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THE PRODUCTIVITY OF THE AGRICULTURAL AND PASTORAL SYSTEM IN ZANSKAR

INTRODUCTION

The Zanskar valley lies at 3600m in Kashmir, India, to the north of the main Himalaya. The latter shelter it from the monsoon and until recently have protected it from Western influences. The Buddhist culture and the farming system of Zanskar are both essentially Tibetan (though with certain of their own characteristics) and, since the Chinese occupation of Tibet, they offer an opportunity to study a relic of Tibetan society which has been preserved by an accident of political history.

Despite the harsh environmental conditions, with winter temperatures down to –30° C and summer rainfall probably less than 100 mm, which might lead one to expect a sparse population of nomadic pastoralists, the valley supports many prosperous villages which have maintained a stable population and subsistence farming system for many centuries. The basis of this prosperity is the unexpectedly productive agriculture, growing intensively irrigated crops of barley, wheat and peas. This is coupled with a pastoral sector which in this environment one might expect to be based on sheep and goats, but in fact is based on cattle, though on the yak, *Bos grunniens*, rather than Indian or European species.

The productivity and stability of this system is the result of close integration at two levels: the technical level which relates the requirements and products of the crops, the livestock and the people; and the socio-religious level which maintains the status of landed peasant farmers linked to a benevolent hierarchy. An important aspect of the latter level is the provision for controlling population and preventing farm fragmentation by monastic celibacy and polyandry (see Crook and Osmaston 1994).

ENVIRONMENTAL CONSTRAINTS

The environmental constraints on the farming system result from the interactions of altitude, relief, climate, soil and water supply. The first two combine to set barriers around Zanskar. In summer the only access is over high mountain passes; in winter the only access is through the gorge of the frozen Zanskar River. As a result the valley has to be nearly self-sufficient in food, and in winter the livestock cannot be driven to lower altitudes as is the practice in Nepal, or to more northerly areas with less snow as is the practice in parts of Tibet. Indeed there is so much winter snow in Zanskar, ususally 1m, occasionally up to 4m, that livestock have to be housed and therefore have to be fed on conserved fodder. This snow also confines the arable crops in a temporal sense. The ground cannot be ploughed and sown till the snow has melted in spring (early May), and the crops must be harvested and gathered in before the first snowfalls in the autumn (early October). This gives a maximum growing season of about 4.5 months. Since the crops are entirely dependent on irrigation, and since most of the irrigation water is derived from melting snow patches, the growing season may be restricted still further in some villages, either because their snow patches are north-facing and so melt late, or because they are small and south-facing and so are exhausted early. No modern European cereal can meet this requirement. I sowed wheat and barley from Zanskar in England, together with the fastest ripening varieties available in Britain, and the Zanskar varieties ripened first.

Agriculture is restricted to a fairly narrow altitudinal zone: 3500m being the lowest limit of the accessible valley, and 4300m the highest cultivated field (at Shade village), though at the latter altitude only barley can be grown. One limiting factor at high altitude is probably the reduced length of growing season, which eliminates wheat. At the lower altitude however, peas can ripen in an even shorter growing season than barley, so perhaps it is lower summer temperatures that restrict this crop. This restricted altitude range forces the farmers to concentrate on the narrow range of crops which grow there, and prevents them diversifying with crops at much lower altitudes, as is common practice in Nepal and the Andes.

Summer grazing is restricted in almost the opposite way. Except for a few productive meadows on the flood plains of the main rivers, the valley floors are dry gravel terraces and fans with a sparse steppe vegetation, reduced by overgrazing to spiny *Astragalus* (*sichu*) and unpalatable *Artemisia* (*burtse, burnak; bur-tse, bur-nag*).

Although these support some flocks of sheep and goats, which can be herded by day by children and housed at night, so that they do not eat the unfenced crops, the cattle and the rest of the sheep and goats are moved up to communal mountain pastures at 4300-4900m. These are watered by melting snow, and remain moister because it is cooler, so that the vegetation is more plentiful and varied, with grasses and palatable legumes, though it still only forms a closed turf in a few favourable localities. In general this is a movement from each village to a series of high camps (*droksa; 'brog-sa*) nearby, which are occupied in turn, much as herds in Europe are moved to the high alps in summer. Sometimes however there is a longer transhumance, and some cattle from all over central Zanskar are sent to graze on the Pensi La or in the Ralakung (Ra-la-kung) Valley north of Phe.

Despite the ruggedness of the landscape there are large areas of cultivable land in the valleys still unused, because of the more serious constraint of irrigation water, somewhat surprising in this country of large rivers. However these are usually incised deeply below the cultivable terraces and fans, so the leat-and-furrow technology of the Zanskari farmer is only able to tap the minor tributaries which provide strictly limited water resources, without which agriculture is impossible.

However, given water, high rates of photosynthesis for long periods are provided by the usually clear skies and high altitude. Moreover the cold winters and dry summers prevent most crop pests and diseases (except pea moth), so that crops are exceptionally healthy, despite a naturally low resistance which is demonstrated when these cereal varieties are grown in Europe and become seriously diseased.

