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Cultural Systems on Tropical Soils

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Systems of soil and crop management in the tropics can be divided into three categories:

1. Traditional sytems which have little or no benefit of modern technology or goods and services of modern industry;

2. Transitional systems which have incorporated into traditional farming systems some of the benefits of modern technology;

3. Modern systems such as commerical plantations which are able to take full advantage of available scientific knowledge and the products of modern industry.

TRADITIONAL SYSTEMS

The traditional systems may be divided into two broad categories: (1) extensive systems of shifting cultivation and (2) intensive systems of irrigated cropping, particularly flooded rice.

Shifting Cultivation

Shifting cultivation, sometimes called slash and burn agriculture, refers to the systems in which land is cleared by hand, most of the vegetation burned, and the land cropped by hand operations for one to three years. The land is then allowed to revert to natural vegetation for a period of five to twenty years before being cleared and cropped again. Meanwhile the cultivator shifts to another site and repeats the procedure. After a certain number of years of shifting from field to field, the cultivator begins the rotation cycle again on the field which has been allowed to lie follow and be regenerated by the natural vegetaion. Sometimes the term "shifting cultivation" is applied to the practice of shifting the homesite or village periodically but more generally the term is now used to refer to shifting of fields around a more or less permanent site.

The practice of shifting cultivation or slash and burn agriculture is certainly not unique to the tropics. Modern agriculture in every civilization whether in the tropics or in the temperate regions has evolved from the traditional practices of some type of shifting cultivation. Letting the land lie fallow to regenerate its productivity after a period of cultivation was a common practice not so many decades ago in Europe and North America and indeed is not uncommon today in some localities on these continents.

At present the practice of shifting cultivation is widespread over large areas of the tropics and in many regions, especially in tropical Africa, where it is the predominant way of life for most of the people. There are a great many variations in the systems of traditional agriculture. Different names are used locally which are included under the general term of shifting cultivation. A few examples are: kaingin, Philippines; chena, Ceylon; milpa, Central America; roça, Brazil; chitememe, Zambia.

Though these subsystems and many others come under the general designation of shifting cultivation, there are substantial differences in detail depending on the local conditions. Soil and climate, vegetation, settlement and land tenure patterns, population pressure, and many other factors influence the way in which shifting cultivation is practiced. For example in the chitememe system on the sandy soils in Zambia in the dry forested areas, a small area is cleared and branches of trees from the surrounding area are brought in, piled up, and burned. A cereal crop such as millet is seeded broadcast with little or no preparatory cultivation and small amounts of other crops such as beans, sweet potatoes, and cassava are planted around the millet. The land may be abandoned after the first year or the cropping may be continued for another year or two depending on the conditions. Even within the chitememe system there are local differences in detail in the

management practices. The area cleared may be no more than 30 feet in diameter or it may be as large as one acre. The sequence or mixture of crops planted may vary from place to place depending on the local conditions.

With the great range of soil and climatic conditions in the tropics and the social and cultural patterns of local communities, the possibility exists for an almost infinite variety of cultural systems within the broad category of shifting cultivation. The practices in the forested zones of the humid tropics will be different than those in the open woodland or savanna areas of the lower rainfall areas; the indigenous communities in the Amazon basin have developed cultural systems different from those in Southeast Asia or West Africa. For those interested in more detailed information on the many kinds of practices included under shifting cultivation, suggested readings are listed at the end of this paper.

Despite the wide variety of systems of traditional agriculture in the tropics, there are certain important features which are common to all of them:

1. The primary objective is to supply the food needs of the family and the community; all other considerations are secondary. The provision of food dominates the life of the cultivator so that the traditional soil and crop management practices are an integral part of the whole social, cultural, political, and economic life of the community. As a way of life it is difficult to modify or improve the system without a full understanding of the social and cultural aspects of the people. In many instances the introduction of better tools, improved seed, fertilizers, and other benefits of modern technology have not succeeded in the modernization of traditional agriculture because of a lack of understanding of the psychological and structural factors in the economic and social life of the cultivator, his family, and the community.

2. Shifting cultivation is an extensive system of farming and as such can only support a relatively low population density. The actual numbers will depend on several factors of which the kind of soil is an important one. On sandy infertile soils a farm family may require 200 acres or more to maintain a stable system to provide a subsistence living. On the fertile alluvial soils only 20 or 30 acres may suffice to support a farm family. In the areas in the tropics where land is still abundant, the practice of shifting cultivation provides adequate food and only at times are there temporary food shortages. The quality of the diet may not always be adequate, especially in protein, but for the most part there are no serious deficiencies.

