
Subis II	1,664.4	1974	1978	144	available
Subis III	1,628.4	1974	1978	160	
Suai I	2,023.4	1978	1980	64	
Suai II	1,821.1	1978	Not completed	74	
Mukah I & II	1,991.4	1975	1980	242	
Mukah III	1,638.9	1976	Not completed	236	
Mukah IV	1,416.4	1976	Not completed	329	Total ending 31/12/81
SUB-TOTALS	18,661.7			2,083	10,502,690
Rubber					
Triboh	304.2	1964	1965	64	
Melugu	780	1965	1969	218	Individual
Skrang	1,233.5	1964	1968	254	costs not
Meradong	1,190.0	1964	1966	263	available
Sibintek	667.2	1965	1967	140	
Lambir	761.8	1964	1966	193	
Lubai Tengah	608.2	1968	1970	45	Total ending 31/12/81
SUB-TOTALS	5,544.9			1,177	3,187,635
Cocoa					
Lambir/Subis	809.4	1975	1982	200	4,964,384
TOTAL:	25,016			3,460	18,654,709

TABLE 49

SARAWAK LAND CONSOLIDATION AND REHABILITATION AUTHORITY SCHEME LOCATIONS, AREAS AND COSTS

Project/ Location	Area (ha)	Date Started	No. of Households Benefitting	Approx. Value Development Cost
<u>Oil Palm</u>				
1) Lemanak	2415	1978	316	
2) Batu Kaya	1172	1979	131	
3) Pakit/Undup	1670	1982	153	
				30,168,000
Palm Oil Mill				19,720,000
Bulking Installation				7,658,000
<u>Cocoa</u>				
1) Kg. Taie	1200	1982	100	5,990,000
2) Paku/Layar	1200	1982	350	9,008,400
3) Bajo/Pandan Blungai				2,891,000
<u>Tea</u>				
Kg. Mayang	200	1982	1000	5,112,500
TOTAL:	7857		2050	80,547,900

M$6 per day and since the scheme started in early 1982 nearly all of the participants have given up shifting cultivation for hill padi. Table 50 gives results of a survey conducted amongst the people of this kampong in November 1982 to determine the extent to which shifting cultivation has been abandoned.

It is clear from the situation at Kg. Mayang Mawang as presented in Table 50 that shifting cultivators will quite readily give up shifting cultivation if a better opportunity presents itself. This is by no means the whole story, however, and many of the farmers interviewed expressed their intention to grow padi by shifting cultivation because they considered that it was disproportionately expensive to purchase their rice. Presumably they would only give up growing hill padi for 'own consumption' when their daily wage rose to a sufficiently high level. In addition all those interviewed regarded hill padi as an important 'fallback' crop that they could rapidly return to when times get hard.

An extremely important improvement to the shifting cultivation system was observed by Cramb (1978) during the baseline survey in the Layar River catchment, Second Division. He noted that longhouses in the Main Layar area were effecting a transition from extensive and traditional shifting cultivation to a more intensive and efficient form (The detailed results of Cramb's survey are given in Cramb, 1980).

Whilst the average area planted to hill padi for all the survey respondents was 1.66 ha (4.1 acres), Cramb found that this differed significantly between the Ulu Layar and Spak (sometimes spelled Sepak) longhouses, 2.87ha (7.1 acres) and the Main Layar longhouses 0.68ha (1.7 acres). The smallest Ulu Layar and Spak farm was 1.53ha (3.8 acres) whereas the largest Main Layar farm was only 1.33ha (3.3 acres). During his survey, the reason constantly given by the Main Layar households for this change to making smaller padi farms was that they were now concentrating on planting pepper.

It was noted that the average length of fallow for the Main Layar farms was 13 years whereas it was 11 years for the upriver ones and as Cramb (1978) notes, this could be a consequence of the recent reduction in farm size. A further consequence of clearing smaller hill padi farms was the reduced importance of the Iban system of labour exchange, or bedurok.

TABLE 50

KAMPONG MAYANG MAWANG, TEBAKANG

House-hold No.	Size of Family	Number of Member Working in the Tea Project	Hill Padi Cultivation (in hectares): Land cleared previously	Hill Padi Cultivation (in hectares): Land cleared in 1982	Wet Padi Cultivation (in hectares)	Other Crops: Rubber (in hect-ares)	Other Crops: Pepper (in vines)
1	7	3	1.6	-	1.2	1.6	-
2	6	2	1.2	-	-	0.8	-
3	8	2	0.8	-	-	0.6	400
4	4	2	1.2	-	-	0.4	200
5	8	3	0.3	-	0.6	0.4	-
6	7	2	-	-	0.8	1.2	-
7	9	3	0.4	-	0.8	1.2	-
8	8	4	0.8	-	0.8	1.2	-
9	9	5	3.2	-	0.2	0.4	150
10	8	1	0.6	-	0.2	0.4	-
11	8	4	1.2	-	0.4	-	-
12	10	2	-	-	0.4	0.8	400
13	6	4	0.2	-	0.8	0.4	200
14	8	3	0.8	-	0.8	1.2	500
15	13	5	1.2	-	0.4	1.2	200
16	7	3	0.4	-	0.8	1.2	400
17	5	2	-	-	0.3	-	-
18	7	3	0.8	-	0.2	-	-
19	5	4	0.8	-	0.4	1.2	-
20	3	2	0.4	-	0.1	0.4	-
21	8	3	0.8	0.3	0.3	0.8	-

TABLE 50 (cont'd).

22	10	4	0.8	-	0.3	1.2	100
23	8	4	0.8	-	0.8	1.2	-
24	5	2	-	-	0.1	-	-
25	5	1	-	-	0.2	-	-
26	7	3	0.4	0.2	-	0.4	-
27	10	3	0.4	-	0.8	1.2	-
28	9	4	0.8	-	0.6	1.2	100
29	6	1	0.4	-	0.4	-	-
30	3	1	0.4	-	0.5	-	100
31	3	1	-	-	0.4	-	-
32	6	3	0.4	-	0.1	-	-
33	7	3	0.3	-	0.2	0.4	-
34	6	2	-	-	0.4	-	-
35	8	3	0.2	-	0.2	-	50
36	2	1	-	-	0.2	1.2	-
37	8	3	0.3	-	0.2	-	-
38	8	2	0.1	-	0.8	1.2	100
39	4	1	0.1	-	-	-	200
40	8	1	0.8	-	0.4	1.2	-
41	8	4	0.8	-	0.2	-	200
42	7	3	-	-	0.4	-	-
43	3	2	0.2	0.3	0.2	-	-
44	6	2	0.8	0.2	-	0.8	-
45	5	2	-	-	1.2	1.2	-
46	6	1	-	-	0.8	0.8	100
47	11	8	0.8	0.8	0.8	0.8	100
48	4	2	0.4	-	0.4	1.2	200
49	8	5	0.8	-	0.8	-	400

TABLE 50 (cont'd).

