# CHAPTER II

# SHIFTING CULTIVATION SYSTEM

## II.1. GENERAL DEFINITION OF SHIFTING CULTIVATION

Shifting cultivation has been defined in various ways. Conklin (1957) gives a general definition: an agricultural system in which fields are cleared by firing and are cropped discontinuously. Pelzer (Christanty, 1986) gives the standard definition of shifting cultivation: an agricultural system which is characterized by a rotation of fields rather than of crops, by short periods of cropping (one to three years) alternated with long fallow periods (up to twenty or more years, but often as short as six to eight years); and by clearing by means of slash and burn. Watters (1971) offers a slightly more detailed definition: 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 20 years but after only 4 to 8 years) and characterized by clearing by slash-and-burn and the almost exclusive use of human energy, employing the machete, digging stick or hoe, with plough only rarely being used. Okigbo's (1984) definition is simple: a farming or agricultural system in which a short but variable cultivation phase on slash-and-burn cleared land alternates with a long, equally variable fallow period.

Many terms have been used to denote shifting cultivation. According to Spencer (Christanty, 1986) at least forty-eight English terms have been used including shifting or swidden: cut-and-burn, five-field, land-rotation, nomadic, slash-and-burn, and transient cultivation. About 60 percent of the scientific literature uses the phrase "shifting cultivation", another 15 percent uses the term "swidden". Local vernacular terms have also been given to shifting cultivation. The term "ray" is used in Vietnam, "tam-rai" in Thailand, "hanumo" or "caingin" in the Philippines and "ladang" in Malaysia and Indonesia (Table 2).

## III.2. CLASSIFICATION OF SHIFTING CULTIVATION

Various classifications of shifting cultivation have been made by several writers. Conklin (Christanty, 1986) distinguished "integral and partial shifting cultivation". "Integral" reflects the fact that the system is an integral part of a subsistence farmer's way of life. "Partial" indicates the use shifting cultivation as a technological expedient for supplemental cash cropping or other form of commercial agriculture. Generally, Conklin's widely asserted classification can be summarized as follows:

**Table 2. Some local vernacular terms used for shifting cultivation in different parts of the world.**

| | **TERMS** | **COUNTRY OR REGION** |
|---|---|---|
| **A. ASIA** | Ladang | Indonesia, Malaysia |
| | Huma | West Java |
| | Juma | Sumatra |
| | Umai | Kalimantan |
| | Ray | Vietnam |
| | Tam-ray, Rai | Thailand |
| | Hay | Laos |
| | Hanumo, Caingin | The Philippines |
| | Chena | Sri Lanka |
| | Karen | Japan, Korea |
| | Taungya | Burma |
| | Bewar, Dhya, Dippa, Erka, Jhum, Khumri, Penda, Pothu, Podu | India |
| **B. AMERICA** | Coamile | Mexico |
| | Milpa | Mexico, Central America |
| | Icheli | Guadalape |
| | Roca | Brazil |
| **C. AFRICA** | Masole | Zaire |
| | Tavy | Malagasy Republic |
| | Chitemene, Citimene | Zaire, Rhodesia, Tanzania |
| | Proka | Ghana |

Source: Okigbo,B.N. 1984. "Improve Permanent System As An Alternative to Shifting Cultivation". In Improved Production Systems As An Alternative to Shifting Cultivation. pp 1-100. Rome. Food and Agricultural Organization Of The United Nations.

1) Integral Shifting Cultivation

-Pioneer swidden farming-significant portions of climax vegetation are cleared annually.

-Established swidden farming title or non climax vegetation is cleared annually.

2) Partial swidden cultivation

-Supplementary swidden farming. A farming system in which part of the effort the farmer's are devoted to shifting cultivation.

-Incipient swidden. A farmer moves into a forest area and clears part of it for continuous agriculture but may be forced to shift after few years, because of rapid yield decline.