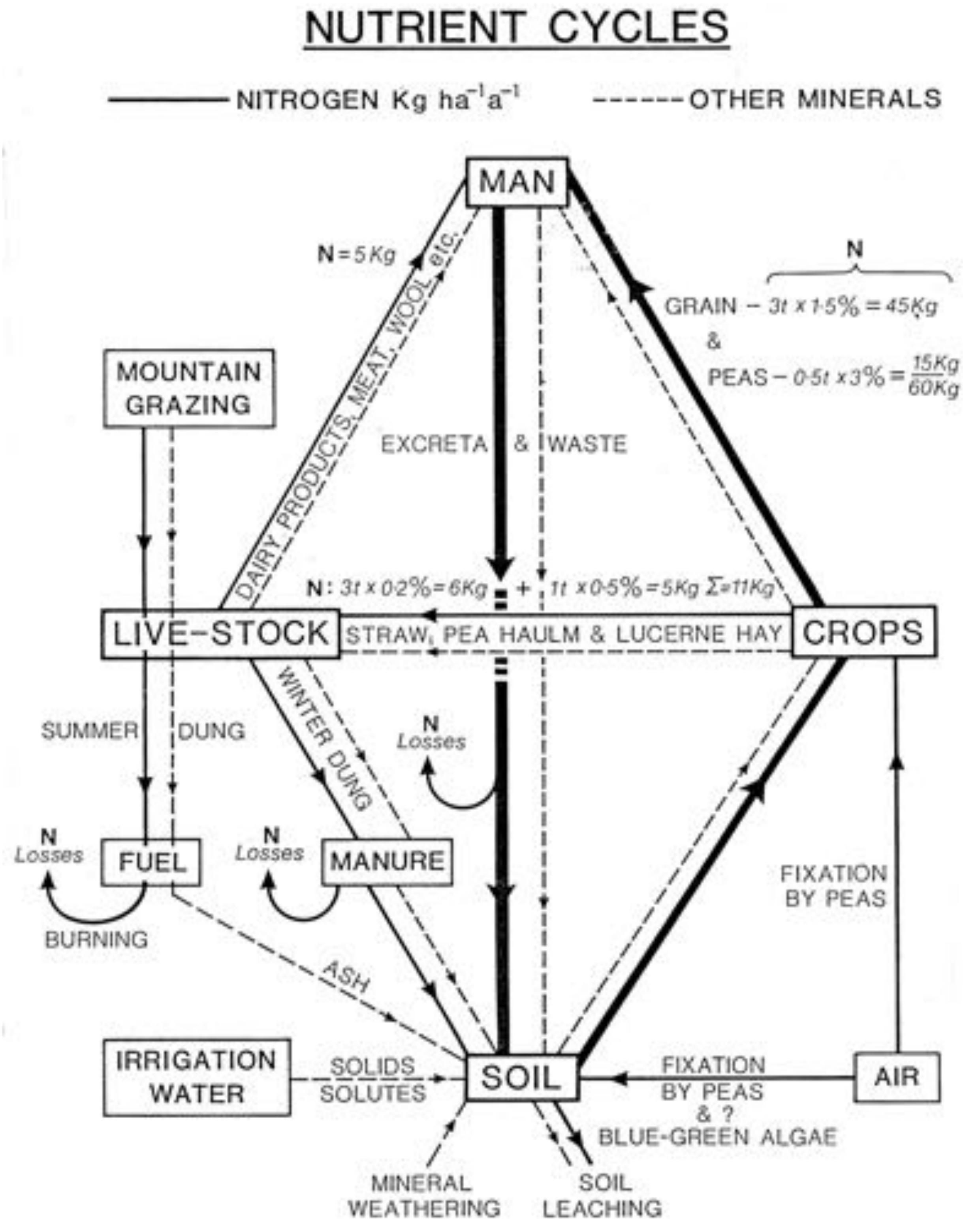

Fig. 1. Nutrient cycling – primarily nitrogen – through the usual agricultural, pastoral and domestic system in Zanskar, without artificial fertiliser. Figures for quantities of crops are taken from local surveys; figures for nitrogen content are standard figures from the literature. Some flows are very seasonal. Nitrogen losses due to decomposition of dung and night-soil in storage are small: in winter they are frozen; in summer they are quickly dried. Those due to soil leaching are unquantifiable. However at Shade (Sha-sde) no peas are grown so no nitrogen is supplied thus.

These are the main external factors of the environment which determine the outlines of the farming system, but there are certain important internal factors too, which determine the interactions of the agricultural and pastoral sectors which are described in more detail below.