50	6	1	-	-	-	-	100
51	6	2	0.2	-	0.3	0.4	100
52	3	2	-	-	0.4	-	-
53	5	-	-	-	0.2	1.2	-
TOTAL	355	139	26.9	1.8	21.8	31.0	4300
Mean	6	3	0.51	0.03	0.41	12.5	81

No. of families practising shifting cultivation previously = 39

No. of families practising shifting cultivation in 1982 = 5

% of the Kampong practising shifting cultivation previously= 73%

% of the Kampong practising shifting cultivation in 1982 = 9%

The comparison of yield between the Main Layar and Ulu Layar and Spak longhouses is most interesting and Cramb (1978) reports that the Main Layar farms produced significantly higher per hectare yields than the Ulu Layar and Spak farms. Since his original work in the Layar catchment, Cramb has researched the trends in far more detail (Cramb forthcoming) and this has confirmed his original hypothesis but seems to indicate that the yield differences are not as great, as originally reported. The reader is referred to Crambs very excellent studies for a more detailed treatment of this most important trend in hill padi production in the Layar catchment.

Cramb's (1978) conclusions on the reasons for the increase in yield from the smaller downriver farms are especially relevant to any consideration concerning the improvement of shifting cultivation practices and are therefore given in full below:

1. As all households in the region are allocated 10 pounds of fertilizer, regardless of the size of their farms, a reduction in farm size leads to an increase in the effective rate of application. Taking the average farm size in the two sub-regions as a guide, upriver farms would receive about 6 pounds per acre and downriver farms about 24 pounds per acre. The recommended rate is 10 pounds per acre, but it seems that an economic response can often be obtained at higher rates.

2. The decision to reduce farm size is essentially a decision to reduce the input of labour involved in clearing and felling. In particular this releases male labour for the cultivation of pepper, which tends to be more of a man's crop, in contrast to hill padi. Thus the available woman-power for the crucial task of weeding the padi would not be reduced in the same proportion, enabling the weeding to be done more thoroughly and in good time. This alone would have a marked effect on yield.

3. A third factor, which would have its full effect only in the long run, is the lengthening of the fallow period permitted by the making of smaller farms. We can imagine a household with 10 equal-sized plots of secondary forest which it clears in a regular succession, so that for every plot the fallow period is 10 years. Suppose in Year 1 the household decides that thereafter it will only farm one quarter of a plot in each year, giving it in

effect 40 small plots instead of 10 large ones. A simple calculation shows that by Year 5 the fallow period of the plot being cleared would have risen from 10 to 13 years, and by Year 10 the fallow would be 17 years. These gains would be only partially eroded by the increase in population in the same period. The exact relation between fallow period and yield per acre is unknown, but there is little doubt that an increase in fallow of only a few years would, other things being equal, lead to an increase in yield.

4. Finally, the marked difference in yields between downriver and upriver farms, as well as being due to factors increasing yield on the downriver farms, may also be caused by related factors which <u>reduce</u> yield on the upriver farms. A typical farmer may be postulated to go through the stages indicated in Table 51. Within this framework, upriver farmers appear to be at Stage 3 and downriver farmers at Stage 4. That is, upriver farmers are finding the demands of pepper cultivation sufficiently great to warrant a reduction in the allocation of <u>labour</u> to hill padi, but they do not yet have enough confidence in pepper to enable them to actually reduce the size of their padi farms. This reduction in the ratio of labour to land, which may affect such activities as clearing the farm of logs after burning, secondary burning, and weeding, would lead directly to a reduction in yield.

TABLE 51*

POSSIBLE STAGE IN THE TRANSITION FROM HILL PADI TO PEPPER

Stage	Padi	Pepper
1	Large farm; maximum maintenance	None
2	Large farm; near maximum maintenance	Small garden
3	Large farm; reduced maintenance	Medium-sized garden
4	Small farm; maximum maintenance	Large garden

*In Cramb (1978) this was Table 7

In summary it can be said that reducing farm size in order to concentrate on pepper leads to a higher yield of padi per acre, because it is associated with more intensive use of a given plot, particularly in terms of fertilizer application and weeding, and because soil fertility is increased by lengthening the fallow period. However, reallocating labour to pepper without reducing farm size leads to markedly lower yield per acre.

Terracing

Bench terracing has been one of the oldest land treatments for erosion control and settled farming on marginal hilly land in many parts of the world (Sheng, 1971). Thiesenhusen (1976) considers that terracing techniques will have to receive greater attention in countries where farmers are forced to operate on steep terrain.

When one considers that terracing techniques are almost universally utilised on steeplands throughout Southeast Asia it is somewhat surprising that the Borneo States of Sarawak, Sabah, Brunei and Kalimantan Indonesia have never developed them. It is likely that the lack of population pressure in Borneo must at least partially account for this fact and until recently, there has been little incentive to change from an extensive shifting agricultural system to a settled intensive one.

In 1978 experiments were started in Sarawak to test the usefullness of dry reverse-sloped bench terraces for hill padi cultivation. The rationale for testing this method was as follows:-

1) By using dry terraces, hill padi could still be grown and therefore the terracing technology would be more acceptable to the shifting cultivators.

2) If the terraces could be used year after year in perpetuity then large areas previously within the shifting cycle would be released for more appropriate use.

3) Successful cultivation of hill padi on reverse-sloped bench terraces would be a logical intermediate step leading to the use of bunded wet terraces for potentially higher yielding wet padi production.

4) The concentration of farming effort on effectively flat land would lead to the extension of a more intensive approach to farming on the part of the shifting cultivators and would also assist in the adoption of cash cropping.

Since the commencement of the experiments and field trials in 1978, approximately 3 hectares of hill padi terraces have been constructed by hand and more recently by machine. It has been found that terraces can very satisfactorily and safely be constructed in Sarawak on slopes up to about 30 degrees. Labour and machine requirements for contruction have been high, with about 1,500 mandays/hectare for hand-built terraces and 200 bulldozer hours/hectare for machine-built terraces. However, with the machine-built terraces in particular it is likely that dramatic reductions in construction time and costs could be achieved with larger hectareages and smaller, more appropriate machines.

The results of the terracing trials conducted to date are given in Table 52. Hatch and Wong (1978) reported that whilst first year yields were encouragingly high, they dropped off rather severely in the second year, probably as a result of the rapid oxidation of organic matter. Since 1978 the trials have shown that yield, particularly at the Department's Agricultural station, Temudok, in the Second Division, increases more or less regularly with increased doses of fertiliser (Chai, 1982a). However, to maintain yields at high levels on annually cultivated dry terraces seems to require considerable inputs of capital and labour and in comparison to either traditional shifting cultivation systems or intensified ones, it may be quite uneconomic. It is clear that the variability of the results from the terracing trials cause considerable difficulties of analysis and assessment and the trials should be continued for several years to resolve these problems.

Many of the current problems with growing hill padi on dry terraces may be alleviated if a suitable off-season leguminous crop could be grown. This would act both as a soil improver and also as a 'cleaning crop'. In addition, the use of irrigated terraces for wet padi should receive detailed attention since regular, moderate-good yields can be obtained from wet rice.

