POPULATION GROWTH, AGRICULTURAL CHANGE, AND NATURAL RESOURCE TRANSITION:
Pastoralism Amidst the Agricultural Economy of Gujarat

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INTRODUCTION

Dr Amrita Patel, Managing Director of India's National Dairy Development Board (NDDB), stated in her keynote address[6] that 'in the coming decade, it is the goal of NDDB that all livestock be removed from degraded *gauchar* (common) lands, to convert small producer dairy herds to completely stall-fed enterprises'. These words express the hopes of an environmentally-conscious leader of cooperative dairy development who understands that village common lands in India, needed desperately for rural water catchment and firewood production, are currently unable to sustain the intense grazing pressures to which most are submitted. Unfortunately, in the state of Gujarat, the very heart of Indian dairy cooperative success, there is presently little hope of reducing grazing pressure on commons, regardless of NDDB's efforts to promote composite feeds and zero grazing. Reduced to a fraction of their former area, and depleted of their most palatable vegetation, Gujarat's common lands are utilised by small ruminant pastoralists who can neither afford commercial feeds, nor can aspire to productive dairying. Nonetheless, these pastoralists, and their goats, sheep, and the manure they produce, are vital to the state's agricultural economy.

How did a pastoral production system arise focused primarily on wastes, rather than products? It is our thesis that it evolved among pastoral groups in the context of rural human population growth and agricultural change. Thus, the objectives of this paper are to introduce the reader to the topic of pastoral adaptation in Gujarat, and to provide a conceptual model of aspects of its evolution. To address these objectives, we offer a 'Boserupian' theory of human population growth and natural resource change, characterise the principal patterns of migratory pastoral production in Gujarat, and comment on the future for pastoral development given the state of theoretical and empirical knowledge.

CHANGE IN RURAL GUJARAT

By global standards, Gujarat is densely populated (210 people/km^2) and its rural population, which was 66% of the state figure in 1991, has increased by >15% over the past decade. Although when measured in gross cropped area per rural inhabitant, Gujarat remains among the least densely populated of Indian states,

[6]At the Indian National Conference of Composite Feed Producers held December 1991 in Anand, Gujarat.

Thus, pastoralists, whose population and demand for resources are also growing, must eventually adjust their production practices to deal with the increased risk of forage shortage as available rangelands shrink, and the ratio of livestock to forage vegetation increases (i.e. as 'grazing fallow' decreases, using Boserup's terminology). In fact, forage scarcities increase in frequency of occurrence as the amount of forage consumption by livestock surpasses the natural thresholds of local ecosystems, promoting a spiral of change that:

- reduces litter accumulation;
- alters surface-soil structure and plant composition;
- reduces the presence of leafy, high-quality forage plants and promotes plants that sequester nutrients in armed and toxic parts;
- reduces total plant cover; and
- can eventually lead to soil loss (see Archer and Smeins 1991, see Thurow 1991).

Pastoral responses to decline in natural forage sources may then manifest themselves as:

1) changes in herd migration patterns (see e.g. Leybourne et al. 1993, Cincotta et al. 1992);
2) increased utilisation of small ruminants, which are selective feeders capable of adapting to armed and toxic forage plants (see Provenza and Balph 1990, see Provenza and Cincotta 1993);
3) entrance into rural or urban labour markets (e.g., Chen 1991);
4) increased utilisation of forage available on agricultural lands (crop residues and fallow weeds), i.e. agropastoralism (Leybourne et al. 1993); or
5) by combining, to some degree, these responses (Cincotta and Pangare 1993).

In Boserup's theory of agricultural change, both technological enhancements of cropping practices and the escalating demand for farm labour per land area, are driven directly by a reduced ability to take advantage of the natural restorative processes of long-fallows i.e. carbon (C) and nitrogen (N) fixation, and plant material decomposition. In an ecological sense, the resultant intensified cropping translates to more rapid consumption of soil nutrients from the available pool, and a demand for elevated rates of nutrient cycling (especially of N) or nutrient import. Thus, rural population growth indirectly creates a demand for livestock as rapid cyclers of nutrients (Powell and Williams 1992, Powell and Ikpe 1992, Cincotta and Pangare 1992). At least initially, intensified cropping supplies both an abundance of seasonal crop residues and a demand for manure, the nexus for agropastoral relationships that allow pastoralists to successfully raise livestock (including milch animals) even as the natural grazing land area per livestock unit decreases. Notably, this demand can also be met through methods of nutrient import, such as mulching of natural materials or application of industrially-produced chemical fertilisers.

