J. ENVIRONMENTAL SYSTEMS, Vol. 22(3) 249-267, 1992-93

ENVIRONMENTAL IMPACT OF SHIFTING CULTIVATION AND ITS MANAGEMENT: A CASE STUDY OF MIZORAM, INDIA

HIMANSHU JOSHI
University of Roorkee, India

KALPATARU KAR
Assistant Conservator of Forests, Aizawal, India

ABSTRACT

Global concern about the environment at the Stockholm Conference in 1972 led several countries to assess the environmental impacts of their development activities. Unlike the case with developed countries, environmental problems in developing countries like India mostly arise due to the lack of balanced development. The ills of the continuing practice of shifting cultivation (jhum) in the northeastern region of India (Assam, Meghalaya, Nagaland, Mizoram, Arunachal, Manipur, Tripura), other regions of the country (Bihar, Orissa, Madhya Pradesh, Andhra Pradesh, and Karnataka), and the world (sections of Africa, Indonesia, Burma, and China) are now being realized. This study examines the adverse effect of shifting cultivation from a holistic view point. Quantification of the effects of management options on overall 'system status' is also attempted by means of the technique of composite programming. This allows alternative management strategies to be compared in light of their efficiency and their potential to arrest environmental degradation.

INTRODUCTION

Physiography, Drainage and Climate

The State of Mizoram (Lat. 20.2°-24.27° N and Long. 92.2°-93.29° E) occupies the North-East corner of India (Figure 1). The whole region of Mizoram consists of ranges of North-South trending hills with little or no valley bottom in between. The hills are very steep and precipitous. The height of the hills generally averages 1,000 meters or so. There are isolated peaks more than 1900 meters high. There

doi: 10.2190/3JA1-1CN3-N1UL-670N
http://baywood.com

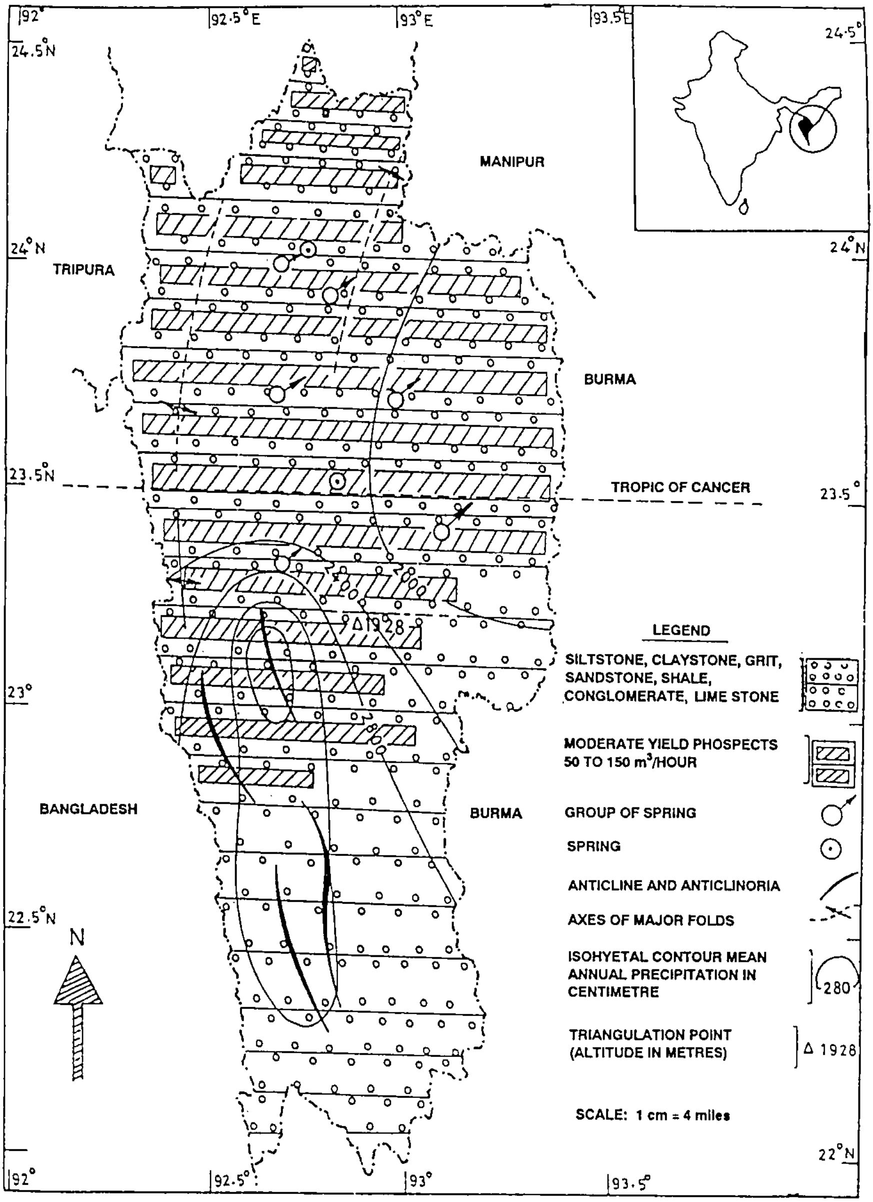

Figure 1. Location and hydrogeology of Mizoram.
Source: Hydrogeological map of India, 1976.

are a few small plains which are said to have been formed in beds of silted up lakes. There are numerous rivers, streams, and brooks in the state. All these rivers are monsoon-fed. In winter and dry season, the volume of water in the rivers is very small. Average winter and summer climatic conditions are similar; summer temperatures are between 18°C to 30°C, winter temperatures are between 11°C to 24°C. The area receives monsoons directly. It rains heavily from May to September. Average annual rainfall is 254 centimeters.

