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Shifting cultivation systems practised in Bhutan*

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Abstract. In the highlands of Bhutan shifting cultivation remains an important land use practice, covering an area of approximately 200,000 ha. Two systems, bush fallow and grass fallow, are described and discussed. The traditional methods used in the two systems are well adapted to available resources. The systems differ in fallow vegetation, altitude range, major crops, fallow period, farming tools, clearing method, labour inputs, and erosion risks. Soils used for the grass fallow system are low in P and N. Major limitations for the bush fallow system are weed competition and the steep terrain. Returns from labour were approximately 10.6 and 4.2 kg grain per day for the bush fallow and the grass fallow system, respectively. Access to market through a recently built road system provides some cultivators with lucrative alternatives in the form of timber, livestock and potato production. Alternative options are more limited in the bush fallow system.

Introduction

Bhutan is a landlocked mountainous country with an area of 46 500 km^2 and a population of about 0.6 million. Agriculture and livestock rearing are the main occupations for over 90% of the population, contributing 36% of the total Gross Domestic Product (GDP) [2]. The country has a low population density (13 persons km^{-2}) and the availability of labour is often a limitation to intensified agricultural production. The traditional, self sustained farming system integrates crop production, livestock production and use of forest products.

Based on the extent of cultivation and their contribution to the daily diet of the rural population of Bhutan, maize (*Zea mays*), rice (*Oryza sativa*), wheat (*Triticum aestivum*), buckwheat (*Fagopyrum spp.*) and foxtail millet (*Panicum milliaceum*) are the predominant agricultural crops. Farming and cropping systems practised in Bhutan vary widely. Agroclimatic conditions, ethnic backgrounds of the rural population, access to market and time of crop introduction appear to be the main factors influencing the type of cropping system used in a particular location. A simple road network built over the last two decades has, for the first time, given access to the market and to inputs such as fertilizer.

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Shifting cultivation is an important, traditional land use form practised in many parts of Bhutan. The area cultivated under shifting cultivation systems was estimated at 32 800 ha in 1988 [2]. With an average fallow period of 5 years the total area used would be close to 200 000 ha. Bhutanese farmers practising shifting cultivation live in permanent settlements and generally have some permanently cultivated land. The practices used are well adapted to the prevailing conditions and have been self-sustaining for generations. Increased population pressures, high labour costs, and the gradual change from a closed subsistence farming system to a market oriented system demand new methods and gradual changes are expected.

Shifting cultivation practices common in Bhutan are sparsely documented. With the changes anticipated in the near future, valuable information on traditional cropping systems is likely to be lost unless efforts are made to evaluate and record it. This paper describes typical shifting cultivation systems practised in the country and discusses their importance, merits, and disadvantages.

Materials and methods

The authors worked in various agriculture projects in Bhutan in areas where grassland shifting cultivation was prevalent. A major objective of these development activities was the transformation of shifting cultivation systems to more productive, sustainable agriculture, pastoral or agrosilvopastoral systems. During the course of these development activities covering the period from 1974–1990 various information was collected, and observations were recorded [5]. Additional information used in this paper originated from various reports as acknowledged.

Information on labour input and burning induced changes in selected soil parameters were obtained from a study made in Bumthang district (Central Bhutan) during the 1989/90 season. This study was conducted in a traditional grassland shifting cultivation area. Labour inputs were recorded separately for each process from four sites. Soil samples collected before and after burning were analyzed from 3 sites (10 sub-samples for each site). Sample areas used ranged from 0.05–0.3 ha.

Shifting cultivation systems

Parent material, soil, gradient, altitude and rainfall are the main criteria determining the suitability, potential and limitation of land for shifting cultivation (Fig. 1, Table 1). Influenced by the above factors, and depending on the natural vegetation developing between two cropping cycles, two distinctly different shifting cultivation systems have evolved in Bhutan (Table 2). Based on the fallow vegetation, the terms grass fallow system and bush