Watters (1971) proposed a similar classification i.e;

a) Traditional shifting cultivation. This has been practiced traditionally by tribal people whose lives and religions have been closely tied to the natural systems around them.

b) Shifting cultivation imposed by necessity. The cultivator is not linked to a tribal community and usually owns no land, or not enough land to support permanent agriculture. Therefore, the cultivator often clears forest for cultivation and starts a cycle of shifting agriculture. This type of shifting cultivation can be called "land-hunger shifting cultivation".

Okigbo (1984) proposed six classifications of shifting cultivation, based on land use factor with:

$$L = \frac{C + F}{C}, \text{ where}$$

L = land use factor

C = number of years of cultivation

F = number of years of fallow

During the early stages of shifting cultivation fallow periods are long, $L = > 10$, when the system becomes one of permanent cultivation $L=1$ (Table 3 ).

**Table 3. Classification of shifting cultivation based on land use factor**

| System | Land use factor (L*) |
|---|---|
| 1 Shifting cultivation | Over 10 |
| 2 Long-term recurrent Cultivation | Between 7 and 10 |
| 3 Medium-term recurrent Cultivation | Between 5 and 7 |
| 4 Short-term recurrent cultivation | Between 3 and 5 |
| 5 Semi-permanent land | Between 2 and 3 |
| 6 Permanent land | Less than 2 |

* L = land use factor, defined as $L = \frac{C + F}{C}$

where C = length of cropping in years
f = length of fallow period in years

Source: Okigbo,B.N. 1984. "Improve Permanent Systems As An Alternative to Shifting Cultivation Intermitten Cultivation". In Improved Production Systems As An Alternative to Shifting Cultivation. pp 1-100. Rome: Food and Agricultural Organization Of The United Nations.

## II.3. DISTRIBUTION OF SHIFTING CULTIVATION

Shifting cultivation has been practiced in many countries, in Africa, Central and South America, Asia and Southeast Asia and Oceania (Figure 2) (Okigbo, 1984).

According to Sanchez (1976) shifting cultivation the predominant practice in approximately 30 percent of the exploitable soils of the world totalling 360 million ha. It is the primary means of subsistence for over 250 million people or 8 per cent of the world's population. Even in the most densely populated tropical region, Southeast Asia, about one-third of total farmland is under shifting cultivation. According to Hatch and Tie (1979) shifting cultivation estimated that there are over 250 million shifting cultivations worldwide, 100 millions in Southeast Asia alone. In Southeast Asia, shifting cultivation has been practiced extensively in Thailand, Burma, Laos, Cambodia, Vietnam, the Philippines and Indonesia. In Thailand, for example, there are 551,144 persons of various hill tribes groups most of whom practise shifting cultivation in 3,408 mountain villages (McKinnon, 1989).

In the Philippines, 65,958 ha forest were destroyed in 1978, of which 54 percent was attributed to shifting cultivation (Sajise, 1986). While in Indonesia, according to Sumitro (1985), shifting cultivation is found all over the islands of Sumatra, Kalimantan, Maluku and Irian Jaya.