THE LIVESTOCK

The domestic yak differs little from the wild yak of the Tibetan plateau, an animal which has become adapted for survival in a harsh climate and with only sparse grazing, and the herds of the higher villages in Zanskar are exclusively yak. Because their milk yield is low, however, only about 1 litre/day (strictly "yak" is only the male of the species, and the female is called "*drimo* (*'bri-mo*)"), farmers in the lower villages often cross them with European type cattle (*Bos taurus*) but never with Indian cattle (*Bos indicus*) as is sometimes done in Nepal. The male hybrids are sterile, but like the mule are valued for their strength, and are used as pack animals and for ploughing. The female hybrids give more milk with a lower fat content than the drimo, but are less hardy and there are some indications that they may be less fertile. It is traditional to use a yak and a cow for the first cross, and to continue crossing back to the yak in subsequent generations (Table 1), though the Indian Department of Agriculture are now encouraging the use of Jersey bulls with the aim of raising the productivity of the cattle. Most farmers have between 1-10 cattle, but also have larger numbers of sheep and goats (*raluk; ra-lug*), and perhaps one or two donkeys or a pony.

The annual cycle starts in spring, when the snow begins to melt and the cattle are turned out to find some early grazing. Dung from the stables and night-soil from the houses are carried out and spread on the fields where barley is to be sown. The rites of spring are celebrated with a ceremonial ploughing in April (Friedl 1983), but the main ploughing does not start till farmers judge that there is no risk of further snow. A pair of yak or dzo is used, farmers sharing with their neighbours if necessary. As soon as the crops are sown, the cattle must be moved away from the unfenced crops to the lowest *droksa*, where they are herded and milked by cheerful young girls from the village, who evidently enjoy this freedom of restraint from parental control throughout the summer. However, there is plenty of hard work too: animals to be milked at dawn and sunset; sheep, goats and calves to be penned safely from wolves; milk to be curdled and then churned for several hours to make butter; the buttermilk to be strained, hung, then finally cut and sun-dried into cheese chips as hard as wood; and, most important of all, the collection of fuel for current use and for the next winter. There are few trees in Zanskar, and their wood is kept for structural uses. Plants with woody rootstocks such as *Artemisia* (*burtse; bur-tse*) and large cushion plants such as *Acantholimon* (*lonze; long-ze*) are collected for fuel, mainly for kindling and for roasting grain, but the mainstay for general cooking and heating is dung. Cattle are efficient, self-powered, fuel harvesters, gathering a sparsely distributed renewable resource which it would be very difficult to gather by hand, and concentrating it into dung-pats which are convenient both to transport and to burn. Girls scour the countryside for dried dung-pats, and the dung which is dropped in the stables each night is also moulded into convenient cakes and put out to dry. Apart from what is needed at the *droksa* (*'brog-sa*), all this fuel is taken down to the village and stored on the roof of each house.

I obtained information on herd reproduction in three different ways: by comparing the numbers of animals of different ages in a herd; by asking direct questions about the behaviour and management of the animals; and by recording "herd histories" for the cattle of individual farmers. Just as some human societies have a strong oral tradition of their own genealogy (usually in the male line), so pastoralists often have excellent memories of the genealogy of their animals, at least in the female line, and can provide historical data of this kind much more readily and reliably than they can answer generalised questions about reproduction rates. From this information it became clear that fertility was low, with females calving only in

Table 1. HYBRIDS OF YAK (*Bos grunniens*) AND EUROPEAN CATTLE (*Bos taurus*)

	English	Zanskari		
	Male yak	*yak* (*g.yag*)		
	Female yak	*drimo* (*'bri-mo*)		
	European bull	*langto* (*glang-to*)		
	European cow	*pashi* (Lad. *balang*, *ba-shi; ba-lang*)		
	Parents		**FemaleOffspring**	**MaleOffspring**
F1	*yak x pashi*	=	*dzomo (mdzo-mo)*	*dzo (mdzo)* (sterile)
F2	*yak x dzomo*	=	*garmo (gar-mo)*	*gar* or *garu (gar, gar-ru)* (sterile)
F3	*yak x garmo*	=	*girmo (gyir-mo)*	*gir (gyir)* (sterile)
F4	*yak x girmo*	=	*lokmo (log-mo)*	*lok (log)* (sterile)
(F5*	*yak x lokmo*	=	*tsigmo*	*?)*
F5/6	*yak x lokmo/tsigmo =*	*drimo ('bri-mo)*	*yak (g.yag)* (fertile)	
F1	*langto x drimo*	=	*dzomo (mdzo-mo)*	*drimzo ('bri-mdzo)* (sterile)
F2	*langto x dzomo*	=	*stolmo (stol-mo)*	*stolpo (stol-po)* (sterile)
F3	*langto x stolmo*	=	*pashi (ba-shi)*	*langto (glang-to)* (fertile)

* This F5 generation is seldom recognized and even the F4 generation is often not distinguished.

alternate years or even less often. Lactation usually continued into the second year at a low level of yield, and it is possible that this inhibits ovulation, as is well known to occur in human societies with prolonged suckling periods, though the low level of nutrition is probably a contributory factor

For most of the summer the yak and dzo are sent to a separate valley to fend for themselves, but in July one or more selected yak are brought back to run with the females, so that calving is concentrated in the spring. Farmers say that dzo often mount pregnant females and cause abortions because their erect penis is extraordinarily long. We were unable to test any of these assertions, which we doubt, but the view is held so strongly that especially libidinous dzo are cross-branded on the tip of the penis to discourage them. We tested a few milk samples for brucellosis (contagious abortion) but found them negative. It is possible that a significant number of young foetuses are resorbed due to the low level of nutrition. The calves are very small and growth is very slow, partly because they are deprived of much of their mother's scanty milk supply, and death rates are high, particularly during the first year, often attributed to respiratory diseases in winter.