3. The traditional systems of shifting cultivation evolve in balance with the ecological environment. They are natural systems which have been developed by the cultivators through generations of trial and error to attain and maintain a stable existence with nature. Shifting agriculture has often been criticized as being wasteful and inefficient but this criticism is hardly warranted. Given the conditions and the tools and resources available to him, the shifting cultivator has evolved an efficient way of life which has sustained him and his family for many generations. Though there have been many suggestions on how to improve the practice of shifting cultivation, it is difficult to find any documentation that a better system could have been developed given the resources and technology available.

4. Shifting cultivation is a flexible system in which the cultivator is continually adapting to his needs within the constraints imposed upon him by the environment and the resources at his disposal. The length of the cropping period, the kinds of crops grown, the length of the fallow period, and the timing of other practices are adjusted to meet the needs of the cultivator.

The common practice of mixed cropping permits the growing of a variety of crops at the same time on the same field and there is usually considerable flexibility in the choice of crops for a particular set of conditions. In addition to food crops which take precedence, it may be possible at times to grow a cash crop which can be marketed locally.

5. Contrary to some critics, shifting cultivation is not necessarily detrimental to the conservation of soil and forest resources. As a matter of fact one of the advantages of the practice is that it involves the minimum disturbance necessary for the production of a crop. The soil is only lightly cultivated with hand implements and many stumps and roots from which the forest regenerates are left in the ground. With a short cropping period the forest can regenerate rapidly and any harmful effects of cropping are relatively small. Thus the soil is conserved against erosion and the buildup of weeds, pests, and diseases is controlled. The cultivated fields are usually in patches and large areas are not normally cleared. Consequently, there is good protection against erosion of a watershed. The organic matter is built up during the fallow period and this provides nutrients for subsequent crops as well as benefitting the physical conditions of the soil. During the regeneration of the forest soil organisms are active and good structure of the surface soil is maintained.

It has been asserted by some that large losses of nutrients occur under shifting cultivation systems but the evidence for this is meager. Certainly losses do occur when the vegetation is cleared and burned and the land is cropped but the magnitude of these losses is probably not very large unless the cropping period is unduly prolonged and the soil is bare for too long a period. But generally with the kind of clearing and land preparation practiced under shifting cultivation and with mixed cropping for a short period,

the nutrient losses from leaching and erosion are probably very small. With the cyclic regeneration of nutrients in the relatively rapid vegetation regrowth, any nutrient losses are probably compensated for by the accumulation in the vegetative fallow.

It is commonly thought that the cultivator shifts to another field after one, two, or three years of cropping because of loss of fertility. This is one reason and may be the principal one on poor soils but in many instances it may not be the most important causal factor for shifting. Often it is the weed growth during the cropping period which takes more labor to control than to clear a field that has been in fallow for some years. Sometimes there is no agronomic reason for shifting but rather social or religious customs, quarrels among the cultivators, redistribution of the community property, etc.

Some writers with a limited understanding of shifting cultivation systems have claimed that these systems are responsible for the gradual formation of hardened laterite or ironstone through the so-called process of laterization. They believe that the soils of much of the tropics will turn to brick if the practice of shifting cultivation continues. This is absurd and there is no evidence that traditional practices of shifting cultivation are mainly responsible for the formation of laterite. Most of the hardened ironstone which occurs in the tropics is a relict of former geological processes and is exposed by natural erosion except in a few areas where man's activities have accelerated the process. Under the traditional system of shifting cultivation, however, the amount of soil deterioration is minimal except where population pressures and other factors have forced a shortening of the fallow period and/or a lengthening of the cropping period. This would have serious detrimental effects on the physical and chemical properties of the soil.

6. The productivity of the soil under shifting cultivation is low. The native varieties of crops generally have a low yield potential and the traditional methods of land clearing, planting, cultivating, and harvesting put a ceiling on production. The lack of fertilizer, improved seed, pesticides, modern equipment, and other inputs of modern technology limit greatly the productivity of the soil. Though the crop yields are generally quite low, they vary considerably depending on the characteristics of the soils. The cultivator knows which crops respond best on which soils and is guided by experience in knowing how long the cropping period should be on particular soils.