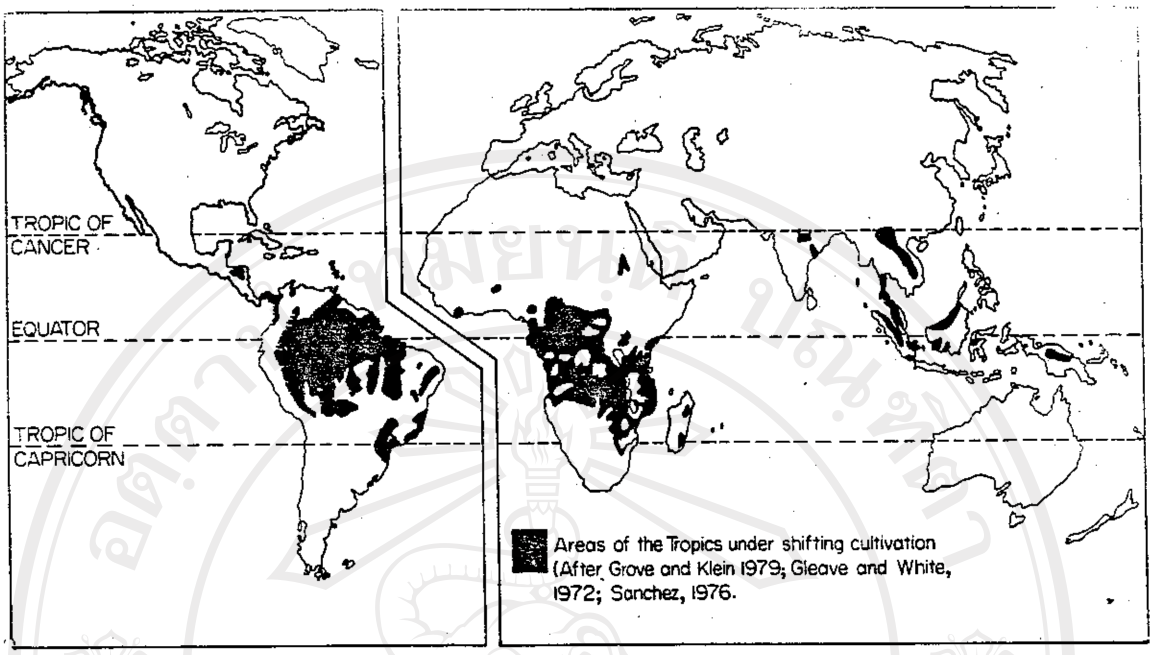

Figure 2. Distribution of shifting cultivation in the tropics (Okigbo, 1984)

## II.4. SOIL FERTILITY IN SHIFTING CULTIVATION

According to Kalpage (1974) shifting cultivation is the traditional way of maintaining soil fertility in the tropics. It involves the clearing of forest or grassland, burning of the debris, growing crops for a period which may vary from one to ten years, but is usually two to four years, and then reverting the land to its natural vegetation so as to restore soil fertility, the length of the fallow period usually extending from less than ten to twenty or more in grass. Nye and Greenland (1960) and Sanchez (1976) suggest that transfer of nutrient between soil and vegetation in the shifting cultivation field can be considered in 3 aspects, i.e, a) uptake by vegetation, b) removal from the vegetation and return to soil, as litter, in rain wash and by burning and root excretions, and c) mineralization of litter. While nutrient losses can be caused by soil erosion (Figure 3 ).

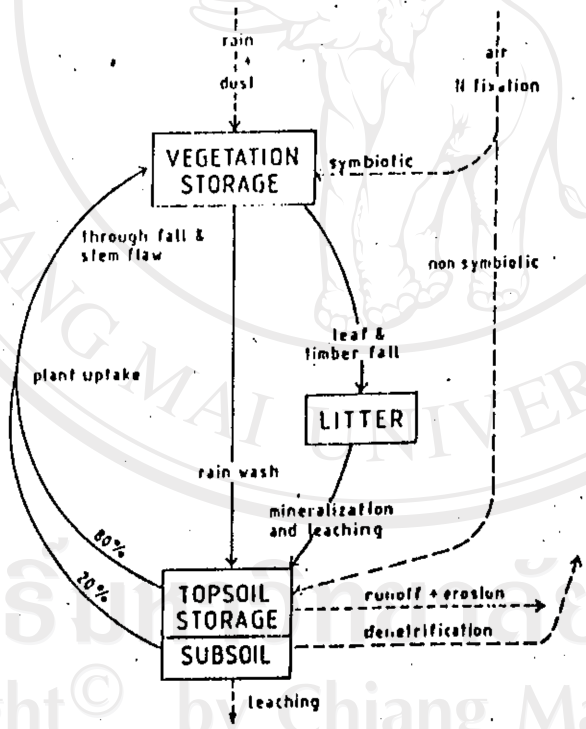

Figure 3. A simplified forest soil nutrient cycle. Dotted lines represent additions or removals from the system (Sanchez, 1976)