Vegetation and Wild Life

Mizoram has tropical evergreen forests, tropical moist deciduous forests, and sub-tropical pine forests. These are rich in valuable timber species in the top canopy. Other valuable trees often are found in the middle and lower stories. Various medicinal plants, evergreen shrubs, and canes form ground cover. Bamboos are abundant. Wild animal populations (including elephants, tigers, and mithun) are low.

Geomorphology

The terrain being immature in response to recent tectonism, topographical features show prominent relief. The major geomorphic elements observed in the area are both structural and topographic *highs* and *depressions* with *flats* and *slopes* sculptured on the topographic surface in a linear fashion. The physiographic expression of the state is imparted by approximately N-S trending steep, mostly anticlinal, longitudinal, parallel to sub-parallel hill ranges and synclinal narrow valleys with series of parallel hummocks or topographic highs. The other geomorphic elements are the high dissected ridges with deep gorges, spurs, keels, and cols developed by intensive erosion during the isostatic adjustment. Stream slopes are moderate. Some main rivers are restricted within comparatively soft shale horizons. The main drainage system in the area falls within the piedmont and straight reaches [1].

Geology and Soils

The general geology is represented by a repetitive succession of neogene arenaceous and argillaceous sediments which were later incorporated in a series of approximately N-S trending longitudinal plunging anticlines and synclines. The topographic expression of the area often imparts fairly good indication of lithology. The arenaceous and argillaceous groups of rocks occur in relatively higher and lower grounds respectively. It appears that Mizoram is composed of mainly sandstone, shales, and slabs of tertiary age. Figure 1 also depicts the hydrogeological status of Mizoram. The surface soils vary from reddish brown to dark brown, sandy to clay loam in texture, acidic to neutral in reaction. The soil is subjected to high rates of erosion even with slight rain. The soils have been classified mostly in the order of Alfisols, Ultisols, and Oxisols which are highly weathered and of low fertility.

SHIFTING CULTIVATION (JHUM) IN MIZORAM

Shifting cultivation activity has been observed to occur in these stages in Mizoram:

1. Site selection;
2. Site preparation: clearing, drying and burning vegetation;
3. Cropping; and
4. Fallowing.

This form of cultivation is the most widespread farming system in the tropics, extending over approximately 30 percent of the exploitable soils of the world and practiced in different historical, environmental, and socio-economic circumstances in Africa, Central and South America, South East Asia, and Oceania [2]. This diversity is also reflected in the innumerable names given to this practice, of which the one common in Mizoram is jhum.

There are about fifty ethnic groups in northeastern India. Lushai, Chakma, Pawai, Lakher, and Hamar are among the prominent groups in Mizoram. The principal livelihood of nearly all of the tribal population is jhum. The tribal population is 92 percent of the total in Mizoram (1981 census) [3]. Salient features of the jhum system are presented.

1. The people practicing jhum generally belong to tribal or rural areas. They have little education. Most of their activities are governed by what has been passed on culturally from generation to generation.
2. The jhum system traditionally represents an agricultural system where production is achieved with minimum external inputs. Burning in this system is considered an important activity as it is believed to reduce the weed growth and provide good harvest. Natural forces are generally relied upon to regenerate fertility of the soil during the fallow period. The use of chemicals (e.g., fertilizers and pesticides) is minimal. Tools used in cultivation are simple: usually chemte or axes (cutting tools) and hand hoes or dibbling sticks (digging tools).
3. The jhum cycle is the total period between two consecutive jhum operations, which comprises of period of cultivation and period under fallow. The periodicity of cropping on a single plot may differ from tribe to tribe and region to region. In Mizoram, newly cultivated land tends to lie within the village boundary ("village supply reserve"). However, cultivation increasingly occurs in the *unallocated* forest. Jhum land belongs to the village as a whole. After a site is selected for jhum, plots are apportioned to the families. Land not under occupation for a certain number of years reverts to the

community. Allotment of the site or land to individual families of a village is made by the village council or the competent authority [4]. Jhum fields are abandoned after cultivation without retaining any individual ownership or interest. This factor does not in general encourage the farmer to undertake soil conservation and improvement measures. The people seldom go back to the same area and they prefer to cut virgin forest instead. The current duration of jhum cycle ranges from three to ten years as compared to thirty to forty years in the past.

4. The entire fabric of life of the people is very intimately connected with the practice of jhum cultivation. In Mizoram, all the festivals or Kut (Pawl Kut, Chapchar Kut, Mim Kut, etc.) are mostly associated with the jhum operation.
5. Jhum cultivators generally produce many agricultural crops (viz. foodgrains, vegetables and, recently, cash crops). High land paddy (i.e., jhum paddy) is the dominant crop of these lands mixed with maize, beans, tobacco, sweet potato, chillies, ginger, and leafy vegetables. The choice of crop in consumption-oriented. Each family grows according to its annual needs. Low crop yields in the recent years and the absence of any surplus for external markets has made this practice quite uneconomical and financially taxing on the tribal families.
6. Formerly, there were enough family members to carry out such a traditional, labor-intensive operation and could fulfill their day-to-day requirements. Nowadays, an exodus of family members in search of better-paid jobs, and rising labor costs, have put tremendous burdens on the cultivators.

IMPACT OF JHUM CULTIVATION ON ENVIRONMENT

Jhum activity is no longer considered environmentally trouble free. Its effects have far reaching consequences. In order to understand and appreciate these effects in totality, it is helpful to divide the environment into several components and subcomponents as exhibited in Figure 2. Impacts on each of these is discussed on the basis of information presently collected for this region.