Meanwhile population growth both rural and urban, drives up demand for animal products per unit land area, especially when assisted by dairy sector development and transport. Technologically intensified milk-production, such as that practised with improved dairy breeds of cattle and buffalo, produces an elevated demand for digestible forage energy and nutrients (high forage quality) per ruminant animal (see Van Soest 1982). At this juncture in agricultural change, the development of farmer-owned, large-ruminant milk production takes on a separate theoretical significance: it undermines agropastoral production relations. With improved dairy cattle, farmers can turn high profits by feeding on-farm fodder and high quality residues (e.g. groundnut leaves) to their own livestock. Pastoralists, their common forage resources quantitatively depleted, their access to forage now limited by customary and institutionalised tenurial exclusion from cultivated land, are left to bargain for low-quality (relatively low rumen digestibility, low N content) crop residues as the only remaining locally-abundant source of rumen-fermentable carbohydrates. However, this supply of vegetable carbon must be supplemented with nitrogen for ruminant digestion, growth, and production and the only accessible source of nitrogenous forages for pastoralists' animals remains on common grazing lands. Where common grazing land is scarce, and difficult to manage because of a large number of users who maintain customary access, residual overgrazed vegetation types tend to be dominated by thorny, sprawling, and toxic species resistant to grazing.

Faced with such a lack of production options, agropastoralists are left with three strategies for utilising their knowledge of livestock:

1) sell their services as livestock keepers for farmer-owned herds;
2) buy imported high quality feed (which must be continuously available at prices that provide a sufficient margin of milk profit); and
3) switch to small ruminant (goat, sheep) production.

The latter strategy is viable because small ruminants are well suited for the grazing conditions of degraded commons. Goats and sheep are selective feeders, and thus capable of learning to choose nutritious vegetation among an array of defensive plant parts (Provenza and Balph 1990). These behavioral traits are more conducive to animal survival, health, and production on degraded grazing land than are the bulk feeding capabilities of larger ruminants (cattle, buffalo). This theory suggests that, with quality biomass production confined principally to croplands, with common land degraded, and subsidised chemical fertilisers available, farmers can clearly obtain the economic 'upper hand' in the latter stages of rural land conversion.

this parameter of agricultural intensity decreased rapidly, by 30% (to 0.54 ha/rural inhabitant) from 1961 to 1980 (Vosti and Lipton 1991). In fact, the figure will continue to decline as rural population grows and cropped area levels off.

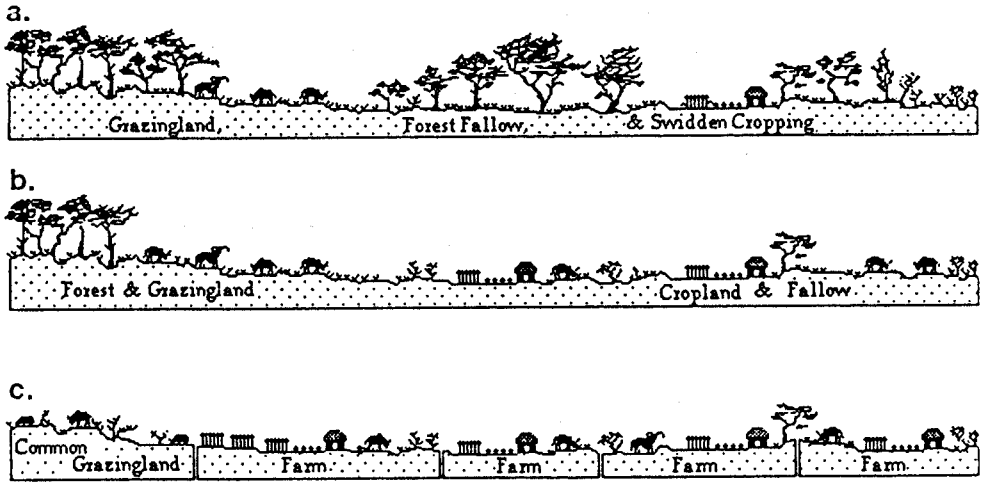
In Gujarat, agricultural expansion has been hastened by the dissolution of common land, a political response to both inequity and high rural human population density. In the 1950s and 1960s, under a wave of state government-supported land reforms known as the Bhoodan Movement (see Chen 1991), village common lands were ceded principally to low caste landless residents (many of whom later lost that land, see Jodha 1989). Initiatives to subdivide and redistribute existing farmland were generally avoided as rural density was already high, and agricultural holdings were already relatively small (Jodha 1989). In Saurashtra, the south central region of Gujarat, the vast majority of village common land was converted to (generally marginal) cropland, and permanent pastures were reduced to less than 20% (7.5% of registered land area) of its level at independence (Abdi 1992). Within a decade, pastoral populations, who were obtaining the totality of their animals' diets from rangeland forage during most of the year, came to depend on agricultural residues and short agricultural fallow for livestock feed (Gadgil and Guha 1992).