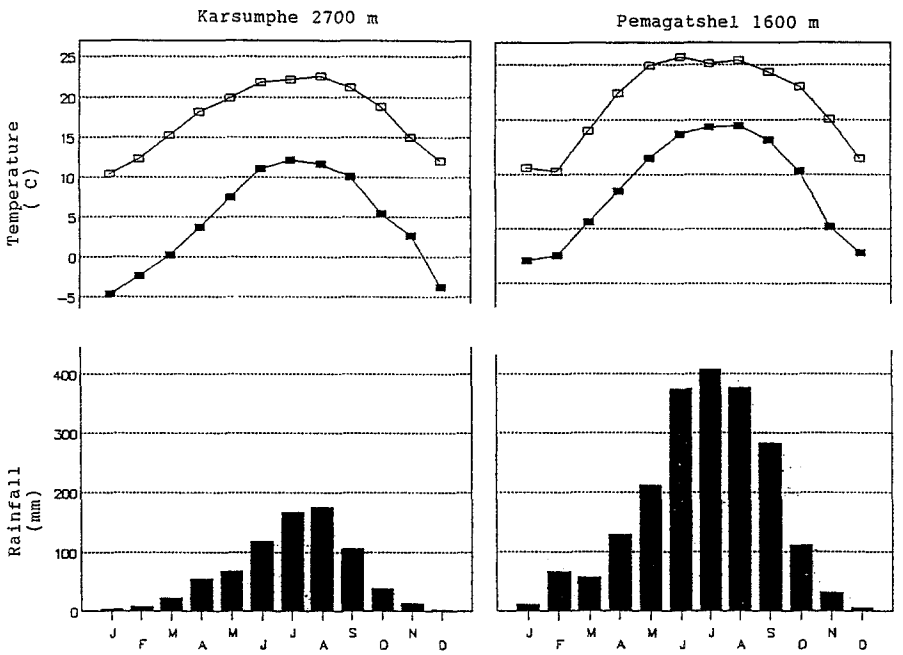

Fig. 1. Monthly average maximum and minimum temperatures and monthly rainfall for Karsumphe, Bumthang (Average 1975—79) and Pemagatshel (Average 1988—90).

fallow system are used in this paper. Limited amounts of above ground fuel biomass and low phosphate availability with the grass fallow system, require a unique land preparation method. Other major differences between the two systems include: altitude range, crops used, fallow period, returns on labour, tools used, and erosion hazards.

Shifting cultivation systems practised in the neighbouring countries, India, Nepal, and Burma, show many similarities. However, some authors claim that the shifting cultivation practices in Bhutan have evolved independently and that there is no evidence to conclude that they have been borrowed from neighbouring countries such as India and Burma [8].

Grass fallow system

Soils in the central part of Bhutan are generally derived from coarse-grained granite-gneiss and thus are very low in available phosphate (Table 1). For permanent cultivation phosphate has to be added regularly to the system. In the absence of phosphate sources the farmers of central and northern Bhutan developed a unique shifting cultivation system with long fallow periods. After fallow periods of 6—20 years the vegetation consists mostly of grasses and

Table 1. Typical shifting cultivation soils (sampling depth 0—10 cm).

Site[1]	Altitude	Available P[2] ppm	Available K[3] ppm	pH	Organic C (%)	Texture	Reference
Bush fallow							
1. Chorten	1200	8	110	4.8	3.3	Sandy loam	[3]
2. Chungkhar	2000	16	121	4.9	4.4	Loam	[3]
Grass fallow							
3. Pralang	2800	0.3	53	6.1	4.4	Sandy loam	Authors
4. Tamshing	2700	0.5	11	6.3	2.3	Sandy loam	Authors
5. Phubjkha	3000	0.3	24	5.4	3.3	Loam	Authors

[1] Districts: Pemagyatsel (sites 1, 2), Bumthang (sites 3, 4), Wandiphodrang (site 5).
[2] Extraction with bicarbonate for sites 1 and 2, extraction with CO_2 saturated water for sites 3—5.
[3] Extraction with ammoniumacetate for sites 1 and 2, extraction with CO_2 saturated water for sites 3—5.

Table 2. Characteristics of shifting cultivation systems used in Bhutan.