In consequence many farmers had difficulty in maintaining their herd size, let alone producing surplus stock for sale, and some indeed had to buy stock. Table 2 shows a model balance sheet for an unusually large Zanskari herd, with the figures rounded off conveniently. It shows that all females have to be kept to maintain the herd size, with little opportunity to cull individuals for low productivity or fertility, and that there is only a small surplus of male animals for slaughter or disposal. Although Zanskaris are Buddhists, and so in principle are vegetarians, they are also practical people and in autumn two or more families will often combine to cull an old or barren animal and freeze-dry the shared meat for eating during the long winter. There is an important export trade in butter, and in live males on the hoof to the Indus Valley for ploughing. I have an impression, though without sufficient data to substantiate it, that it is the higher villages with mostly pure yak herds that have the best fertility, survival and output of surplus stock, while the lower villages with yak-cow hybrids and cows have the worst (though probably greater butter production).

It is very difficult during a week or two at any one *droksa* to gather reliable information or observations on annual milk and fat production, for the women are secretive about it and intolerant of interference with their normal milking routine, and the milk taken by suckling calves is variable. However indications were that *drimo* may yield 1-2 litres a day in summer, and dzomo, etc. rather more. My attempts to obtain analyses of milk samples also met with difficulties, some due to veterinary restrictions on import into England, some due to long transit times to laboratories in India which resulted in fat coagulation, and I do not regard the results as reliable. Local information suggested that a female should produce 15-30 kg of butter during the summer after calving.

The figures I have used in Table 2 are therefore partly based on data given by Bonnemaire and Jest (1976) for yak herds in Nepal and elsewhere, and should only be regarded as approximate. For a mixed herd of hybrid cattle (*dzomo*, etc.), the milk and butter yields would be about double these, but the herd structure is much more complicated. Pure "European" cows are needed to produce a continuing supply of first generation hybrids, as later generation hybrids have a low survival rate; otherwise cows must be bought in from elsewhere (see Crook & Osmaston 1994).

For comparison, Table 3 shows a comparable balance sheet based on a proportion of my own fairly typical dairy herd of Friesian cows in England. It seems that in terms of butter they are nearly twenty-five times as productive per livestock unit (a measure of the grazing and fodder requirements of an adult animal), and twice as productive in terms of animals. Part of this difference is due to genetic improvement, but this impro-

Table 2. A MODEL HERD OF PURE-BRED YAK & DRIMO IN ZANSKAR

HERD COMPOSITION

1 yak aged 5-9 years	1 livestock unit
5 drimo aged 5,6,7,8,9 y.	5 ,, ,,
(allow 20% calving and rearing losses)	
2 calves aged 0-1 year, 1m, 1f.	0 ,, ,,
2 aged 1-2 years (each 0.25 l.u.)	0.5 ,, ,,
2 aged 2-3 years (each 0.5 l.u.)	1 ,, ,,
2 aged 3-4 years (each 0.5 l.u.)	1 ,, ,,
2 aged 4-5 years (each 0.75 l.u.)	1.5 ,, ,,
———	———
16 animals	10 livest. units

ANNUAL REPLACEMENTS

1 drimo aged 5 years for dairy herd.
0.2 yak for draught animal (i.e. one every fifth year).

ANNUAL OUTPUT

1 cull drimo for slaughter.
0.2 cull yak for slaughter (i.e. one every fifth year).
0.8 yak aged 5 years for sale (i.e. four years in five).
————
Net Output: 2 animals each year.
NO surplus breeding females.

MILK & BUTTER PRODUCTION

5 drimo calving in alternate years give -
5x120 = 600 litres of milk @ 7% fat = 40 kg butter.

ANNUAL PRODUCTIVITY

4 kg butter per livestock unit.
0.2 adult animals per livestock unit.

<u>N.B. Livestock unit = l.u.= a notional factor for expressing grazing and fodder requirements of livestock of different ages (and species) compared with adult cattle.</u>

vement can only be expressed in terms of higher production if the plane of nutrition permits it. Such comparisons need caution as livestock units in Zanskar and England are not quite the same; my cattle would die if subjected to the scanty grazing and harsh conditions of Ladakh.

AGRICULTURE

The following account is based primarily on Tongde (sTonng-sde), a typical large, "lowland" village of central Zanskar, which I studied in detail, with some less reliable information from Shade, one of the smallest, highest and remotest villages (Table 4).