Impact on Air

Air Temperature

Impact of deforestation and erosion due to jhum on the temperature is still not very clearly understood. However, in as much as the forests act as buffering zones, they are expected to check the temperature extremes and prevent temperature rise by absorbing gases like CO and CO_2. The temperature variation during 1961 was found to be 18.7°C-25.4°C in summer and 11.8°C-24.7°C in winter. In 1984, the variations were found to be 19.2°C-27.4°C and 14.2°C-22.6°C respectively. These values represent an average of three locations (Aizawl, Kolosib, and

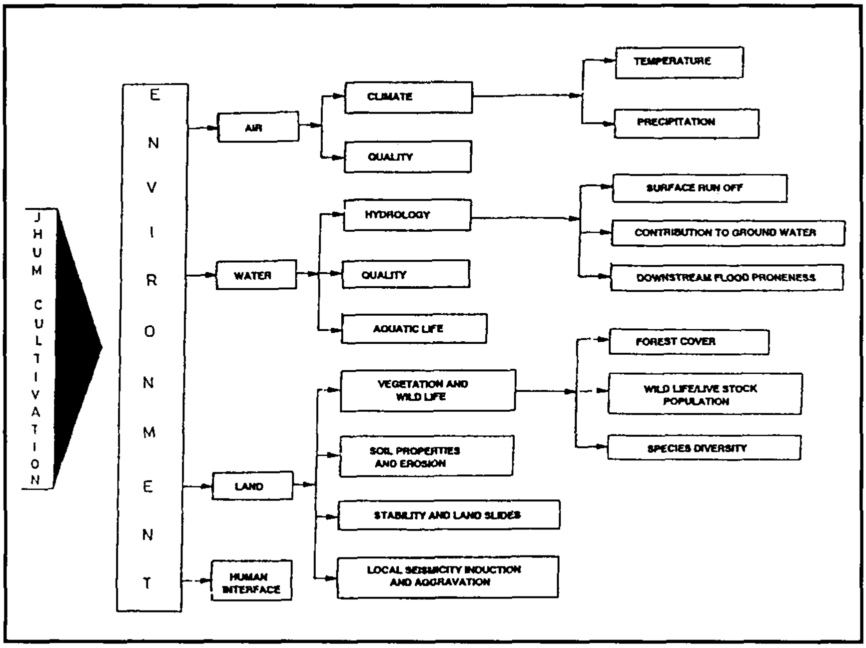

Figure 2. Division of environment into components.

Siphir). A moderate but steady rise in temperature was observed during these years. The contribution of jhum activity to the increase is unknown.

Precipitation

Experiences in other Indian states reveal that forests do not appreciably affect rainfall over large areas but may have limited effects on local rainfall and its distribution. An increase in the number of rainy days and rainfall due to the plantation of trees in Nilgiri hills has been reported. Some recent studies also indicate an increase in the trend of local precipitation by way of increasing rainy days. However, comparison of rainfall data from different stations in Mizoram yields no clear conclusion in this regard.

Air Quality

It is anticipated that periodic cutting and burning of vegetation, household activities, and erosion may lead to adding particulates and combustion-generated gases (e.g., carbon oxides, sulfur oxides, etc.) to the atmosphere. Though this effect may not be very widespread and may have strong local or seasonal characteristics yet under specific climatic conditions, such as inversion, the problems may become serious. Unfortunately, no data on this matter is available for Mizoram.

Impact on Water

Hydrological Parameters

Jhum and other associated human activities result in the compaction of the local surface, which reduces infiltration, thereby increasing overland flow. Various studies in and outside the country reveal that the forest floor layer at the soil surface serves a variety of hydrologically useful functions, e.g., reduction of rainfall impact and of subsequent erosion, providing resistance to overland flow, allowing more time for infiltration, and thereby affecting surface runoff. Jhum activity reduces these useful functions.

In Mizoram, 90 percent of the annual rainfall is confined to the monsoon period, extending over a period of 4 to 5 months. Only three streams run year-round. Due to topographic and soil conditions, and to severe depletion and erosion of forested and vegetated areas, a large volume of monsoon stream flow is lost, and flooding damage is widespread. Precise estimates of these runoff losses is unavailable. During the non-monsoon season, Mizoram experiences drought conditions; inhabitants travel long distances to fetch water.

Water Quality

In Mizoram, comprehensive studies of water quality effects of depleted forest cover, cultivation practices, and other activities are yet to be initiated. Clearing the forest exposes forest streams to direct solar radiation, raising stream temperatures on clear days, so leading to important physical and biological changes in the aquatic ecosystems. Temperature increases of 5° to 10°C are common [5]. As water temperature increases, its oxygen holding capacity decreases and rates of biochemical processes are accelerated. A typical diurnal pattern of stream temperatures in forested and clearcut catchments is shown in Figure 3.

Forest fires destroy trees and forest floor organic materials. Effects on catchment water quality depend on the frequency, extent, and severity of burning, watershed physical conditions, post-fire weather, and the rapidity of reforestation. Light wild fire or prescribed burning may have no detectable effect on discharge quality, but frequent or severe wild fires cause serious acceleration of erosion and sedimentation, especially when heavy rains follow burning. Also, the forest canopy destruction results in stream temperature changes comparable to the effects produced by clearcutting [6].