Use of Fertilizers

At present the State Government of Sarawak supplies

TABLE 52

RESULTS OF NPK TRIALS ON HILL PADI ON TERRACES, 1978-1982

Treatment			Grain yield (kg/ha)							
			ARC				Temudok			
N	P_2O_5	K_2O	1978/79	1979/80	1980/81	1981/82	1978/79	1980/81	1981/82	Mean
0	0	0	2,041	766	464	480	628	835	440	808
10	10	10	2,8862	1,191	776	678	1,012	851	832	1,172
20	20	20	2,502	928	588	707	890	813	885	1,045
50	30	30	2,456	994	587	561	986	1,080	1,567	1,176
70	30	30	2,483	1,213	810	551	865	1,225	1,808	1,279
90	30	30	2,610	1,250	631	1,066	1,051	1,457	1,871	1,419
120	40	40	3,449	1,694	735	999	1,153	1,639	2,446	1,731
L.S.D. (P=0.05)			503	N.S.	N.S.	202	268	340	758	
C.V.			20%	60%	65%	19%	19%	20%	36%	

Ammophos (N11, P48) to hill padi farmers at a subsidised rate and most farmers proclaim the value of it for increasing harvests. However, the way in which the fertilizer is applied seems to be of particular importance.

Chai (1982b) has reviewed the results of the fertiliser research that has been conducted on hill padi since it started in 1957. He split the research into three programmes as follows:-

1) Seed-dressing programme.

2) NPK fertilizer programme.

3) Nitrogen top-dressing programme.

Seed-Dressing Programme

From 1960 to 1963, 35 experiments using ammophos at the rate of 0.37kg/kg seed (2 lbs per gantang) were conducted and only 12 experiments showed a significant increase in grain yield over the no seed-dressing controls.

From 1962 to 1972, 23 similar experiments were conducted using ammophos and only 9 showed significantly better yield than the controls.

Starting in 1972, attempts were made to assess the value of some of the cheaper and commercially available formulations. Table 53 summaries the results of the 8 experiments conducted between 1974 and 1982.

Chai (1982b) concludes that based on the seed dressing experiments conducted to date, it seems probable that this method of applying plant nutrients has very little value for the hill padi crop.

NPK Fertilizer Programme

From 1960 to 1966 a total of 36 experiments on major nutrients (N.P.K.) were conducted in Sarawak. The results of these trials are summarised in Table 54.

Chai (1982b) points out that the majority of the

TABLE 53

RESULTS OF SEED-DRESSING FERTILIZER TRIALS ON HILL PADI, 1974-1982

Year	1974 - 75	1974 - 75	1977 - 78	1981 - 82	1981 - 82	1981 - 82	1981 - 82
Site	Kpg. Sadanau 1D	Kpg. Sadanau 1D	Kpg. Punau 1D	Pl. Bentang 1D	ARC 1D	Tg. Bekap 1D	Temudok 2D
Treatment[1]	Yield(kg/ha)	Yield(kg/ha)	Yield(kg/ha)	Yield(kg/ha)	Yield(kg/ha)	Yield(kg/ha)	Yield(kg/ha)
Ammophos[2]	1,174	1,496	1,074	870	733	279	846
12:12:17:2+T.E.	*	*	1,315	894	689	373	784
9:12:6:1 mixture	1,351	1,655	1,124	769	1,122	254	795
Control (no fertilizer)	1,028	1,327	993	759	710	275	718
L.S.D.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	22	24	20	22	56	35	11

1 - Fertilizer rate at 1 kg fertilizer per gantang seed (equivalent to 0.37kg ammophos/kg seed)

2 - 11 : 48 for 1974 - 75 and 18 : 48 for 1977 - 78 and 1981 - 82.

Source: Chai (1982).

TABLE 54

RESPONSE OF HILL PADI ON NPK TRIALS, 1960-1966

Year	No. of experiments S	NS	NA	T	Division	N	P	K
1960	8	0	0	8	1,2,3	+	+	0
1961	1	3	1	5	1	+	+	0
1962	6	0	0	6	1,2	+	+	+
1962-3	2	1	4	7	1,5	+	+	0
1965	2	1	0	3	1,5	+	+	+
1966	2	6	0	8	1,5	+	+	+
	21	11	5	37				

S - Significant response
NS - Non-significant response
NA - Not analysed
T - Total No. of experiments
\+ - Positive response
0 - No response

Source: Chai (1982b).

positive responses were to phosphorus whilst responses to nitrogen were somewhat less clear. Responses to potassium occurred on specific soils only (e.g. Tarat series).

Nitrogen Top-dressing Programme

There have been a total of 51 nitrogen top-dressing trials, 27 of which gave singificant responses whilst 23 showed no differences in treatments. Table 55 gives details of the nitrogen top dressing trials.

The various fertilizer trials that have been conducted in Sarawak and which have been outlined above do seem to have given responses very much in line with the observations of many other workers researching into nutrient cycling relationships under shifting cultivation. Potassium does not appear to be all that important whereas phosphorus seems to show the most marked and consistent response. The situation with nitrogen, as reported from other parts of the world, is rather confusing. Quite frequently no response whatever is achieved by applying nitrogen and in some cases it can even depress yield. Certainly many workers have pointed out that under traditional forest fallow systems nitrogen may well be adequate and does not limit growth. Where forest fallow periods have markedly declined, however, it may well be that nitrogen will give some positive boost to yield and as Chai (1982b) points out, this will particularly be the case where phosphorus is also applied to the crop.

The results given above indicate that basal and top-dressings give the best results whereas seed-dressing seems to be of very limited value. This observation is all the more relevant due to the fact that the majority of subsidised Ammophos fertilizer is applied by shifting cultivators as a seed dressing. In the past the Department of Agriculture's recommendation has been to apply Ammophos at the rate of 0.38 kg/kg seed (2lbs per gantang) mixed with the seed. This has proved quite popular and has the benefit of being a very convenient method of applying the fertiliser. However, it may well be that the time has come for a thorough review of both the type of subsidised fertilizer supplied to the shifting cultivator and the time and method of application.

Evidence from farmers themselves on the benefits of using fertilizer seems to be overwhelmingly positive but as

TABLE 55

RESPONSE OF HILL PADI ON NITROGEN TOP-DRESSING TRIALS, 1965-1976

Year	No. of experiments				Division	Response	Timing
	S	NS	NA	T			
1965	3	0	0	3	1,5	+	21 DAS
1966	3	3	1	7	1,5	+	21 DAS
1967	9	4	0	13	1,5	+, -	21 DAS
1968	9	0	0	9	1,5	+	21 DAS
1969	0	6	0	6	1,5	(+), (-)	20, 80 DAS. No Control
1970	0	2	0	2	5	(+)	-do-
1971	0	3	0	3	1,5	(+)	-do-
	0	3	0	3	1,4,5	0	-do-
1972	1	1	0	2	1,5	+	Not known
	1	1	0	2	1,5	+	-do-
1976	1	0	0	1	1	+	-do-
	27	23	1	51			

S - Significant response
NS - Not significant response
NA - Not analysed
T - Total no. of experiments
\+ - Positive response
(+)- Suggestive positive response
\- - Negative response
(-)- Suggestive negative response
DAS- Days after sowing

Source: Chai (1982b).