The arable (i.e. irrigated) fields are situated on one flank of a large alluvial fan, where the Tongde stream issues from the mountains, and are protected by a high rocky spur, on which the monastery (*gonpa*) stands, from disastrous spring floods which spread gravel over the fan. About two thirds of the land is privately owned by the occupants of 29 main farm houses (*khangchen*), each of which may have one or more subsidiary dwellings for relatives (*khangchung*). The rest of the land is owned by Tongde or other monasteries (*gonpa*) and rented to farmers. The fields are small and usually rather rounded, with wide banks of permanent grass or alfafa (*buk-suk*) between them which are cropped for hay, an essential item of winter forage for sheep and goats, lactating mares and cows. Indeed such banks amount to about half the irrigated area.

The cultivated area is limited by the water supply, so that the latter is strictly rationed. Farms are divided into seven groups, each of which share the water on one day each week. Although storage reservoirs hold part of the night's stream-flow they are not large enough, so throughout the night farmers with oil lamps walk to and fro around the fields like will-o'-the-wisps, blocking a furrow here, guiding the water there.

Except for a few households where labour is short, the fields are weeded very carefully by hand. The growth of the resulting weed-free and disease-free cereals crops compares favourably with that of European crops that have had heavy applications of fertilisers, weed killers, pesticides, fungicides and growth regulators.

The pea crops are less good and may be attacked by pea-moth. However they play an important part in maintaining fertility, being used in a rather flexible 3-course rotation of peas- barley-wheat, without fallow. At Shade one variety of barley is the only crop that can be grown (Table 5).

The harvest starts in August with the hay and the peas, followed by the barley and finally the wheat. In Zanskar the perennial hay is cut with a sickle; the peas are pulled by hand from dry ground, leaving the roots with their nitrogen-rich nodules in the soil; and the cereal crops are pulled by hand from moist, newly irrigated ground with their roots, thus maximising the yield of forage and minimising the risk of carrying disease over from one crop to the next. Thus these apparently simple differences in husbandry have excellent economic and scientific bases. The apparently more "advanced" practice in the Indus valley of harvesting cereals with a sickle, may in fact be a retrograde step!

Threshing starts in early October when the cattle are brought down to the village. Long before dawn one is woken by the shouts and songs of the girls who drive a team of half-a-dozen or more cattle and horses, tied in line abreast, round and round the circular threshing floor. The chaff and broken straw are winnowed from the grain, and both are then stored in the farmhouse.

Table 3. A MODEL HERD OF FRIESIAN COWS
(based on my farm near Bristol, England)

HERD COMPOSITION

NO bull (all breeding by A.I.)	
5 cows aged 3,4,5,6,7 years	5 l.u.
(allow 10% calving and rearing losses)	
4.5 calves aged 0-1 year (each 0.2 l.u.)	0.9 l.u.
4.5 aged 1-2 years(each 0.5 l.u.)	2.25 l.u.
4.5 aged 2-2.5 y. (each 0.8 l.u.x 0.5y.)	1.8 l.u.
———	———
18.5 animals	c.10 l.u.

ANNUAL REPLACEMENTS
1 heifer replacement for dairy herd.

ANNUAL OUTPUT
1 cull cow for market.
1.25 heifers for sale aged 2.5 years.
2.25 bullocks for sale aged 2.5 years.
———
Net output: 4.5 animals each year.

MILK PRODUCTION
5 Friesian cows calving every year give -
5 X 5000 litres of milk @ 4% fat = 1000 kg butter

ANNUAL PRODUCTIVITY
100 kg butter per livestock unit
0.45 adult animals per livestock unit

Table 4. CULTIVATED LAND AT TONGDE AND SHADE VILLAGES.

	TONGDE	SHADE
Arable area	57 ha	4.3 ha
Hay area	57 ha	?
Number of fields	718	?
Average field size	0.08 ha (1.6 kanal)	?
Nbr of Khangchen	31	5
Arable per ,, ,,	2 ha	1 ha
Altitude	3600 m	4200-4300m
Site	Alluvial fan	Sand stone slopes
Crops	Barley(4 var.), wheat, peas.	Barley (1 var.)

It is now urgent to roast and grind enough grain to provide flour for the winter before the water-mills are immobilised by the freezing of the streams. This task accomplished, the farmer can relax from the exertions of the summer, though when the mountain slopes and fields are covered with snow the cattle have to be housed, at least by night, so there are then daily chores of feeding and watering the stock. Otherwise life alternates between the long cold nights when the family huddle around a dung fire in a smoky inner room, and bright sunny days enlivened by monastic festivals, archery competitions, beer parties and journeys to Leh down the frozen Zanskar Gorge.

Information on accurately measured crop yields is not available, partly because of the problems of making accurate observations when the crops from several small fields of uncertain area are threshed together; partly because of the natural caution of farmers in the face of tax-collectors; partly because of the lack of the incentive of an active grain trade and the general adequacy of food supplies — as Crowden has pointed out, the large amounts of barley used for brewing beer are a good indication that there is enough to eat. Yield estimates recorded by Crowden (1977) for villages in Central Zanskar ranged from 2.7 to 3.0 tonnes/ha, which are slightly lower than estimates given me for some of the best parts of the Indus Valley (Tashi Rabgias, pers. comm.) of 3.2-3.8 t/ha.