In shifting cultivation fields, when a clearing is abandoned after cultivation, regeneration of forest vegetation can be very rapid, depending upon health and extent of coppiced vegetation and remaining seed bank on the site. The rate of accumulation of nutrients in the forest vegetation is more in the early years of the fallow when most of the vegetative growth takes place (Table 4 ) (Kalpage, 1976). Table 5 shows effect of the fallow in shifting cultivation. Accordingly, it is clear that effect of the fallow in shifting cultivation is critical. Soil fertility can be maintained by inputs of nutrients during fallow period. Soil fertility is decreased due to nutrients use by crops and as a result of soil loss through erosion. According to Kalpage (1974) yields in successive seasons decrease because the fertility of the soil gradually diminishes, not so much because of pests, diseases or weed increase. Though in some areas these do contribute to yield decline over time.

Soil losses by erosion and crop uptake occur mainly during the cropping period. Nutrients are used, particularly by annual crops such as corn (Table 6). Additionally, during the early cropping phase, soil erosion is high because of through-fall and stem flow during the rainy season, and because the land surface is not densely covered. Erosion decreases after harvesting and when the land surface is well covered by vegetation during fallow period (Table 7).

Table 4. Mean annual increases of nutrient storage in fallow vegetation* (kg/ha)

| Forest Fallow Period | N | P | K | Ca | Mg |
|---|---|---|---|---|---|
| Yangbi over first 5 years | 114 | 6.3 | 91 | 84 | |
| Yangbi over first 18 years | 39 | 5.9 | 34 | 46 | |
| Kade over first 40 years | 40 | 2.8 | 17 | 54 | 7 |

*) Include roots

Source: Kalpage,F.S.C.P. 1974. Tropical Soils: Classification, Fertility and Management. London and Basingstoke: The Macmillan Company of India.

Table 5. Effect of the fallow in shifting cultivation

| | Forest (kg/ha) | Savanna (kg/ha) |
|---|---|---|
| 1 Litter production | 11,200 | 9,000 |
| 2 Root added per year | 5,600 | 3,050 |
| 3 Organic materials added to soil per year | 16,800 | 3,050 |
| 4 Maximum humus level after 10 year (0-30 cm layer) C | 67,000 | 56,000 |
| N | 6,200 | 3,900 |
| 5 Rate of increase of humus C per year | 280-670 | 79-191 |
| 6 Rate of increase of soil N per year | 7.9 | 7.9 |
| 7 Rate of increase of N in fallow vegetation/year | lost on clearing and burning | 11 |
| 8 N added in rain per year | 7.9 | 7.9 |
| 9 P in soil after 10 years | 13.4-33.7 | 3.4-10.1 |
| 10 P in fallow vegetation after 10 years | 33.7-45 | 11 |
| 11 Erosion losses | less | more |
| 12 Leaching losses | more | less |

Source: Kalpage,F.S.C.P. 1974. Tropical Soils: Classification, Fertility and Management. London and Basingstoke: The Macmillan Company of India.

**Table 6. Uptake of mineral nutrients by maize crop and unfertilized soil in Namphrom Thailand.**

| Element | Average Uptake (kg/ha) |
|---|---|
| N | 99.3 |
| $P_2O_5$ | 42.9 |
| $K_2O$ | 107.2 |
| $CaO$ | 24.0 |
| $MgO$ | 15.7 |

Source: Kamanoi, et al in Kuyuma and Pairintra, eds, 1983. Shifting Cultivation : An Experiment at Nam Phrom, Northeast Thailand, and Its Implications for Upland Farming in The Monsoon Tropics. Tokyo: Research Institute Tokyo University of Agriculture.