	Grass fallow	Bush fallow
Districts	Bumthang, Tongsa, Wangdiphordrang, Thimphu	Tashigang, Mongar, Pemagatsel, Shemgang, Samdrup Jongkhar
Altitude range (m)	2500—3500	300—2500
Major fallow species	Blue pine, grasses	Shrubs, trees
Above ground biomass at end of fallow (MT ha^{-1})	< 2 (range 0.5—20)	> 10 (Range 5—40)
Major crops	Buckwheats, wheat	Maize, millets, rice
Parent material	Coarse grained granite-gneiss, quartzite	Various including: quartzite, phyllite schist, limestone
Cropping period	2—3 years	1—2 years
Fallow period	6—20 years	2—8 years
Clearing methods	Cutting and drying top 5—7 cm soil, adding fuel, making mounds, burning, spreading mounds	Slashing vegetation, burning
Labour inputs	High	Moderate
Main tools	Hoe, plough	Knife, sickle
Effect of clearing on natural vegetation	Complete destruction	Only partly killed
Erosion hazard	High	Medium
Major limitations to longer cropping periods	Phosphate, nitrogen	Weed competition Topography
Main C and N losses through burning of	Soil organic matter	Above ground biomass
Benefits during fallow period	Livestock grazing	Fire wood production, livestock grazing
Approximate area (ha) not including fallow land	10 000	20 000

forbes interspersed with blue pine (*Pinus wallichiana*). Prior to cultivation the top soil layer is cut with a hoe at about 5–7 cm depth and allowed to dry completely for several months. The dry top soil is then collected in mounds about 2–3 m apart (1200–2500 mounds ha^{-1}). Small quantities of fuel consisting either of blue pine needles collected at the site or brought in from

nearby forest or dry manure is added to each mound. After ignition of the fuel the organic material in the dry soil mounds continues to burn slowly, gradually reaching temperatures of 500 °C and beyond (measurements made by authors). The burning usually lasts for several hours. The soil which is spread a few days after burning makes a friable, smooth seed bed, but because of the almost complete kill of the vegetation it is fully exposed to the forces of erosion.

Through the burning process some of the plant nutrients accumulated in the plant biomass and the soil organic matter become readily available to the new crop (Table 3). The soil pH increases and it is assumed that the intense heating makes bound soil phosphate more available. Andriesse and Koopmans [1] have shown an increase in available phosphate when red-yellow podzolic soil was exposed to tempertures above 150 °C in laboratory conditions. During the burning process most of the organic matter and much of the nitrogen is lost. Changes in soil organic C and N from 3.3% to 0.8% and 0.17% to 0.08%, respectively, amount to losses of approximately 18 MT C and 0.6 MT N ha^{-1} (Table 3). The burning process reduces the C:N ratio substantially and thoroughly destroys weed seeds present in the soil mass of the mound.

Table 3. Changes in selected soil parameters through the burning process (grass fallow system)[1].

Parameter	Before burning	After burning
pH	6.0	6.9
Available P (ppm)[2]	0.28	0.31
Available K (ppm)[2]	35	69
Total N (%)	0.17	0.08
Organic C (%)	3.3	0.8

[1] Measurements by author (average figures for 3 sites).
[2] Extraction with CO_2 saturated water.

The most important crop used in this system is bitter buckwheat (*Fagopyrum tataricum*). Other crops used as second or third crop after bitter buckwheat include sweet buckwheat (*Fagopyrum esculentum*), wheat and mustard [6]. A commonly practised 2 years cropping cycle in Bumthang consists of bitter buckwheat followed by sweet buckwheat, with average yields of 1.9 and 1.4 MT/ha, respectively [6]. The lower yield in the second year can partly be attributed to declining soil fertility.

The burning process described above, is used only for the first crop. Field preparations for the succeeding crops are carried out with the help of bullock drawn implements or the hoe. Phosphate and nitrogen in the form of ash produced from burning manure is generally added to the second crop [4].

The soil preparation as described above is extremely labour consuming and the return for the labour input is low (Table 4). With a buckwheat price of about 4 Nulgultrums (1 Nulgultrum = 0.04 US $) per kg the shifting cultivator would earn only 17 Nulgultrum per day, which is far below the minimum daily wage of 30 Nulgultrum.

Table 4. Comparison of labour input and productivity for shifting cultivation and permanent systems.

	Maize		Bitter buckwheat	
	Bush fallow	Permanent	Grass fallow	Permanent
	Labour input (days/ha)			
Field preparation[1]	50	40	305	32
Sowing	32	25	3	60
Weeding	92	150	—	—
Watching/protecting	66	60	19	15
Harvesting	24	24	30	30
Threshing	23	20	20	20
Total	287	319	377	103
Yield (MT/ha)	3.0	3.0	1.6	1.4
Yield/labour input (kg/day)	10.6	9.4	4.2	13.6
Source	[8]	[8]	Authors[2]	Authors[3]

[1] Field preparation bush fallow: site inspection 1 day, cutting and clearing 42 days, burning 42 days.
Field preparation grass fallow: cultivation 149 days, cutting/carrying fuel 46 days, making mounds 77 days, burning 19 days, spreading 14 days.
[2] Average of 4 sites measured.
[3] Estimated.