To check these figures I measured some small sample plots in standing crops at Tongde in 1980 and estimated that average wheat and barley yields were about 4 t/ha, with a wide range from about 1 to 8 t/ha. These figures are corroborated by measurements in 2 fields of barley at Padum by Chalmers and Ramm (1984) which averaged 3.5 t/ha.

Crowden was told by officials at Padum that at Shade village yields were depressed to 1.3 t/ha. On the contrary I found that yields there were higher than at Padum, averaging about 5 t/ha, probably due to a fertile soil and abundant manure and water. This official view seems to reflect a Plains-trained agriculturalist's perception of Shade (Sha-sde) as a remote cold village that must have poor crops!

It is interesting that similarly barley yields in Scotland are higher than in England due to the cooler and longer period of ripening.

These yields are shown in Table 6 together with comparable data from other countries, and it is clear that yields in Zanskar are much better than most, and nearly as high as those obtained from intensive high input farming in Europe. These cereal yields are due partly to favourable environmental conditions: abundant water, light and nutrients, warm days and cool nights (so that respiratory losses are low), freedom from weeds, pests and diseases. On fields which are starved of dung or water the yields are low. Partly too they are the result of centuries of selection of strains with the desirable characteristics of fast growth, early ripening and high yield. The wheat ear has awns unlike most European wheats, and some of the barleys have very large awns which contribute significantly to photosynthesis. The barleys have naked grains which make them easier to thresh, and because they have six rows of spikelets instead of the two usual in Europe the number of grains per ear is

Table 5. CROP VARIETIES GROWN IN ZANSKAR

Zanskari name			
Phonetic	**Translit.**	**Meaning**	**Description**
BARLEY			
Ne-nak (Lad. *naknas*)	*nag-nas*	Black barley	Black or purple grains. Very hardy but not liked.
Che-ne (Lad. *chunas; chu-nas*)	*lci-gnas*	Heavy barley Long thick awns. Hardy.	Grey plump grains. Good for beer.
{*Yang-ma*	*(g)yang-ma*	Early ripening	Yellow grains, short
{*Yang-kar*	*(g)yang-dkar*	White wealth	awns. General purpose.
Ser-mo	*gser-mo* (?)	Yellow mother	Best quality yellow grains. Less hardy. Long awns.
Trug-zur	*drug-zur*	Six-cornered	Yellow grains. Dense short awns.
WHEAT			
Tro-chen	*gro-chen*	Big wheat	Awned. Less hardy.
Tro-chung	*gro-chung*	Small wheat	,, More hardy.
PEAS			
Sren-mar	*sran-dmar*		Small, black or olive streaked.
ALFAFA, LUCERNE			
Buk-suk (Lad. *'o*l)	bug-sug		Grown for forage
'MUSTARD', RAPE-SEED			
Nyus-kara,	*yungs-dkar*		Formerly grown for oil.
BUCKWHEAT			
tra-wo	*bra-wo/gra'o*		Fast growing. Seldom grown.

Table 6. CROP YIELDS IN TONNES/HECTARE

A. Average yields				
ZANSKAR	**alt.**	**Yield**	**Crop**	
Tongde	3900m	4 t/ha	Barley and wheat	(O)
Padum	3900m	3.5	Barley	(1)
Padum	3900m	2.5	Barley and wheat	(2)
Karsha	3900m	3	Barley and wheat	(2)
Shade	4500m	5	Barley continuous)	(O)
Tongde	3900m	0.5	Peas	(O)
ENGLAND				
1935-45		2	Winter wheat	
1984		7	Winter wheat	
1984		5	Spring barley	
1984		1	Peas	
Rothamsted, 100 years		1	Barley. No manure or fertiliser.	(3)
continuous cropping.)		5	Barley. 35t/ha/yr animal manure	(3)
N.AMERICA & CANADA		2	Barley and wheat	
INDIA & AFRICA		1	Barley and wheat	
B. Maximum yields on small plots				
ZANSKAR				
Tongde	3900m	8	Wheat	(O)
Shade	4500m	11	Barley	(O)
TIBET				
Shigatse	3900m	13	Winter wheat	(4)
Lhasa	3700m	9	Spring barley	(4)

REFERENCES: (O) Crook & Osmaston 1994 (1) Chalmers & Ramm 1984 (2) Crowden 1977 (3) Rothamsted 1966, Warren & Johnston 1967 (4) Li Ji-you

high, so that ear and plant population densities can be low. The quality of the grain is uniformly excellent, with a high specific weight, which contributes to the high yields. Some figures for the maximum yields of sampled parts of fields in Zanskar are also given, together with yields from experimental plots at Shigatse, Tibet, all of which are very high and show the potential of these crops under optimum conditions.