**Table 7. Erosion in various tropical forest and tree crop system (ton/ha/year)**

| Land use type | Erosion | | |
|---|---|---|---|
| | Minimal | Median | Maximal |
| Multistoried tree gardens | 0.01 | 0.06 | 0.14 |
| Shifting Cultivation, fallow period | 0.05 | 0.15 | 7.40 |
| Shifting Cultivation, cropping period | 0.40 | 2.78 | 70.05 |
| Tree crops with cover crop/mulch | 0.10 | 0.75 | 5.60 |
| Natural forest | 0.03 | 0.30 | 6.16 |

Source: Wiersum,K.F. 1984. Surface Erosion under Various Tropical Agroforestry Systems. In Proceeding Symposium on Effect of Forest Land Use On Erosion an Slope Stability. C.O' Loughlin and Pearce (eds). Honolulu: East-West Center.

According to Trenbath (1990) the rate of proportional reduction of yield to soil fertility during the cropping phase is 0.3/crop of initial soil fertility. Based on a long term simulation experiment, the soil fertility on eroded soil is 30 % less than for uneroded soils (Walman, 1985).

## II.5. SUSTAINABILITY AND POPULATION PRESSURE

### II.5.1. SUSTAINABILITY OF SHIFTING CULTIVATION

The term sustainability with respect to resources and the environment is now used extensively. It is found in government policy pronouncements, publications and popular media. However, until now it remains an ambiguous term. This has caused difficulties in judging sustainability of the resources and the environment, and particularly of agroecosystems. Conway (1983) defines sustainability as the ability of a system to maintain productivity in spite of a major disturbance, such as that caused by intensive stress or large perturbation. He defines stress as a regular, sometimes continuous, relatively small, and predictable disturbance. A perturbation is an irregular, infrequent, relatively large, and unpredictable disturbance, such as one caused by a drought or flood. Lack of sustainability may be indicated by declining productivity. On the other hand collapse may come suddenly and without warning.

The concept of sustainability, is not restricted to ecological sustainability. Harwood (1990) and Firebaugh (1990) have discussed the concept of sustainability with regard to agricultural fields. According to Harwood (1990), a sustainable agricultural system is one which can evolve indefinitely toward greater human utility, greater efficiency of resource use, and a balance with the environment that is favorable both to human and to most other species. Three major points can be noted with respect to agricultural systems; (1) agriculture must be increasingly productive and efficient in resource use, (2) biological processes within agricultural systems must be much more controlled from within (rather than by eternal inputs of pesticides), and (3) nutrient cycles within the farm must be much more closed. Firebaugh (1990) suggests some basic requirements of sustainable agriculture, such as (1) an equitable access by all farmer to fertile land, credit, and agricultural information, (2) the maintenance and support of independent agriculture areas in which farmers, both women and men, maintain their culture, (3) the development of cultivation, food processing and food storage methods that ease the intense demands on women's labor, (4) a high degree of species diversification to maintain flexible crop patterns, (5) the management of soils fertility through organic matter cycling (to avoid dependence on imported nutrient), and (6) an appropriate use of water and fuel resources. Dixon and Fallon (1989) have discussed the concept of sustainability broadly. According to them the word sustain originally comes from the latin, "sustenere", meaning to hold up or keep elevated. In the context of resources and the environment, then , to sustain would literally mean to maintain or prolong the productive use of resources and the integrity of the resources base.

This implies, among other things, that there are physical and other constraints to human development.

According to Dixon and Fallon (1989) three distinct uses of the concept can be identified: (1) as a purely physical concept for a single resource; (2) as a physical concept for a group of resources or ecosystem; and (3) as a social-physical concept.