In summary, the traditional system of shifting cultivation is widespread over large areas of the tropics and in many regions it is the predominant way of life. There are a great many variations and differences in the subsystems of shifting cultivation but there are certain important features which are common to all of them. The primary objective is to provide a food supply and the soil and crop management practices are integrated into the whole fabric of the life of the family and the community. Shifting cultivation is an extensive system of farming in which a substantial acreage is required to support a farm family. Systems of shifting cultivation have evolved in balance with the ecological environment and are efficient systems considering the resources and technology available to the cultivator. They are flexible systems and under good management provide for conservation of soil resources and protection against erosion of watersheds. The production of crops is low in these systems because of the traditional land preparation and cultivation practices and the lack of inputs of modern technology.

Flooded Rice

This is an intensive system of traditional agriculture which has been widespread in many tropical countries, especially in Asia, for many centuries. It is a permanent farming system which has supported high densities of population in contrast to the traditional systems of shifting cultivation. The traditional system of flooded rice is most widely practiced in the fertile alluvial soils of the flood plains of the great rivers of Asia. However in some countries where the population densities are very high like parts of Ceylon, Java, and the Philippines, terraced fields were constructed on the hillsides for cultivation of flooded rice.

There is a great variation in the traditional methods of providing water for flooded rice cultivation: Impounding natural rainfall by embankments or bunds; relying on seasonal flooding; building small dams and ditches for water control; and construction of irrigation systems. Though little or inadequate water control is common in traditional practices, efficient irrigation systems for flooded rice have been used for centuries in places like China and Ceylon.

The traditional method of planting rice is to sow seed in nurseries and transplant to the field after about six weeks. In some areas, however, seed is broadcast but the yields are usually lower. During the period the seedlings are in the nursery the fields are flooded and puddled by cultivation usually with oxen or buffaloes drawing various types of crude plows or harrows depending on the locality. For good weed control, reducing water losses by drainage, and ease of planting, thorough puddling by repeated plowing is usually done preparatory to planting. The seedlings are transplanted by hand to the field which is kept waterlogged during the growing season of

four to eight months. Harvesting is generally done by hand primarily because the indigneous varieties mature unevenly.

In most areas the water supply is adequate for only one crop of rice and the rest of the year the land lies fallow. However in certain areas in some countries where the population is very dense a double crop of rice is obtained where there is sufficient water and the cultivators have organized an irrigation scheme and are able to time the land preparation, planting, and harvesting for a second crop. Where it is not possible to get a second crop of rice, a short season annual crop is often obtained provided the rice fields can be drained and there is an adequate moisture supply to mature a crop.

The maintenance of fertility in rice paddies for intensive cultivation is much less of a problem than in the uplands. Regeneration of fertility by the flood waters are usually adequate to meet the needs for a good crop of rice. Often the irrigation waters provide a substantial amount of plant nutrients. Losses of nutrients by erosion or leaching are generally small. Organic matter additions from crop residues and weeds and animal manure provides a source of nitrogen. In addition there is some nitrogen fixed by blue-green algae in the flooded fields. Also there may be some nitrogen fixed by free living organisms such as Azotobacter.

In summary, traditional cultivation of flooded rice is a permanent system of intensive cultivation which permits a much higher density of population than shifting cultivation. In many places a good crop of rice can be produced annually and sometimes two crops and the fertility maintained with traditional practices. As in the case of shifting cultivation the yields are much lower than could be obtained with inputs of modern technology but the productivity varies considerably depending on the kind of soil, available water supply, and social and economic factors.

TRANSITIONAL SYSTEMS

As indicated above, traditional systems of soil and crop management have generally provided adequate food for the cultivator and his family. However, as the population pressure increases where the land resources are limited, there is a greater need for increasing the productivity of the soil and the quality of the diet. Also, demands for more health, educational, and transportation services require a shift from the traditional subsistence economy to a more market oriented economy. This means that some of the benefits of modern technology need to be incorporated into the traditional systems or the systems modified to meet the increased requirements.

It should be emphasized that the modernization of traditional agriculture requires not only technical changes in soil and crop management practices but also requires adjustments in social and cultural patterns and in the psychological outlook of the cultivator, his family, and the community. There have been many failures as well as successes in the transition from traditional farming to modern agriculture. The failures generally result from insufficient attention to factors other than technical although lack of understanding the technical consequences of applied technology have contributed. For example, the introduction of an improved high yielding grain variety into a shifting cultivation system many not be successful because other associated inputs have not been provided. On the other hand, in areas where improved high yielding varieties of oil palm have replaced the indigenous varieties, substantially increased yields have resulted. It is certain, however, that the traditional cultivator will be reluctant to accept any innovation unless he is sure his basic food needs will be met.