THE INTEGRATED SYSTEM: Fig.1 page 36

Besides the direct operational interdependence of the agricultural and pastoral sectors described above, there is an equally important concealed interdependence based on the cycling of nutrients and the maintenance of fertility. In all agricultural systems, crop yields are controlled primarily by plant nutrient levels in the soil, and hence in the long term by the balance between supply and removal of essential nutrients. Since the largest factor in removal is usually the produce of the crop, yields tend to stabilise at a value where supply equals removal. In developed Western agriculture, large supplies of inorganic fertilisers are provided which permit continuous removal of high yields. In primitive agriculture, inputs may be limited to the slow decomposition of soil particles, so output is correspondingly low and it may even be uneconomic to grow a crop every year. In intermediate cases many strategies are followed to boost supply or minimise removal and in Zanskar several of these are successfully employed.

The collection of cattle dung from the mountain pastures is not only a fuel-gathering process but also a fertiliser-gathering process, since the ashes are eventually spread on the fields with the rest of the household waste. This primarily represents a source of potash and a little phosphate, since nitrogen and sulphur will be volatilised in the fire. Some naturally dissolved salts are applied in the irrigation water, especially lime, and the deposition of fresh silt from glacier melt-water is a continuing source of fresh, unweathered minerals.

The main emphasis, however, is on the prevention of losses. The residues of all the crops consumed by both man and animals are returned to the fields in the form of night-soil and manure, so that losses from this primary cycle are quite low. Even in the case of nitrogen, where losses are most likely from manure, these are minimised by the cold dry conditions which rapidly stop decomposition. Some losses from the fields by leaching are inevitable, because if irrigation is reduced to try to prevent them, the worse evil of salination is likely. However they can be minimised by avoiding over-irrigation and where water is short there is every incentive to do this.

Nitrogen presents a particularly interesting problem. All the night-soil and stable manure represent only recycled nitrogen and some other source is needed to make good the small but inevitable losses. In the lower villages the inclusion of peas, which have nitrogen-fixing nodules, in the rotation is the obvious answer, but at Shade barley is cropped continuously, year after year, with no leguminous crop, nor fallow with leguminous weeds. I am told that at some villages in the Indus Valley too, farmers similarly crop continuous barley, or at lower altitudes continuous wheat.

It is known that in S.E. Asia the high productivity of irrigated rice is maintained by the fixation of nitrogen by blue-green algae in the flooded fields. Fields in Zanskar only have surface water for an hour or so each week, but recently it has been realised that the yields still obtained at Rothamsted Experimental Station, England, after over a century of continuous wheat or barley, must be partly attributable to the fixation of nitrogen by blue-green algae living in the soil of unirrigated fields (est. 15kg/ha/a). Presumably this may be occurring in Zanskar, though fixation may be halted during the six months of snow-cover and experiments to detect it elsewhere in Ladakh failed to do so.

The survival of a system of animal husbandry, which by conventional measures has a very low productivity, in conjunction with highly productive arable crops is at first sight a curious paradox. Why do the people bother to maintain the inefficient livestock sector? However, the success of the whole agricultural and pastoral system in Zanskar is largely due to its efficiency in conserving soil nutrients, and to the ability of the hardy local cattle to maintain the necessary inputs of draught-power and manure on a scanty diet. The livestock are essential for the crops, and for the supply of fuel without which the grain could not be cooked. Add to this the numerous dairy, textile, hide and meat by-products of the livestock and reasons for their maintenance become stronger still. Moreover it might be difficult to employ the main labour involved, that of the young girls, on other more productive work, so the labour cost is small. The cattle contribute to warmth in winter not only by their dung, but by occupying and warming the outer rooms of the house around the central living room of the family.

THE FUTURE

With such a closely integrated system, any social or technical changes may have unforeseen effects, and well-meant ideas to improve it need careful consideration. Some social changes are probably inevitable and desirable, such as the increase in opportunities for independent and non-celibate careers for younger brothers and for sisters, resulting in a rise in population which is already evident. However, if this is accompanied by strict enforcement of existing legislation governing the equal division of inherited property, this may lead to farm fragmentation and uneconomic holdings, as seen elsewhere in India. Although polyandry is already only a minority practice, it is unfortunate that imported concepts of marital morals should discourage such an economically sensible custom.

Technical innovations based on an inadequate understanding of a system are often advocated by "experts" trained in different circumstances. The low milk productivity of the local cattle naturally prompts recommendations to raise this by importation and use of expensive pedigree Jersey bulls. This firstly ignores the fact that butter production is less important than dung production, and it is certain that "improved" Jersey hybrids will be less hardy and less efficient producers of dung from mountain pastures; nor are the males likely to match the dzo for ploughing. Secondly that improvements in animal nutrition and husbandry could lead to great improvements in fertility, survival and production from existing genetic resources; once surplus female stock are available, farmers will be able to breed and cull selectively to improve their herds, which is impossible at present. Cattle numbers are limited by summer grazing as well as winter fodder. I suspect that the former are fully exploited (and possibly overgrazed), so a herd increase will depend on an increase of both summer and winter forage crops. However improved husbandry and faster growth should make it possible to raise productivity from the existing herd.