For the above reasons, the suspended solids in the water bodies are quite high in general and alarming during monsoons. Along with the topsoil, minerals and other nutrients are expected to find their way into water bodies, promoting eutrophication. External inputs (fertilizers, pesticides) are presently small, but decreasing land productivity may force cultivators to use them (perhaps indiscriminately), posing a potential threat to receiving waters in the near future. Changes in various water quality parameters and flow conditions, as described, ultimately disturb

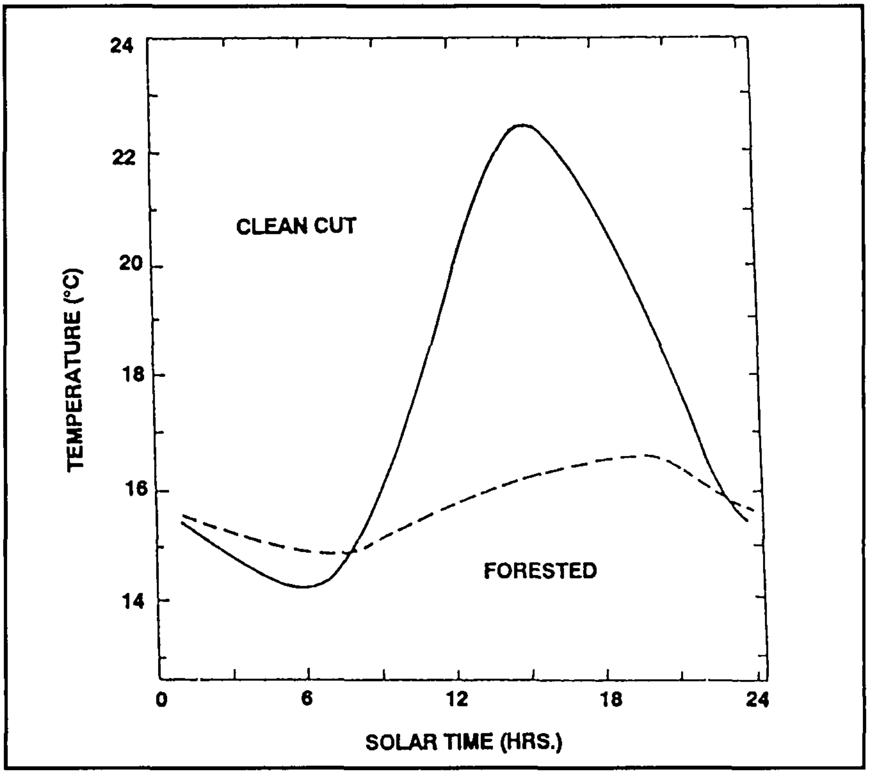

Figure 3. Typical diurnal pattern of stream temperatures in clean water in forested and clean cut areas.
Source: Lee, 1980.

aquatic life. Fish yield has already become very meager in Mizoram. The rich diversity of the aquatic system also may be reduced.

Impact on Land

Forest Cover

Forests have been reported to cover 75.6 percent of Mizoram; the state reportedly owned about 45 percent of the forested area, and village and district councils owned 44 percent and 11 percent, respectively. However, a systematic, precise survey has not been made. After persistent jhum cultivation, only very few pockets of forests are left now which can be said to have original vegetation. Some recent remote sensing studies have reported area for dense forests (crown density more than 40%) and open forests (crown density between

10 to 40%) as 3,883 and 14,295 km^2 respectively (total area of Mizoram is 21,087 km^2). A decrease of 914 km^2 of forest cover between 1981-83 and 1985-87 has been reported [7].

Wildlife and Livestock Population

Mizoram, once very rich in wildlife, has witnessed severe depletion in its population due to the disturbance of their habitat, scarcity of food, and interference in the food chain. Important animals that used to be found in Mizoram were the tiger, leopard, bison, elephant, goral, serow, wild pig, wild dog, pengolin, and the flying squirrel. The python, cobra, and krait were among the common snakes. The important birds used to be hornbills, eagles, hawks, partridges, pheasants, parrots, and thrushes. Fish were the main aquatic animals.

Available data records a cumulative reduction of 36.6 percent in wildlife population from 1979 to 1985. Many animals, including tigers and bison, have been found to be on the verge of extinction. The livestock population has also been observed to decrease steadily. The reasons may be manifold (e.g., disturbance of the primary trophic component in food chain, scarcity of food, slaughter of livestock for local consumption, inefficient management of livestock and their feed).

Plant Succession and Species Diversity

The entire forest region in Mizoram is in early successional stages. Bamboo, an early successional species predominates in the landscape along with *Melocanna Bambusiods, Bambusa tulda*, and *Dendrocalamus longispathus*, and other species [8]. In the absence of any seed or mother trees in the area cleared for cultivation, the members of compositeae species are first to colonise, common ones being *Conizoides, Michenia*, and *Eupatorium*. These grow very profusely with crop and require several weedings. After harvest, they maintain a near complete dominance. These species are followed by Gramineae species which start making their presence felt in second year. These weeds and grasses in jhum generally attain a height of 2.5-3 m, and dominate up to the fourth year.

The *Gramineae sere* does not vanish as fast as the compositeae, but are gradually eased out by *Macaranga, Schima* and other tree species, which are not climax community, and would have been replaced by a different plant sere, had it been allowed to grow; but in jhum areas, the progression is halted. Table 1 indicates that there is very little diversity in the early successional stages and that diversity increases up to a fifty year fallow (with maximum dominance at about 5 years).

Soil Properties

Significant changes in physical and chemical properties are reported after clearing and burning of vegetation. Soil and air temperatures increase and their fluctuations become wider. This, in conjunction with a reduced soil organic content, makes the soil structurally fragile and influences its flora and fauna quite adversely. Microbial population is reported to be completely destroyed in case of an intense fire for two to three days.