Cramb and Dian (1979) noted in their baseline studies, there was a fair amount of disagreement among farmers as to when it should be applied and they found strong supporters for both the seed dressing and top dressing methods.

Characteristics, Improvement and Selection of Hill Padi

There are a bewildering number of different hill padi varieties in Sarawak and a list of those hill padi varieties that have so far been collected by the Department of Agriculture is given in Appendix 2. It is very likely that several of these are duplicates but with different local names. A varietal selection programme for hill padi was initiated in 1963/1964 and 93 local hill padi varieties were subjected to preliminary assessment. Chin (1982) reports that 27 of these were then put under replicated field trial on farmer's land. The trials were conducted for three years but no outstanding differences between varieties were detected. Chin (1982) has pointed out that top-yielders in one location generally did not maintain the same ranking in another site or season. Details of the trials are given in Table 56.

Three varieties, Serasan Puteh, Buntar B and Sampangan B have been selected for multiplication for issue to farmers. The first two were selected because of their consistently high yield (Table 56) whilst Sampangan B was selected because of its good grain characteristics. The higher yielding Paya Ulu was rejected because of its long awns.

Hill padi varieties are long maturing at 160-180 days and some are day-length sensitive. They are quite different from wet padi varieties having tall, broad, pale green and drooping leaves. They have a very thick culm and poor tillering ability. They tend to have a longer root system than wet padi. Due to its tallness, it is rather prone to lodging if the yield is heavy but this is seldom a problem under traditional circumstances since yield is normally limited by poor fertility and weed competition. It appears to be rather unresponsive to fertiliser application and its yield potential is low. It is of course quite drought resistant but it would appear that high yield and drought resistance are non-compatible characteristics.

Very little work has been done on the diseases that afflict hill padi but there is no doubt that it is seriously

TABLE 56

SUMMARY OF 3-YEAR RESULTS ON HILL PADI VARIETIES CONDUCTED IN FARMERS' LAND

Varieties	Mean grain yield (kg/ha)
1. Paya Ulu	2321
2. Serasan Puteh	2275
3. Buntar B	2215
4. Payau B	2213
5. Sebulu A	2200
6. Ikan	2167
7. Sait B	2143
8. Sampangan B	2121
9. Sampangan A	2094
10. Randau A	2074
11. Ringke	2071
12. Palasan A	2069
13. Entabang	2066
14. Raton B	2065
15. Rejang	2001
16. Buntus	1990
17. Ganan B	1957
18. Merjat	1957
19. Ngawan	1938
20. Nyandal	1900
21. Kasua	1886
22. Runtu	1867
23. Payau A	1861
24. Nyandar C	1835
25. Kejang	1774
26. Sebuyau	1699
27. Majat D	1662

susceptible to Blast (Piricularia oryzae). One very important feature of hill padi is that it can produce fertile grains even under conditions of very low fertility and serious moisture stress. This is obviously important for the production of seed for the following year's planting. Some of the agronomic characteristics of some hill padi varieties are given in Appendix 3.

It is clear that very little work nas been done on the improvement or selection of hill padi in Sarawak and indeed, the same could be said for nearly every other country where farmers grow dry rice. It is the breeding and improvement of wet padi varieties that has received the greatest attention and where the most dramatic strides have been made in improving yield. However, there is no reason to suppose that similarly dramatic improvements cannot be made if the same effort and investment are put into hill padi improvement. It is most unlikely that hill padi could ever yield as well as wet padi in absolute terms, but some improved characters of yield, fertiliser response and disease resistance could be incorporated into selected varieties.

Upland Padi

Upland rice has been defined as one in which the crop is grown on flat or sloping fields that are not bunded. It is entirely dependant on rainfall for moisture (Chin, 1982). Some trials have been conducted by the Department of Agriculture to test IRRI upland rice varieties. Chin (1982) reports that some of the selections (e.g. IR2035-206-1 and IR2035-419-3) could give very high yield.

Use of higher yielding upland rice as an alternative to hill padi has been proposed by various workers and a small and unreplicated field trial was conducted in 1977/78 by the Methodist Agricultural Rural Development Programme at Nanga Mujong, Seventh Division (ARDPRO, 1978). Results of this trial are given in Table 57 and whilst some varieties like IR3646-9-3-1 gave encouraging results, no firm conclusions can be drawn because of the lack of statistical completeness. Unfortunately, these trials were not continued.

Hill Padi or Wet Padi?

It is commonly held that due to its taste and other

TABLE 57

UPLAND PADI TRIAL, NG. MUJONG

Selection No.	Actual plot size m^2	Yield in gram	Yield kg/ha	Disease score 1-5 1=least	Stand	Plant height	Days to maturity	Grain Size
IR 1529-430-3-1	10.5	1,350	1,285	2	poor	short	125	long
IR 4892-1-2-5 Rfd 2189	10.0	1,646	1,646	1	good	med.	105	med.-full
IR 7777-7-1-1 FT 3-2008	10.0	595	595	3	poor	med.-short	135	med.-full
IR 3646-9-3-1 Rfd 2115	0.55	2,135	2,497	1	good	med.	125	long
IR 9669 (IR 83/CANEON) URYT	10.0	1,556	1,556	1	fair	short	140	short
IR 3880-13-7 Rfd 2074	8.8	1,513	1,719	2	fair	med.	110	med.-full
C22	10.0	1,255	1,255	2	fair	short	130	short
RP-KN 2-Reg.	8.74	9.24	1,057	4	fair	med.	120	short

favourable qualities, hill padi is the only rice that the Iban (and probably other shifting cultivators) wish to grow and eat. Whilst the taste of hill padi is better than wet padi and is undoubtedly favoured by the Dayaks, its importance is often given too much weight. Masing (1982) has observed that taste is probably not nearly as important as quantity. Hill padi has been grown mainly out of necessity and in very many cases shifting cultivators, if given the choice, would prefer to grow wet padi. The present shifting cultivators are perfectly well aware of the fact that with wet padi, one can obtain more yield with less work. As Cramb and Dian (1979) have observed, there are a considerable number of shifting cultivators who already grow large quantities of wet padi where suitable land is available. It is not at all unusual for families to make long journeys to wet padi areas remote from their longhouse, in order to grow wet padi.

Many religious practices are associated with the growing of hill padi and as a consequence, it has often been incorrectly assumed that this would create resistance to the growing of wet padi by Dayak populations. Masing (1982) has also pointed out that the religious practices can be easily transfered to wet padi and this involves no major trauma. Padi 'pun' can still be grown, the only difference being that it is a wet padi variety rather than hill. One disadvantage with growing wet padi instead of hill is that the large number of intercrops associated with shifting cultivation cannot be grown. However, this is not considered to be a serious problem and is far outweighed by the yield advantages of wet padi.