There is controversy over whether it is possible to modify gradually the systems of shifting cultivation in order to meet the rapidly increasing

demands for food and fiber in the tropics. Some believe that it will be necessary to develp a continuous cropping system, especially in the forested areas, in order to meet the needs. In order to do this successfully much more technological knowledge has to be developed than is now available on how to manage economically the many kinds of soils in the tropics considering the available resources. Others feel that there must be a gradual evolution from the traditional practices to modern systems and of necessity this is a slow continuous process. Not only must the agronomic and economic value of new techniques be demonstrated but the cultivator has to be educationally and psychologically prepared to accept them. Subsistence agriculture has to be integrated gradually into a market economy in harmony with the social progress of the cultivators. Some of the failures of the Belgians in the Congo have been attributed to excessive haste or lack of adjustment to local conditions in the application of new practices.

In an effort to establish a transitional system to improve the traditional patterns of shifting cultivation, Belgian scientists in the Congo over a period of years developed the corridor system of forest fallow from the native Bantu system. They adjusted the fallow and cropping cycles to the kinds of soils and other factors and systematized the rotation by laying out corridors of perhaps one kilometer in length and one or two hundred meters wide. They determined how long the natural fallow had to be to maintain a permanent system with optimum productivity under the particular soil and climatic conditions. It could be three years of cropping and twelve years of fallow or five years of cropping and fifteen years of fallow, etc. Each year one corridor would be cleared and one would be returned to fallow. Mixed plantings of crops were usually used such as corn, upland rice, peanuts, cassava, bananas or others. Where compost or fertilizer was available one food crop

such as peanuts might be grown. Occasional corridors were left in permanent crops like oil palm or fruit and nut trees. Improved crop varieties and fertilizers were gradually introduced into the system and also other improvements were made. Whether this slow gradual approach to the development of a modern intensive system of soil and crop management is the most appropriate still remains to be determined.

In many instances the length of the fallow period has been successfully reduced where fertilizers and pesticides were available to maintain a longer and more productive cropping period. This has permitted the introduction of industrial cash crops once the food requirements are met. Edible legumes for both food and green manuring have been successfully introduced in some shifting cultivation systems.

MODERN SYSTEMS

In many areas of the tropics there are soil and crop management systems which make full application of both modern scientific knowledge and the products of modern industry. These systems usually involve large holdings under a plantation type of operation, generally under a single administrative unit concentrating on one commercial crop. The crops grown are both industrial and food crops such as sugarcane, bananas, coffee, cacao, rubber, cotton, pineapple, etc. These large plantation type operations require a high level of managerial skill and business acumen. The most successful conduct substantial research activities with a skilled staff directed toward a continual improvement of production practices for increasing yield and quality of the crop.

The crops produced in these large commerical operations are largely for export. Markets, transportation, government policies, and other social and economic factors are as important as the technological inputs for successful

enterprises. Ordinarily the best soils available with a favorable topography for mechanized operations are selected. However the natural fertility of the soil is much less important in modern cultivation systems than in traditional agriculture. The availability of goods and services and the effective use of modern technology minimizes the dependence on natural conditions. The necessary nutrients can be supplied by fertilizers; any water deficiency can be corrected by irrigation; weeds, insects, and diseases may be controlled by pesticides; land preparation, planting, and harvesting are largely mechanized.

In contrast to the traditional or transitional systems of agriculture, the productivity of commercial plantations is high. Crop yields may be five to ten times as much as those in the other systems. The high yields obtained in the modern systems are a result of putting together under good management the best combinations of practices with adequate resources to take advantage of the available technical knowledge and the products provided by industry. The high productivity demonstrates the possibilities of modern technology for developing the agricultural potential in many areas of the tropics. There is still much that needs to be learned in the application of the principles of biological and physical sciences for effective exploitation of the natural resources in the tropics. Equally important if not more so are the economic, social, educational, and political problems which need to be solved before the knowledge that is available can be applied effectively.

Concluding Statement

It should be emphasized that there are many important agricultural systems or subsystems in the tropics, both traditional and modern, other than those discussed above; extensive and intensive livestock production in

the savanna areas, combinations of crops and livestock, and forestry enterprises to name a few.

Another point that needs to be stressed is that the grouping of the systems which have been discussed were grouped for convenience of discussion and are rather arbitrary. Actually there is a wide range of systems or subsystems grading from the simplest of the traditional to the most complex and sophisticated of the modern. The combinations of practices are almost infinite and the choice of one is dependent at any one site on a great number of factors including environmental, economic, social, and political.

Suggested Readings

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