This deterioration in soil structure leads to erosion losses of fine topsoil and alters the soil moisture regions, resulting in a decrease in an already small water-holding capacity. Decrease in soil biological activity and crustal formation due to rapid desiccation has been observed to result in reduction of micropores in the surface horizon due to which water intake rate is considerably decreased and runoff losses increase (see Table 2) [9].

Severe depletion of soil fertility due to nutrient imbalance in soils affected by jhum cultivation has been reported in many studies around Mizoram [10, 11]. Along with such factors as reduced organic matter, water holding capacity, and plant nutrients, the addition of ash produced after burning and the generally high pH values of jhum soils exacerbate the depletion. Total N,P,K; available P,K; and exchangeable Ca, K have been found to be low under jhum [11]. C-N ratios have also been found to be lower in jhum plots at surface and at subsurface. Heavy loss

Table 1. Species Diversity and Dominance in Successional Stands from 0 to 50 Year Old Fallow

Successional Ages of the Fallow (Year)	Diversity	Dominance
0 (freshly burned)	0.12	0.215
5	0.21	0.705
10	1.01	0.519
15	1.48	0.556
20	1.50	0.501
50	1.93	0.212

Source: Ramkrishna and Toky, undated.

Table 2. Runoff and Soil Loss Under Different Systems of Land Management

Item	Jhumming	1/3rd Terracing	Complete Bench Terracing	Puertorice Terracing
Runoff (mm)	114.00	81.40	32.80	256.30
Runoff percentage of rainfall	5.30	3.90	1.50	12.90
Soil loss (tons/ha)	40.90	5.80	5.00	39.30

Source: ICAR, 1977, 1978.

of nitrogen from the ecosystem from burning of slash alone is estimated around 173 kg/ha.

The degree of erosion is found to be higher in the upper layer; the erodability of topsoil under preserved or non-jhumed areas has been found to be less than under jhumed conditions [11]. Studies have revealed that the soil erosion problem in jhum land is primarily of the splash and wash type. Soil erosion from slopes (60-70%) under different stages are shown in Figure 4, which indicates that the second year of jhum cultivation is more hazardous than the first year, whereas quick forest regeneration significantly reduces soil erosion during the first abandoned year [12]. Soil loss under different systems of cultivation has also been studied by Indian Council of Agricultural Research (ICAR) [13].

Instability and Landslides

The repetitive cycles of exposure of soil and rock surface followed by weathering result in disintegration and formation of joints and cracks, which trigger slides.

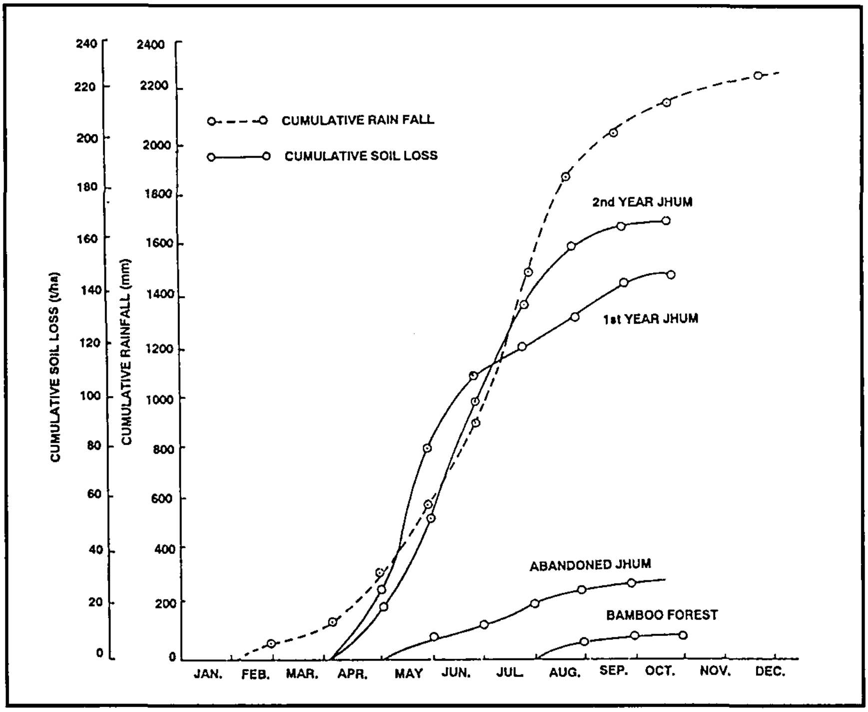

Figure 4. Soil loss from 60-70 percent slope under various stages of jhum cultivation.
Source: Singh and Singh, 1980.

Furthermore, the percolation of water through disintegrated slopes generates higher pore pressures and accelerates the loss of stability, promoting slides of the geologic strata dip slopeward [14]. In addition, in such internally weak terrain, related human activities, such as blasting and quarrying, increase the chances of heavy landslides, of which Mizoram is already a serious victim.

Seismicity Induction and Exaggeration

Northeast India has experienced many moderate and large earthquakes. The activity is associated with two major structural features, the Himalayan Arc and the Arkan Yoma folded zone [15, 16]. In the event of an earthquake, differential vibrations between rock strata and the loosened topsoil system may aggravate landslide effects in areas where jhum cultivation is practiced.