Resettlement

This is a solution that is often proposed for shifting cultivators living in remote and inhospitable areas and certainly there are cases where it is the only sensible action that can be taken. However, due to the social and psychological problems that can be associated with it, the very greatest of care must be taken before resettlement schemes are implemented. There have been a number of quite small scale resettlement schemes conducted in Sarawak and these have frequently been undertaken for security reasons. Such schemes have been implemented by either SLDB or FELCRA (Federal Land Consolidation and Rehabilitation Authority) acting in concert with RASCOM (Rajang Security Command).

To give a hypothetical example for Sarawak, one could conceive of a river system that we shall call the Batang Serak. This river system can be roughly divided into three zones - a lower, middle and upper. The lower zone has fairly good topography of either flat or very gently undulating land. The middle zone has little or no flat land but has a reasonable proportion of gentle to moderate topography. The upper zone, however, consists of very steep land with only very small areas of moderately sloping land. Shifting cultivation settlements exist the whole length of the Serak River but in the lower and middle zones, there has been movement towards growing wet padi and cash cropping is widely practised on land of reasonable potential. In the upper zone only hill padi is grown and whilst cash cropping is carried out, the land is generally poor and the distance from markets is great. Communication with the lower and middle zone is not too difficult but it can be extremely difficult and even dangerous with the upper zone. Provision of government services such as education, health, agriculture, water etc. is extremely expensive.

In such cases as the Batang Serak, resettlement of at least some of the upper zone longhouses may be very beneficial. The money previously expended on bringing services to the people could be reallocated to settling them on better land where there is some potential for future growth and development. Some upper zone longhouses would remain and the people employed to manage and protect the forest that hopefully would develop once shifting cultivation ceased. Relieving the government of the burden of serving the upper zones would provide finance for improving road and river links to the lower and middle zones.

The above has been a very simplistic and broad hypothesis which must be viewed with the greatest of caution. However, it does serve to illustrate the manner in which resettlement should be considered - the selected and careful movement of people who are farming on land of the poorest type and which has no possible agricultural potential, rather than the wholesale movement of complete watersheds.

The need to implement larger resettlement schemes has, however, become more apparent lately with the need to move whole watershed populations because of hydroelectric schemes. The Batang Ai is the first such large scale scheme to be undertaken and as a result, nearly 500 families (in 20 longhouses) will have to be moved. The relocation is deemed necessary not only because some longhouses will be affected by flooding but the watershed itself must be protected from continued shifting cultivation. The proposed farm plan for the resettlement scheme is shown in Figure 5. Each family will be allocated between 4.5 and 6.8 hectares to be used for rubber, cocoa, padi and grazing.

However, one wonders whether this allocation will be sufficient for people who were previously accustomed to having a much higher land holding (associated with shifting cultivation). In addition, the land allocation makes no allowance for population expansion and the division of family ownership.

A hydroelectric scheme has also been proposed for the Rajang catchment and this would produce anything up to 2,500 MW of power. If the Rajang scheme were to be fully implemented, then over 2,000 families (Pelagus 1,635, Bakun 607) would be affected and they would nearly all be shifting cultivators. It is to be hoped that the lessons learned from the Batang Ai resettlement scheme can be used for the benefit of those that will be affected by the much larger hydroelectric schemes on the horizon.

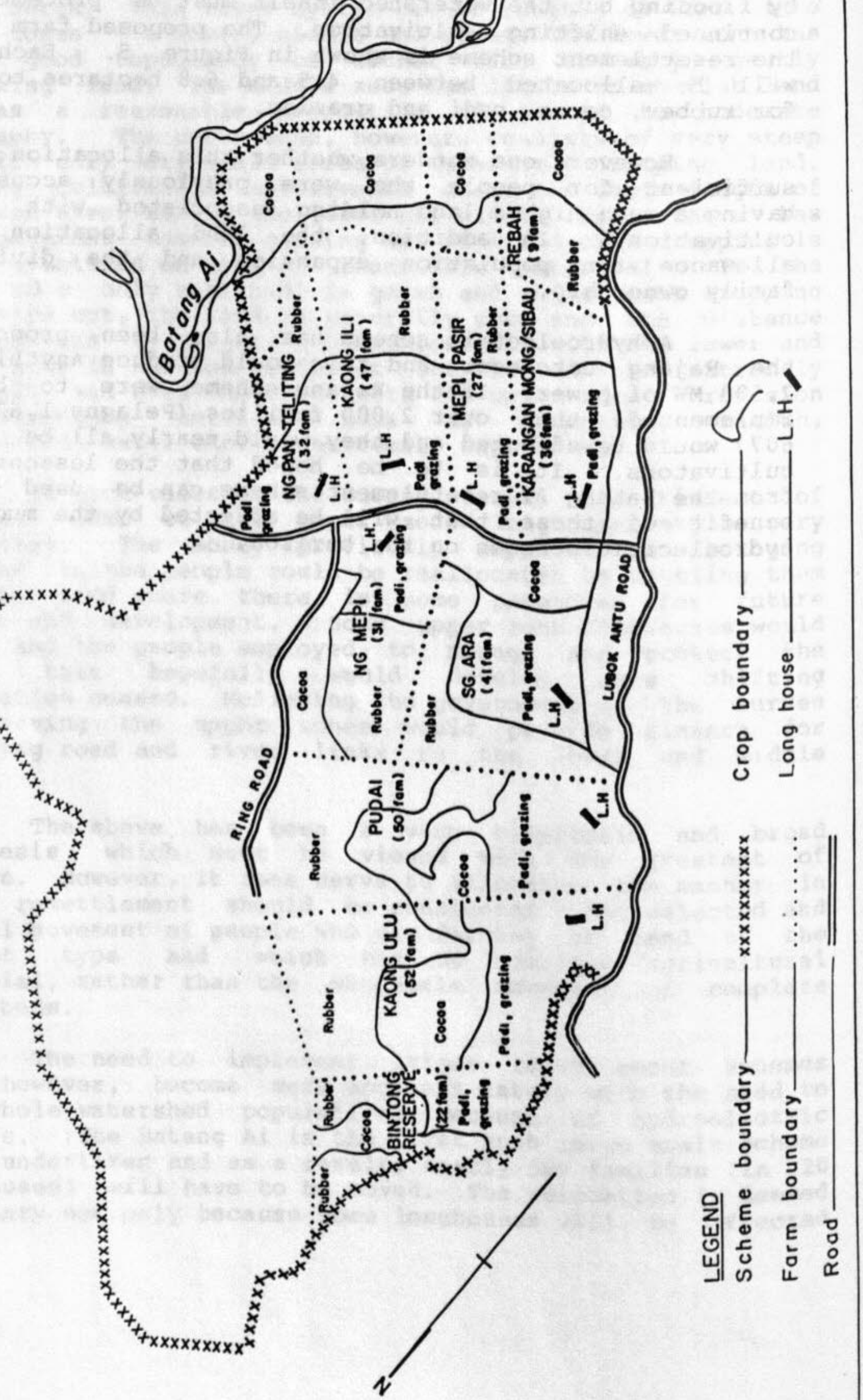


FIG 5 PROPOSED FARM PLAN FOR BATANG AI RESSETTLEMENT SCHEME

SCALE 1 : 50,000

SUMMARY AND DISCUSSION

As was pointed out in the Preface, it is not the intention of this review to recommend any answers or solutions to those problems created by shifting cultivation. Rather it has been an attempt to bring together much of the very valuable work that has been done so that those charged with the responsibility to do so can make more informed decisions. It is also hoped that this review will serve to highlight those many facets of shifting cultivation in Sarawak about which we still have very scant and inaccurate information. Below I have summarised the various features of shifting cultivation which have been dealt with in greater depth in the text, together with recommendations concerning future work that should be undertaken to improve our knowledge on the subject.