There are good opportunities for introducing a wider range of secondary crops, vegetables and trees, but in view of the data given above it is doubtful if large genetic improvements can be made in the staple food crops, though trials should certainly be made. The harvest index (ratio of grain: straw) is already good (45-50%) and in view of the importance of straw for fodder there is no great need to improve it. Improvements in husbandry appear to offer more scope, and the controversial questions of mechanisation and use of fertilisers immediately arise. These have important political and economic undertones; for instance the extent to which it is desirable for Zanskar to be dependent on subsidised imports from India that have to be brought over long rough roads and high passes, when already in the Indus valley imports of cheap grain from India are undercutting the prices regarded by local farmers as marginally profitable. There seems little point in mechanisation at present, but undoubtedly the use of nitrogen fertilisers could raise production. However, if it is in the form of ammonium sulphate (as it is at present) it could lead to serious leaching of other nutrients from some soils, and for this reason its use has mostly been abandoned in England. Because straw production limits the cattle stock that can be fed, while the cattle stock limits the area of cereal crops that can be harvested and adequately manured, productivity cannot be increased quickly from internal resources. Moderate use of fertilisers might enable production to be raised to a higher plane, but research is needed on the natural sources of nitrogen. If these are indeed blue-green algae, then it is important to know whether artificial nitrogen fertiliser has a depressing effect on them as it does on nitrogen fixation by clover.

The most important single measure to raise production to support an increasing population is the improvement of irrigation facilities, especially in villages where lack of water is already restricting the area cultivated. Losses by seepage from long leats are serious; already the government has subsidized the lining of a few with masonry, for example at Zangla, but more could be done. Some rather larger works are in hand, but progressing slowly: the construction of a small canal from the Sani River to irrigate a large area of the Padum plain; and the provision of another reservoir at Tongde. Besides growing more grain, increased irrigation could permit the growing of more alfafa both for conservation and direct feeding, which would make a big contribution to the standard of livestock nutrition and productivity.

Finally, apparently non-agricultural innovations could disrupt the system. Fig.1 shows that the most important single factor in the maintenance of soil nitrogen levels is the return of human excreta to the fields. The introduction of flush water-closets would break this link, apart from the serious problem of pollution to water-supplies that is likely to ensue. Before a policy is adopted of encouraging (or even permitting?) the installation of W.C's., the problems and direct costs of effective sewage disposal need to be considered, especially during winter when waterpipes and drains freeze and decomposition ceases. To this must be added the hidden costs of replacing the manurial value of human excreta by artificial fertilisers; even if the treatment process is designed to produce a sludge suitable for agricultural use, much of the nitrogen will be lost.

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KEY WORDS: Zanskar, Himalaya, agriculture, pastoralism, system, productivity, yak, dung-fuel, nutrient-cycling, development.

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RESUMÉ : Le paysage du Zanskar, rude et montagneux, s'étire entre 3500 et 7000 m. Le climat est semi aride en été, et très froid en hiver. Néanmoins les villages sont prospères. L'économie locale repose sur une combinaison d'agriculture intensive et irrigée au fond des vallées et d'élevage extensif de yaks et autres animaux sur les alpages. Les recoltes sont excellentes mais la production animale, entre autres en produits laitiers, est très pauvre. Cependant les fermiers ne peuvent pas se passer du bétail nécessaire au labourage, au battage des blés, à la production de bouse-combustible et à celle d'engrais naturels. Ainsi les secteurs agricoles et pastoraux sont totalement interdépendants et forment ensemble un système actuellement très productif, mais sensible aux aléas de l'évolution sociale et économique.

ABSTRACT: Although Zanskar has a rugged mountainous landscape lying between 3500 and 7000 m, which is semi-arid in summer and bitterly cold in winter, it supports prosperous farming villages. The farming is based on a combination of intensive irrigated cultivation in the valley bottoms, with the extensive grazing of yak and other livestock on the mountain slopes. The grain yields are excellent, but the production of livestock and dairy products is very low. However the farmers cannot dispense with the cattle because they are essential for ploughing, threshing, the production of dung-fuel and the maintenance of soil fertility. Thus the agricultural and pastoral sectors are closely interdependent and together they form a productive and hitherto stable integrated system, which may however be sensitive to changes associated with social and economic development.

ZUSAMMENFASSUNG: Zanskar, eine wilde Landschaft zwischen 3500 und 7000m.üMh, ist im Sommer halbtrocken, im Winter bitter kalt, unterstützt aber wohlhabende Bauerndorfer. Die Landwirtschaft basiert auf einer Kombination von intensivem Ackerbau in den Talgrunden und extensiver Weidekultur durch Yak und anderem Vieh auf den Berghangen. Die Getreideernten sind hervorragend, die Produktion an Vieh und Milchprodukten dagegen sehr niedrig. Die Bauern können aber ohne Rindvieh nicht existieren, da es für Pflugen, Dreschen, die Produktion von Dungbrennstoff und zur Aufrechterhaltung der Fruchtbarkeit des Bodens notwendig ist. So sind Ackerbau und Weidekultur dicht voneinander abhängig, und sie bilden zusammen ein produktives und bisjetzt stabiles System, das aber gegen Änderungen, die mit sozialen und ökonomischen Entwicklungen zusammenhangen, sensitiv sein kann.