Human Interface

One of the great disadvantages of jhum cultivation is that it takes too long—about a year—to produce a major crop. The fact that the entire northeast of India and Brahmaputra basin do not produce as much food grains as the Gangetic basin [17] reflects the poor circumstances of agricultural production. A sample 49.81 ha of jhum has been shown to provide bare sustenance to 178 persons for just four months, which is an extremely low production compared to that under settled agriculture [18]. It has been reported [19] that jhum cultivators have the largest family size of the occupations studied (jhum, salary class, casual labor, trade). Seventy percent of the population engages in jhum cultivation. Sixty percent of these cultivators identify jhum as their main occupation, whereas only about 25 percent have indicated so for settled cultivation. Comparing this to an earlier study of same region during 1976-77 [20], when more than 80 percent of the population appeared to depend upon jhum alone, there appears to be a shift of cultivators from jhum to alternative and more remunerative occupations, including settled cultivation, fruit trees, coffee plantation, and sericulture.

Per capita income has also been found to be ranked in the decreasing order of the surveyed categories as traders, salaried class, casual laborers, and jhum cultivators. Some 12.3 percent of Mizoram families have been reported to be living on a starvation diet, and 55.2 percent only slightly better. These facts bear testimony to the poor economic condition of jhum cultivators, who for this reason are partially or wholly indebted throughout their lives. There has been a rise in general literacy due to the opening of many primary and middle schools with low fees. Inadequate nutrition, scant medical facilities, poor housing, a lack of basic amenities, and lack of knowledge of land and crop management also contribute to the extremely difficult lives of jhum cultivators [20].

QUANTITATIVE EVALUATION OF MANAGEMENT OPTIONS

It is established beyond doubt that in order to effectively tackle so many problems simultaneously, an efficient multidisciplinary management is required. It would be best if at the planning stage, several comprehensive management strategies are proposed and evaluated, and the best one then implemented. Decision-making under these circumstances should be based on priorities developed in consultation with concerned experts and the suffering people.

Techniques for evaluating and comparing such comprehensive integrated management approaches should use quantification where possible and appropriate, and should be simple enough to comprehend. The Multicriterion Decision Making (MCDM) technique, based on composite programming seems well-suited in this regard [21]. Mathematical details have been discussed elsewhere (e.g., [22]). Here a sample application is provided for purposes of illustration.

In this methodology, the system to be studied is taken to have two major interacting components, an ecological (natural resources) subsystem, and a socio-economic (consumptive) subsystem. These are represented as "third level" indicators. Each third level indicator is determined by a set of second level indicators (e.g., water quality, health, and nutrition) which, in turn depend on basic indicators. Basic indicators are parameters that can be directly observed, measured, or computed, such as dissolved-P load, sediment yield, diversity, GNP, energy production, and infant mortality.

After identifying the system's structure, ideal and worst values for each basic indicator are defined. These limits, together with a scheme for assigning weights reflecting judgments of relative importance, are meant to accommodate changes in priorities. In principle, the values of all basic indicators with respect to the zero option (present state) and other proposed management options may be observed, measured, or computed with the help of available information, precise field monitoring, or reliable models.

In order to transform the different basic indicators to a common scale, all are normalized first. Next they are aggregated into second level indicators and lastly into overall composite system indicators as per equations (1), (2), (3) and (4):

$$L_j = \left[\sum_{i=1}^{n_j} \alpha_{ij} \, S_{ij}^{\,P_j}\right]^{1/P_j} \tag{1}$$

$$L_k = \left[\sum_{j=1}^{m_k} \alpha_{jk} \, L_{jk}^{\,P_k}\right]^{1/P_k} \tag{2}$$

$$L = [\alpha_1 L_1^2 + \alpha_2 L_2^2]^{1/2} \tag{3}$$

$$\text{Composite indicator values} = (1-L_j), (1-L_k), (1-L) \tag{4}$$

where:

L_j, L_k, L = Composite distances for second level group j of basic indicators, third level group K and final overall system respectively.

α_{ij}, α_{jk} = Weights expressing the relative importance of basic indicators in second level group j and third level group k respectively such as

$$\sum_{i=1}^{n_j} \alpha_i \text{ and } \sum_{i=1}^{m_k} \alpha_j = 1$$

S_{ij} = Actual value of basic index i in second level group j of basic indicators.

P_j, P_k = Balancing factors among indicators for second level group j and third level group k.

L_{jk} = Second level composite distance for ecology (k = 1) and socio-economics (k = 2).

α_1 and α_2 = Weights indicating the relative importance between conservation and development.

L_1 and L_2 = Composite distances for ecology and socioeconomics respectively.

The values of the overall composite indicators are calculated for all options. The option yielding the highest value is taken as the best and the rest ranked in a decreasing order of the indicator values. Conceptually, as the highest indicator value corresponds to the *least composite distance* between the actual point and the ideal point (1,1) as shown in Figure 5, the management option yielding the same is considered to be the best in overall sense as it remains closest to the ideal point.

Table 3 displays the complete structure of indicators considered. Values of basic indicators with respect to Management Options 0,1 and 2, ideal and worst values of basic indicators, and, finally, the importance and "balancing factors" are presented in Table 4. The basic and second level indicators have been selected for the purpose of illustration; the list is by no means comprehensive. Additional indicators may include standing crop, flora and fauna diversity, soil indicators, trophic biomass, and seismicity (in the terrestrial category); GNP, ratio of agricultural to industrial GNP, and energy consumption (in the economy category); and literacy, higher education, infant mortality, and disease (in the health category). Additional secondary level indicators (e.g., climate) may also be parsed in terms of basic indicators (e.g., diurnal temperature variation, precipitation distribution). Basic indicators which may not be directly quantifiable, may also be considered but they have to be ranked according to subjective perceptions.