1. Shifting cultivation is carried out on the moderate to steep topography that occupies about 80% of the land area of the State of Sarawak. The soils in these areas are generally extremely poor, being derived from sedimentary rather than igneous parent materials. They are referred to as the Red Yellow Podzolics (yellow to red loamy sands to clays). They are deeply weathered soils and rather low in plant nutrients, particularly phosphates.

2. Very little work has been done on the nutrient cycle that supports shifting cultivation and the associated length of forest fallow period. The small amounts of plant nutrient that are available are mainly concentrated in the very shallow topsoils. The only empirical work conducted in Sarawak (Andriesse, 1977) showed that as one would expect, there are large increases in major nutrients in the soil immediately after the burn but these quickly return to normal levels. Andriesse (1977) suggested that a fallow period of twenty years would be sufficient to reinstate the fertility of the soil.

   From the various surveys undertaken and notably those by Cramb and Dian (1979), it is clear that the average forest fallow period for the State is rather less than twenty years and in some places is well below ten years. In the longer settled areas particularly, the shortening of the forest fallow period is becoming very pronounced.

Recommendation. It is clear that we still know very little about nutrient cycling under shifting cultivation and it is an area of research to which far more effort should be devoted. Until we do get a better understanding of the availability and behaviour of the various major nutrients (but particularly phosphorus and nitrogen) under Sarawak conditions, it is difficult to see how any meaningful recommendations can be made to farmers as to the length of forest fallow they should attempt to maintain. Similarly, the continued provision of subsidised ammophos fertiliser must be reviewed in the light of our lack of knowledge about nutrient cycles under shifting cultivation.

One of the most basic shortfalls in our knowledge about shifting cultivation is its actual extent in Sarawak. It would appear, by referring to current statistics and mapping, that the area planted each year could be between 75,000 and 150,000 hectares! The total area of the State that is or has been under the influence of shifting cultivation could be as high as 3 million hectares. The survey techniques currently used by the Department of Agriculture (and other departments and agencies) are probably not very accurate and fail to take account of the complexity of the system.

Recommendation. It would seem absolutely essential that efforts are made to determine the exact areas that are planted to hill padi and which areas are actively within the shifting cultivation cycle. Without this most basic of information, it is hard to see how any sensible plan for future development, research, extension or assistance can be formulated. Because of the remoteness of the areas involved, it is considered that use of satellite imagery may be particularly helpful for this process. Coverage of Sarawak is available from all three currently functioning Landsat satellites at very low cost. Use of satellite imagery also provides the potential for identifying the ages of forest fallows and so would be an invaluable research tool.

4. It does appear that in certain areas at least, the land within the shifting cultivation cycle is being extended quite significantly (e.g. Tatau & Kemena) probably as a result of recent migration. Presumably the areas from which the migrants came are now under less pressure from shifting cultivation and therefore the situation in these regions would have improved somewhat. Once again this is something for which there is little information available.

Recommendation. It is clear that we need much more information on the movements of shifting cultivators and the trends that are taking place in the extent to which the system is being used to provide food. Is the area under shifting cultivation (once we know what that is) increasing or decreasing? Once again remote sensing techniques could help here but on-the-ground surveys would also be important.

5. The cycle of shifting cultivation in Sarawak does not vary greatly from that of most integral shifting cultivators in moist tropical forest. The slashed jungle is left to dry for several weeks and then burned and then the hill padi is planted just before (ideally) the first rains. Weeding of the farms is very important for healthy growth of the padi. Harvesting takes place about six months after planting. The crop is stored at the kampungs generally in the threshed condition. Losses during storage may be high. The average State yield of padi is given at about 700 kg/ha but this conceals an enormous variation from zero up to in excess of 2,000 kg/ha. Fertilisers, herbicides and weedicides are used to some extent on the crop but little is known about the most efficient methods or times of application or the yield responses achieved.

Recommendation. Whilst a great deal is now known about the yearly hill padi cycle, we are still lacking a great deal of well researched information on the influence of weeds, pests and diseases and the optimum time and types of fertiliser placement. It would appear that with fertilizer treatment particularly, much more basic research is required on the time of application. In addition, far more information is required on yields and the influence of various management practices on them. Whilst we believe that yields are increased by efficient weeding, use of pesticides and application of fertilizers, there is very little actual data to support this belief and virtually none on responses to various levels of treatment. The myriad of other details relating to shifting cultivation such as drying periods of the slashed areas, optimum burning times, optimum planting times, seeding rates and spacing, types of intercrops, storage etc must also be looked at in greater detail.

Associated with the question of yield and production is that of malnutrition. Some surveys that have been conducted do seem to indicate that malnutrition might be a problem for shifting cultivators. The extent of the problem is not known, however, and it would be irresponsible to make any firm statement on its existence or seriousness.

Recommendation. That further surveys be undertaken amongst shifting cultivators to determine their nutritional status.

In recent years shifting cultivators have been blamed for a whole variety of environmental damaging effects. However, it now seems clear that logging and timber extraction must take a lot of the blame that was previously laid at the door of the shifting cultivator. Not only do traditional logging methods tend to destroy more trees than they harvest but they also lead to serious soil erosion, impeded drainage, siltation and flash flooding. All of the evidence available from studies carried out in Sarawak indicate that few if any of these undesirable effects can be laid at the door of the shifting cultivator.

Nonetheless, there is no doubt that shifting cultivators are invading permanent forest areas at a rate that gives serious cause for concern.

Recommendation. Further urgent research is necessary to determine the exact extent of invasion of permanent forest. In order that more precise information can be obtained on the influence of logging operations, it is recommended that the monitoring of small watersheds be undertaken.

8. There are several alternatives that have been proposed worldwide for shifting cultivators and it is disturbing to note that a rather high proportion of them have not been very successful. Where solutions that involve forestry or reafforestation have been proposed, it is clear that these will only work if the shifting cultivator is allowed to reap a fair proportion of the wealth of the forest. However, there is no doubt that in Sarawak at least there is an enormous potential for the employment of a large number of shifting cultivators in forestry and forest-allied industry.