As a purely physical concept for a single resource the term refers to management of a particular class of biologically renewable resources (such as fisheries and forests) defining physical limits to exploitation. In this case, sustainability means using resources no more than will permit long-term maintenance of the physical stock. Regarding fisheries, for example, if natural growth and reproduction exceeds mortality, there is some annual increment in fish biomass available for harvest. If annual harvest is just equal to the annual amount increase in biomass, a steady state physical equilibrium can be reached. Within changes in fish population or technology, the quantity of annual harvest can change over time. In theory this pattern of harvest and regeneration could continue indefinitely.

In forestry, sustained yield timber may still create problems with increased soil erosion and sedimentation, changed water yield, as well as wildlife habitat and species diversity. Therefore while forest production may continue in sustainable manner, there are associated costs in terms of the on-site and off-site impacts of soil erosion and changes in local hydrology.

As a social-physical-economic concept, sustainability can be defined broader than the first and the second concept. Because here what is included is not only a purely physical concept for a single resource or for a group of resources or ecosystem as mentioned earlier, but also a economic and social aspects. For example, effect of forestry development on environment, such as erosion, sedimentation, plant and wild animals lost, in terms of socio-economic measurements. Costs and benefits in monetary unit have to be calculated. In these analyses, the present value as well as future value with respect to intra and inter-generational equity for the long run must be considered.

In judging the sustainability of agroecosystems, one requires considerations of several factors: ecological, economic and sociocultural. In other words, the sustainability of agroecosystems is achieved by maintaining a specified dynamic level of production (economic), ecological and sociocultural conditions over the long run.

### II.5.2. POPULATION PRESSURE

The relationship between population and natural resources, particularly food supply has been discussed since Malthus published his famous "Essay on the Principle of Population in 1789.

According to Malthus (Gatak and Ingersent, 1984), interrelationships between population and natural resources, particularly food, are as follows.

(a) Increased population causes parallel increase in the demand for food.

(b) This increased demand for food can be met either by bringing "new" land into cultivation, or by cultivating existing cultivated land more intensively than before, i.e. by applying more labor.

(c) Land is not only scarce but also variable in fertility. The most fertile land is cultivated first. Then, in response to continuing population pressure, less and less fertile land is successively brought into cultivation.

(d) If additional labor is applied to existing land its marginal productivity will gain decline due to diminishing returns.

(e) Since diminishing marginal returns to agricultural labor are inevitable and unavoidable, food production will always tend to grow less rapidly than population.

Generally, according to Malthus model in the long run, population growth is limited by food supply. However, Boserup (1965) and Wilkinson (1973) argue that food supplies actually increase in response to population growth (Ghatak and Ingersent, 1984). According to Boserup, as population pressure increases, progressively more intensive systems of land use are adopted, combined with consequential change in method of cultivation and the choice of tools, in order to offset any tendency for food output per capita to decline, due to diminishing returns. For example, according to Boserup, in development of intensification of shifting cultivation can be divided into 3 categories, i.e: a) the lowest level of population density is characterised by the system of "forest fallow", with a fallow period of 20-25 years between successive crops, b) at a somewhat higher level of population density, forest fallow give way to "bush fallow" in which the fallow period is reduced to 6-10 years, c) shortening the fallow period raises the labor, land ratio as well as output. In response to further development growth and increase in the agricultural labor supply, bush fallow is successively followed by "short fallow" with fallow period of 1-2 years only.

Meanwhile, according to Wilkinson (1973) in the natural world "ecological equilibrium" is the norm. Rather than over-exploit their resources build up a pattern and a rate of resources use which the environment can sustain indefinitely. In maintaining ecological equilibrium, traditional people usually use some traditional taboos. Ecological disequilibrium can occur as and when the constraints which maintain human societies in ecological equilibrium break down. For example, traditional beliefs and customs may be undermined due to contact with alien cultures. When ecological equilibrium breaks down, society will try to find ways of developing its technology in order to increase the yield from the environment, such as in agriculture more intensive systems of land use, frequently involving the sacrifice of leisure, are adopted.