As noted, option zero refers to present state. Indicator values for the same are based on collected data [23, 24]. Some indicators are readily taken from available data (e.g., wildlife population and disease statistics). Others require calculation (Shannon's index of plant diversity, crop revenue, sediment yield [25]). Still others must be estimated, often arbitrarily (runoff losses, nutrient loads, project investments, water supply). Options 1 and 2 refer to the management plans. The former has been assumed to be a low capital option emphasizing soil-protective

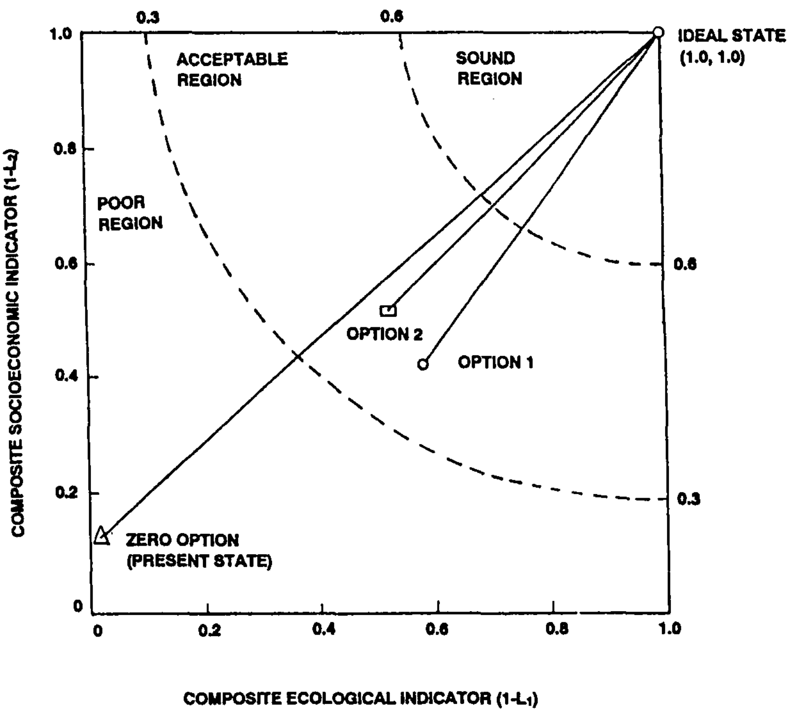

Figure 5. Graphical presentation of system status with respect to different management options.

crop rotation, better soil conservation measures to check erosion, increased afforestation, wildlife protection, small-scale storage schemes, and better medical facilities (etc.). In the latter option, however, more emphasis is placed on such erosion control measures as terracing and sediment-retarding basins, the creation of large, multipurpose water storage systems, and crop rotation with cash crops, but with less emphasis on afforestation, wildlife preservation, medical facilities (etc.).

The values of the basic indicators corresponding to these options are assumed, although they can take into account direct observations or computations made from trial or pilot projects. The values of ideal and worst indicators, and the

Table 3. Structure of Indicators

Basic Indicators	Units	Composite Indicators: Second Level (j)	Third Level (k)	Final Level
Runoff losses	10^8 m^3/yr			
Dissolved-N	10^3 tons/yr	Aquatic		
Sediment bound N	10^3 tons/yr	System		
Fish population	Number			
			Ecology	
Sediment Yield	10^6 tons/yr	Terrestrial		
Wildlife population	Number	System		
Plant diversity				System
Crop revenue	10^7 Rs.	Economy		
Project investment	10^7 Rs.		Socioeconomy	
Water supply	10^6 m^3	Health		
Disease onset	% population affected			

weighing factors should emerge from a set of priorities as indicated earlier (e.g., goals, quality standards, permissible limits, etc.). The computed values of the overall composite indicator (1-L) on the basis of existing data set, for three options viz. 0, 1 and 2 are 0.079, 0.489 and 0.517, respectively. Figure 5 displays these three options in the form of distances of the option points from ideal points and exhibits the extremely poor status of the current state (0 option). The system status is improved under both options, with option 2 scoring slightly better than option 1. This analysis may be extended to demarcate regions of highly desirable, acceptable, and poor status on the basis of overall composite distances of indicators.

Although the technique has methodological pitfalls involving what is to be measured and how, and involving the incorporation of subjective factors such as relative weights, the composite programming approach to MCDM is a tool that helps integrate and structure complex environmental problems such as that of shifting cultivation. The technique can yield interesting results and insights.

CONCLUSIONS AND SUGGESTIONS

An attempt has been made in this article to describe the adverse effects of jhum cultivation on various components and sub-components of the environment.

Table 4. Values of Indicators, Importance and Balancing Factors

	Basic/First Level					Second Level			Third Level			Final		
Indicators	Ideal Value	Worst Value	Management Option 0 (Current values) 1985 state	Management Option 1	Management Option 2	α	p	Indicators	α	p	Indicators	α	p	Indicators
Runoff losses	100	500	500	225	175	0.4								
Dissolved N	0.5	10	10	5	3	0.3		Aquatic system						
Sediment bound N	0.1	30	300	10	5	0.1	2		0.5					
Fish population	2500	500	1000	1500	2000	0.2				2	Ecology	0.5		
Sediment yield	3	13	13	7	5	0.5		Terrestrial system						
Wildlife population	3000	1808	1808	2500	2000	0.2	2		0.5					
Plant diversity	2.5	1.82	1.82	2.3	1.9	0.3							2	System
Crop revenue	200	67	67	100	175	0.6	2	Economy	0.6					
Project investment	10	100	10	40	75	0.4				2	Socio-Economy			
Water supply	20	3	3	10	18	0.6	2	Health	0.4					
Disease onset	50	95	95	65	80	0.4								

Clearly many precise and detailed studies would be necessary for an adequate and comprehensive quantification of these effects.