This system was perhaps the best and/or only approach for the Bhutanese highland farmer to obtain a crop under the given conditions without any outside P and N-inputs. Due to the high labour requirement and thanks to the availability of phosphate fertilizers, a gradual change to permanent systems is taking place. Cropping systems using wheat, buckwheat, rye, potato, and white clover have replaced shifting cultivation in some areas while other areas have been changed to permanent pasture with white clover as the main component.

Bush fallow system

This system follows the widely used and well described practices of slash and burn [7]. The vegetation, consisting of trees, shrubs, other perennials, and

annuals, is cut during the dry season, allowed to dry and burned shortly before planting the seed. Seeds are either dibbled or broadcast without incorporation. Crops used include maize, millet, rice, buckwheat (Table 5). Cropping cycles used vary from region to region. For Kheng (Shemgang) it was estimated that 90% of the area is used in a system where one cropping season is followed by 3 years of fallow [9].

Table 5. Bush fallow shifting cultivation systems in Keng (Shemgang), planting season, yield and relative importance[1].

Crops	Season							Yield range (MT/ha)	Importance (%)[2]
	Jan.	Feb.	March	April	May	June	July		
Foxtail millet	←	—	—	—	—	→		0.4—1.5	40
Finger millet	←	—	—	—	—	→		0.4—0.9	30
Maize		←	—	—	—	→		0.4—1.5	15
Upland rice			←	—	—	—	→	0.4—0.8	14
Buckwheat			←	—	—	→		0.5—0.8	1

[1] Adapted from Zimmerman et al. 1989.
[2] In percent of total cultivated annually under slash and burn systems area.

Many of the perennial plants, particularly woody species, survive the burning and start coppicing vigorously with the onset of the rainy season. The soil is never fully exposed to erosion. Weeds, although thought to be the main detriment to longer cropping periods, are thus very important in stabilizing the system. Hoe and/or plough are rarely used for cultivation although weeding hoes are common. Any tillage work on steeper slopes would cause disastrous erosion damage. Continuous cropping would therefore not be possible without changing the slope gradient by terracing or bunding. The presence of stones, would be another constraint to permanent cultivation in many areas.

Compared to systems with continuous cropping, the slash and burn system often provides better returns on labour inputs (Table 4). This is mainly due to high labour requirements for weeding in the permanent system. In some areas the wood produced during the fallow period provides the main source of fire wood. Aside from systems with permanent tree cover, the presently used slash and burn system may not only be the most productive but also the least destructive.

Government interventions and anticipated future development

Shifting cultivation is regulated through the rules and regulations governing land ownership and forest use and protection. Land used for shifting cultivation is usually owned by the cultivator. Reducing shifting cultivation was and remains an important objective of the Ministry of Agriculture. The Government provided various incentives to farmers to assist them to convert shifting cultivation land into land used for permanent cultivation. Through terracing, contour-bunding and the establishment of orchards, substantial areas have been brought under permanent cultivation.

The extension package provided by the Department of Animal Husbandry, including more productive cattle breeds, seeds of perennial fodder plants and subsidized phosphate fertilizer, has had a major impact in areas where grass fallow shifting cultivation was practised. White clover, grass mixtures are widely used in the fallow period.

Although ecological concerns are voiced with increasing frequency and urgency, it will be mainly economic incentives which will motivate farmers to change to other land use systems. Highly profitable alternatives are presently available to farmers practising grass fallow shifting cultivation in the form of livestock and timber production. It is thus anticipated that the shifting cultivation in temperate regions of Bhutan will be replaced rapidly by other systems of which agrosilvopastoral systems hold prime potential.

Options in the bush fallow system are more limited. The extreme topography not only limits the choice of permanent systems but also affects market accessibility. The shift from a subsistence farming system to a market oriented farming system will take much longer under such conditions. Perennial plants, especially fruits and fodder crops, will be important components in permanent systems [3]. The proximity of such lands to roads will significantly influence the transition from shifting cultivation to permanent systems.

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