   Recommendation. Strenuous attempts should be made to develop forestry management systems that give maximum opportunities for the shifting cultivator to switch his effort into this sector of the economy.

9. One approach to assisting the shifting cultivator in Sarawak has been through agencies such as SLDB and SALCRA and in the future, LCDA which instigate large scale land development schemes for crops such as oil palm, rubber, cocoa and pepper. A recent smaller scale scheme for lowland tea has also been started.

   Recommendation. That these large scale development schemes be closely reviewed to determine whether they are bringing the greatest possible benefit to their target groups. The lowland tea scheme should receive particular attention since it is rather smaller than the other development schemes and is therefore likely to be more sensitive to and readily accepted by the people themselves.

10. On the Layar river in the Second Division, Cramb (1979) observed the fact that some longhouses were intensifying their shifting cultivation process by reducing the size of their annual clearances. This appeared to lead to an increase in per unit area yield, whilst at the same time releasing some labour for cash crop farming and very importantly, increasing the forest fallow periods.

   Recommendation. That priority be given to carry out further in-depth studies of this intensification process. In the meantime, every effort should be made to extend the features of the intensified form of shifting cultivation to all other farmers in the State. The ntensification process may be the first step in a chain of events that may lead to completely new agricultural systems for the shifting cultivator, but in any event it will give some breathing space whilst other alternatives can be considered and implemented.

11) Terracing for hill padi cultivation on a settled basis has been tested in Sarawak for the past four years and so far the results have not been very encouraging. Yields have remained quite low despite the use of substantial quantities of inorganic fertilizer. The low levels of organic matter and serious weed infestation on continuously cultivated terraces is considered to be one of the prime factors limiting higher yields. Attempts to utilise <u>Leucaena leucocephala</u> as a source of organic matter and nitrogen has failed due to poor growth of the Leucaena on Sarawak's acid soils.

Recommendation. That the research on terracing be continued and attempts made to overcome the problem of low organic matter levels. A search for an indigenous version of <u>Leucaena leucocephala</u> should be undertaken. Research on wet padi terraces should be stepped up since this technology holds greater hope for improving yields. It appears that wet terraces are already successfully used in certain parts of Sarawak (e.g. Baram area) and this technology could be usefully spread to other shifting cultivators. Availability of water at high levels may be a problem for the development of wet terraces in Sarawak.

12. So far very little work has been undertaken on the breeding or improvement of hill padi varieties but there is no reason to suppose that hill padi cannot be improved in the same manner (if not to the same extent) as wet padi.

Recommendation. That a breeding programme for hill padi be started in Sarawak to produce or identify a hill padi variety that is suited to Sarawak's environmental and soil conditions.

13. Whilst hill padi is favoured for its pleasant taste and consistency, there is no reason to believe that shifting cultivators will strongly resist a change

to growing and eating wet padi provided suitable land is available. There are already many examples of hill padi farmers successfully and with minimal fuss, making the transition to wet padi cultivation.

Recommendation. Since growing wet padi is an acceptable alternative to hill padi, it would seem essential that every effort be made to identify potential wet padi land in the interior of Sarawak. Since these are likely to be small in extent (but nonetheless of useful area), an attempt must be made to include them within existing departmental responsibility. Unfortunately at present, only the very large potential wet padi areas receive the attention of the Department of Drainage and Irrigation. Consequently, the potential of very many small to medium sized padi areas in the interior is not fully realised. This situation should be remedied.

14. Resettlement of shifting cultivators is often proposed as a solution for farmers living in very remote areas. Certainly it has an important role to play in the development of any country, including Sarawak, but many of its implications and spin-offs are not entirely appreciated. In addition, there are innumerable cases worldwide of resettlement schemes being undertaken with quite insufficient planning and without adequately consulting the people involved. At best this produces a rather dissatisfied group of settlers who may attempt to move back to their home ground or other areas completely unexpected. At worst, such schemes can produce very frustrated and psychologically disturbed groups of people who become totally dependant on welfare handouts.

Recommendation: Resettlement of shifting cultivators should be treated with the greatest of caution and only implemented after thorough examination.

Conclusions

There are two features of shifting cultivation in Sarawak which, it is felt, should always be at the forefront of the minds of those who consider this form of agriculture. Firstly, it works!. It is not a temporary form of totally exploitive agriculture but is rather a very sophisticated and rational system of land use. In many cases, it may be the only method that can produce food from certain types of land.

Secondly, it is, for the foreseeable future, here to stay! It is not a system that will just quietly disappear if we keep our eyes closed long enough. It is by far and away the predominant system of agricultural land use in the State and the time is long overdue for sufficiently large funds to be allocated in order that every facet may be studied and better understood. Only then can sensible recommendations be made as to how the system should develop or change.

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APPENDIX 1

VEGETATION SUCCESSION IN SHIFTING CULTIVATION AREAS OF 3 TO 15 YEARS OLD, NANGA TAPIH AND BATU LINTANG, ULU BETONG

Tree Species dominating 3-year old secondary forest

1. Melastoma malabathricum L.
2. Dillenia suffruticosa (Griff.) Mast.
3. Glochidion lutescens Bl.
4. Macaranga beccariana Merr.
5. Homalanthus populneus Pax.
6. Vitex pubescens Vahl.
7. Anisophyllea disticha (Jack) Baill.
8. Timonius lasianthoides Val.
9. Ficus fulva Reinw.
10. Ficus uncinata Becc. var. uncinata Corner.
11. Ficus grossularioides Burm. f.
12. Macaranga costulata Pax. ex Hoffm.
13. Leucosyke capitellata (Poir.) Wedd.

Tree Species dominating 6-year old secondary forest

1. Leucosyke capitellata (Poir.) Webb.
2. Dillenia suffruticosa (Griff.) Mart.
3. Melastoma malabathricum L.
4. Vitex pubescens Vahl.
5. Glochidion lutescens Bl.
6. Macaranga costulata Pax. ex Hoffm.
7. Macaranga beccariana Merr.
8. Ficus uncinata Becc. var. uncinata Corner.
9. Ficus grossularioides Burm. f.
10. Ficus fulva Reinw. ex Bl.
11. Artocarpus elasticus Becc.
12. Vernonia arborea Ham.
13. Eugenia lineata (Bl.) Duthie

Tree Species dominating 9-year old secondary forest

1. Dillenia suffruticosa (Griff.) Mart.
2. Adinandra cordifolia Ridl.
3. Glochidion lutescens Bl.
4. Vitex pubescens Vahl.
5. Macaranga beccariana Merr.
6. Artocarpus elasticus Bl.
7. Cratoxylum glaucum Korth.
8. Vernonia arborea Ham.
9. Anisophyllea disticha (Jack) Baill.
10. Psychotria viridiflora Reinw. ex Bl.

Tree Species dominating 12-year old secondary forest

1. Ilex cissoidea Loes.
2. Cratoxylum glaucum Korth.
3. Adinandra cordifolia Ridl.
4. Ficus brunneo-aurata Corner
5. Euodia nervosa K.et V.
6. Dillenia suffruticosa (Griff.) Mart
7. Anisophyllea disticha (Jack) Baill.
8. Vitex pubescens Vahl.
9. Psychotria viridiflora Reinw. ex Bl.