One of the most pressing needs for Mizoram and Northeastern India as a whole is to strengthen the information base—in its collection and dissemination aspects both. This article has sketched several areas where effective monitoring and processing of information is called for. Hydrometeorological observatories are a must in at least three district headquarters of Mizoram. Water and air quality monitoring needs to be initiated for selective parameters at several representative locations. Remote sensing techniques need to be actively incorporated in land use monitoring and studies. Precise geomorphological mapping of this region is strongly suggested as it provides a rationale for more effective land resource assessment. Monitoring for seismicity, mass movements, and its causes need to be geared up. Greater thrust should be given to exploring the dynamics of various components of hydrological cycle. This requires locating a sizeable number of experimental watersheds in each of the states. Lastly, creation of information banks and clearinghouses is seen as an urgent need of the time so that information from several disciplines may be documented and made available.

In order to comparatively evaluate various management strategies and to select the best one for implementation, the composite programming based approach appears to be quite useful, and not unduly complicated.

Holistic management of jhum cultivation requires a sincere will, appropriate planning, efficient implementation, and, above all, dedicated and harmonious participation of several agencies and individuals. The fact that the prolonged efforts and massive investments made until now have not been able to produce the most desirable results calls for a critical appraisal of the earlier approaches and a fresh orientation.

REFERENCES

1. G. S. I. (Geological Survey of India), *Geology and Minerals' of the States of India*, Miscellaneous Publication, Part IV, 1974.
2. B. N. Okigbo, Improved Permanent Production System as an Alternative to Shifting Intermittent Cultivation, in *Soil Bulletin 53*, FAO, Rome, 1984.
3. P. C. Goswami, Importance of Socioeconomic Factors and Role of Incentives in Controlling Shifting Cultivation in North East India, *Indian Forester, 111*:1, pp. 1-11, 1985.
4. R. N. Loganey, *Jhum Cultivation and Rehabilitation of Degraded Forest*, Proceedings 2nd Forestry Conference, FRI and Colleges, Dehradun, India, 1980.
5. R. Lee and D. E. Samuel, Some Thermal and Biological Effects of Forest Cutting in West Virginia, *Journal of Environmental Quality, 5*, pp. 362-375, 1976.
6. J. D. Helvey, First Year Effects of Wild Fire on Water Yield and Stream Temperature in North Central Washington, in *Watershed in Transition*, American Water Resource Association, Urbana, Illinois, 1972.
7. N. Ravi, *THE HINDU: Survey of the Environment, 1991*, National Press, Madras, India, 1991.

8. P. S. Ramakrishna and O. P. Toky, Preliminary Observations on the Impact of Jhum (Shifting Cultivation) on the Forested Ecosystem, *Proceedings on National Seminar on Resources, Development and Environment in Himalayan Region*, FRI and Colleges, Dehradun, India, ND.
9. R. Lal, Soil Erosion and Shifting Agriculture, in *Soil Bulletin 24*, FAO, Rome, 1974.
10. E. S. Thangam, Shifting Cultivation and Rehabilitation of Degraded Areas, *Proceedings 2nd Forestry Conference*, FRI and Colleges, Dehradun, India, 1980.
11. M. N. Jha, P. Pande, and T. C. Pathak, Studies on Changes in the Physico Chemical Properties of Tripura Soils as a Result of Jhuming, *Indian Forester, 105*:6, pp. 436-443, 1981.
12. A. Singh and M. D. Singh, Effect of Various Stages of Shifting Cultivation on Soil Erosion from Steep Hill Slopes, *Indian Forester, 106*:2, pp. 116-121, 1980.
13. ICAR (Indian Council of Agricultural Research), *News Bulletin of ICAR Research Complex*, Shillong, India, 1977-78.
14. R. M. Rice, Forest Management to Minimize Landslide Risk, in *Guidelines for Watershed Management, FAO Conservation Guide*, FAO, Rome, 1977.
15. P. N. Agrawal, Damage to Buildings during December 31, 1984 Cachar Earthquake, Northeast India, *Bulletin Indian Society of Earthquake Technology, 22*:1, pp. 53-72, 1985.
16. P. N. Agrawal, *Ground Failure during December 31, 1984 Cachar Earthquake, Northeast India*, Proceedings 8th Symposium on Earthquake Engineering, University of Roorkee, Roorkee, India, 1986.
17. T. Angami, *Jhum Cultivation and Rehabilitation of Degraded Forest*, Proceeding 2nd Forestry Conference, FRI and Colleges, Dehradun, India, 1980.
18. J. S. Ganguli, *Economic Problems of the Jhumias of Tripura*, Calcutta, Bookland Pvt. Ltd., India, 1968.
19. North Eastern Hill University, Lungdai Village Survey Report, Mizoram, India, 1986.
20. Government of Mizoram, Socio Economic Review, Mizoram, India, 1979-80.
21. UNESCO, *Methodological Guidelines for the Integrated Environmental Evaluation of Water Resources Development*, UNESCO, Paris, France, 1987.
22. A. Bardossy, *The Mathematics of Composite Programming, Working Paper*, Tiszadata, Miko, u.1.1012, Budapest, Hungary, 1984.
23. Government of Mizoram, Statistical Hand Book, Mizoram, India, 1983.
24. Government of Mizoram, Statistical Hand Book, Mizoram, India, 1985.
25. G. D. Miraki, *Sediment Yield and Deposition Profiles in Reservoirs*, Ph.D. Thesis, University of Roorkee, Roorkee, India, 1983.

Direct reprint requests to:

Himanshu Joshi
Department of Hydrology
University of Roorkee
Roorkee-247667, U.P.
India