According to Okigbo (1984), experiences in tropical Africa, initial increases in population occurred as people become assured of more regular sources of food through the domestication of plants and caring of animals, followed by introduction of Asian and later American crops. The development of agriculture ushered in an era of more reliable food supplies than were possible with hunting and gathering alone. Besides, commercialization of production of certain commodities not only disrupted the traditional farming systems but often did so at the expense of food crops. It also resulted in the practice of cultivation of one crop, year in, year out (i.e, monoculture) on the same piece of land, after in pure culture instead of the traditional mixed cropping. Where annual staples are grown as row crops, loss of soil fertility and structural degradation of the soil result more quickly due to lack of rotation for sustaining production with minimum hazard to the environment (Okigbo, 1984).

### II.5.3. USING SYSTEM MODELING IN SHIFTING CULTIVATION

Modeling of shifting cultivation has been used by several authors, such as Foin and Davis (1987) and Trenbath (1989).

Three conceptual models of population regulation in Maring ecosystems of New Guinea based on available secondary data have been evaluated by Foin and Davis (1987). These three models are: First, a local stability model in which each population seeks its own equilibrium state. Second a regional stability model, in which each population is ultimately unstable, but population persists somewhere in space. The third, a disequilibrium model, in which neither stability nor population regulation is attained.

Foin and Davis used the DYNAMO program for their model. The results of their evaluation concluded that the first model was accepted, but the second and third models were rejected. The first model on local stabilization, is a reasonable model for the New Guinea Highlands. The simulation also supports the feasibility of malarial mortality controlling population in Maring ecosystems. However, it rejects the Rappaport model that population size is regulated by a ritual cycle of warfare (kaiko). The baseline simulation, as well as a number of variants, all show that disease mortality is about ten times greater than war mortality in the system. War mortality becomes important only under extreme conditions. Accordingly, in the simulation, at least, it is malarial mortality influenced by malnutrition which imposes control on population growth. Using simulation to evaluate stability in the Maring ecosystem, Foin and Davis (1987) concluded that:

1) The Maring populations are equilibrium seeking;
2) With limited rates of changes and sensitivity to disturbance, the Maring are most often moving transitionally from some displacement toward some equilibrium; and
3) It is extremely difficult empirically to detect equilibria under these conditions

Trenbath (1989) in evaluating the development of shifting cultivation systems has used the mathematical model approach. Three contrasting models are described which predict the consequences of shifting cultivation carried on in different ways, i.e, 1) a simple empirical model, 2) a simple graphical model, and 3) a complex process-oriented model.

The first model is used to estimate soil fertility change and level of subsistence food production in relation to five biological and five management variables. The effect on the soil is given in percentage change in fertility per cycle of certain years and human food production is given in man equivalent-year/year. The results show that there is a response of soil fertility and food production to variation in duration of fallow and cropping phases.

The second model, is a simple graphical one can be used in analyzing hypothetical relationships between soil fertility in successive years during cropping and during fallow. In the graph, initial fertility is plotted horizontally and final fertility, one year later is plotted vertically using the same scale. During cropping and during fallow time, soil fertility decreases and increases respectively. The model provides new interpretation based on soil fertility with regard to the problem if non-regeneration of forests. Land intensification beyond a certain level causes non regeneration of forests and potentially permanent low fertility.

The third model simulates changes through time in three variables, namely biomass of grass weed, biomass of trees, and soil fertility. Runs show that without considering erosion interaction between these three variables is sufficient to produce the same threshold effect as was mimicked with the second model. Intensification of cropping beyond a certain level causes forest regrowth to give way to permanent grass with minimal restoration of fertility. These results are very useful for understanding the system and implementing policy. According to Trenbath (1989) the model of shifting cultivation is very useful, such that it could help planners identify sustainable forms of shifting cultivation for areas where other more suitable productive options do not exists.