Tree Species dominating 15-year old secondary forest

1. Tarenna intermedia Val.
2. Ilex cissoidea Loes.
3. Adinandra cordifolia Ridl.
4. Ficus brunneo-aurata Corner
5. Vitex pubescens Vahl.
6. Artocarpus elasticus Bl.
7. Euodia nervosa K. et. V.
8. Dillenia suffruticosa (Griff.) Mart.
9. Anisophyllea disticha (Jack) Baill.
10. Psychotria viridiflora Reinw. ex Bl.

APPENDIX 2

HILL PADI VARIETIES

Abey	Bisbang C	Gelap
Anak China	Buda	Genan
Angkatan Barit	Buluh	Genan B
Aur	Bungan A	Genan A
Avung	Bungan B	Iban
Avung I	Buntar A	Ibat
Avung II	Buntar B	Ikan
Avung III	Buntis	Jelimbai
Ajek A	Belangsai	Jaleh
Ajek B	Bangan	Jet
Bali	Badeh	Kadungkang
Bangang	Biris I	Kersik
Bayong	Biris II	Kumpai
Bayung	Biris III	Kampar
Belau	Bensu	Kanto
Berangan	C 22	Kantu
Beras China	China	Karat B
Berembun	Danau	Kasua
Beruak	Dari	Kau Kau
Bidong A	Engkabang A	Kejang
Bidong B	Engkabang B	Kepapa
Bilimbang	Enchangan	Kerangan
Bisbang	Enchangan B	Karesik A
Bisbang A	Entemut	Karesik B
Bisbang B	Entaba	Kunyit
Kui	Nyandar	Pulau Bawang
Hitam I	Nyandar A	Pulau Raja
Hitam II	Nyandar C	Pulut Baloi
Langkatan	Padi Bali	Pulut Gelayan
Lantit	Pun	Pulut Kanowit
Lapit	Padi Adan	Pulut Melanjan
Lawai	Paku	Pulut Siam
Limbang	Padi Bandung	Pulut Bulu
Lansat Jaleh	Padi Hitam	Paya Ulu
Majat A	Padi Besai	Pulut Melajar A
Majat B	Padi Kuning	Pulut Melajar B
Majat C	Padi Mit	Pulut Sebayan
Majat D	Padi Pun	Pulut Tinggi
Mama	Padi Barit	Pulut Ikan
Mara	Padi Limbang	Pulut Rambai
Mas	Padi Meai	Pulut Wan
Mau	Padi Panjang	Puya
Mayang	Padi Raya	Padi Panjai
Mayang Tapang	Padi Tarat	Padi Lentit

Mit Merundai
Maba
Merjat
Mudah
Munsang A
Munsang B
Nanung
Ngawan
Nomor Dua
Nyandal
Padi Letap
Padi Randay
Padi Engkabang
Padi Danau
Padi Jaba
Padi Sadong
Padi Kersik
Padi Manang Unggat
Padi Sukong
Padi Matang
Padi Manggok
Padi Aring
Padi Kantu
Padi Jambu
Pulut Kijang
Pulut Bakong
Pulut Sibau
Pulut Kejera
Pulut Udor
Pulut Kembayau
Pulut Temedok
Pulut Jantan
Pulut Injin
Ragom/Pun
Rajang
Randau E
Randau D
Randau B

Pait
Palasan A
Palasan B
Parajugan A
Parajugan B
Paya Ulu
Payaw A
Payaw B
Payaw C
Ping
Randau C
Randau A
Rejang A
Ringke
Rotan
Rotan A
Rotan B
Rotan C
Ruan
Runtoh
Runtu
Sabaga
Saloh
Sampet
Sabong
Sadong
Siat A
Siat B
Samanbo
Sambas
Sampangan A
Sampangan B
Sebulu A
Sebulu B
Sebungkang
Sang Kadau
Sebuyau
Sedong

Padi Pasir
Padi Indai Jasuban
Padi Abang
Padi Chundang
Padi Epawah
Padi Rangkang
Padi Mansau
Padi Indai Minon
Padi Aras
Padi Spuru
Sekayam
Seluang
Selelong
Sensay
Serandah
Serasan Puteh
Seru
Siam
Siya
Terbat A 1
Tambang
Tapang
Taning Pelandok B
Taning Pelandok C
Telasan
Telaseh
Tulang
Turi
Ubar
Ulor
Ung

APPENDIX 3

HILL PADI VARIETIES : AGRONOMIC CHARACTERS

	Blade length (cm)	Culm height (cm)	Spikelet fertility (%)	Threshability	Maturity period (days)	Panicle length (cm)	Grain colour	Blast resistance	Potential yield (kg/ha)
Buntar B	62	121	80	Intermediate	132	24	White	Susceptible	1,918
Serasan Putih	69	114	77	Intermediate	142	31	White	Susceptible	1,962
Sampangan B	51	123	93	Shattering	113	28	White	Moderately susceptible	1,883
Palasan A	70	110	76	Shattering	117	30	White	Susceptible	1,988
Palasan B	67	114	66	Shattering	118	27	White	Susceptible	
Rejang A	59	117	86	Intermediate	114	130	White	Susceptible	1,338
Ping	55	116	90	Shattering	107	29	White	Moderately susceptible	
Payaw B	64	112	85	Shattering	119	2.9	White	Susceptible	1,883
Nyandal	62	141	80	Shattering	140	28	White	Susceptible	1,742
Mayang	61	113	68	Shattering	165	26	White		
Ringka	63	113	62	Shattering	118	33	White	Susceptible	1,839
Sampangan A	60	115	82	Shattering	110	30	White	Moderately susceptible	1,724
Beruak	65	123	62	Shattering	119	30	Red	Moderately susceptible	
Genan B	63	120	72	Shattering	114	27	White	Susceptible	1,883
Paku	61	137	77	Intermediate	159	24	White	Susceptible	
Ikan	61	125	87	Intermediate	119	30	White	Susceptible	2,033
Paya Ulu		108	79	Intermediate	137	21	Red	Susceptible	2,005
Sebulu A	70	122	75	Intermediate	114	31	White	Susceptible	1,707

APPENDIX 3 (cont'd).

Randau A	59	121	88	Intermediate	114	31	White	Susceptible	1,927
Kasua	63	116	82	Shattering	108	36	White	Susceptible	1,716
Kejang	49	127	81	Shattering	113	31	White	Susceptible	1,470
Rotan B	51	122	85	Intermediate	124	34	White	Moderately susceptible	1,804
Rejang	61	108	72	Shattering	133	26	White	Susceptible	1,442
Nyandar C	69	131	76	Shattering	136	33	White	Susceptible	1,602
Ngawan	66	119	72	Intermediate	115	20	White	Susceptible	1,857
IR 36		49.8			118				3,170
C 22		120.3			120	24.9			2,895

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