THEORY: CONCEPTUALISING PASTORAL CHANGE IN GUJARAT

The history of pastoral adaptation in Gujarat provides evidence of an 'untold' complement to Boserup's theory of human population growth and agricultural change. At the core of Boserup's theory (Boserup 1965) is the assumption that any uncultivated arable land, whether at early stages of plant succession following recent cultivation or covered in natural vegetation at late stages of succession, should be regarded as 'fallow': land upon which there is a natural positive accumulation and storage of nutrients for plant growth. Boserup's theory of agricultural change proposes that increases in local rural population density eventually force agricultural households to adopt regimes of shortened fallows (i.e. higher frequencies of cropping and higher ratios of cultivated to uncultivated land) which stimulate an increased use of production-augmenting agricultural technologies.

The history of Gujarati pastoralism suggests the need for a complementary theory focused on the natural resource user, rather than the farmer. Such a theory proposes that as short-rotation farming takes over forest and fallow land, rural producers relying on natural resources, such as pastoralists (but also wood-cutters, hunters and various natural resource gatherers), are also forced to reduce the length of their 'fallow' period by harvesting renewable natural resources from a rapidly decreasing land base at an escalating frequency (see Fig.1).

Fig. 1: **An intuitive successional model of land-use change (after Boserup 1965). As agriculture intensifies, from swidden farming (1a) to demarcated holdings completely occupied by continuous cropping (to 1b, and then 1c), land reserved for natural resource harvesting (i.e., grazing, wood cutting, gathering, hunting) is eliminated. Simultaneously, intensification leaves farmers with insufficient fallow to dedicate to necessary environmental services, including nutrient import and cycling, both facilitated by livestock. If common grazing land remains intact after continuous cropping is assumed, livestock can import nutrients from afar.**



Whereas economists may assume that pastoralists would switch to cropping with the loss of accessible forest and rangeland, in this complementary theory we propose a non-equilibrium solution. A variety of socio-economic forces exist that maintain modes of natural resource production or slow occupational transition. These include:

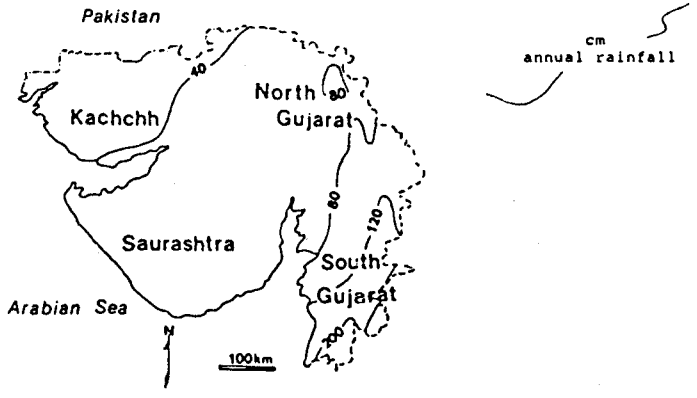
- the transition costs of switching from one set of knowledge and skills to another;
- religious and cultural traditions that tie households to their mode of natural resource production; and
- institutionalised impediments to transition such as obstacles to acquisition of land title and credit.

EMPIRICAL EVIDENCE: REVIEWING PASTORAL PRODUCTION IN GUJARAT

Remnant grassland pastoralism in the Banni

The Banni Grassland in Kachchh District (Fig. 2), an area less than 2500 km^2, is Gujarat's only remaining semi-arid natural grassland, representing a very small remnant of what was once an expansive rangeland production system.

Fig. 2. Map of Gujarat, in western India, showing its four regions.



Although the Banni is administratively protected as grazing land, soils are poorly drained and saline, and thus are generally beyond the margin of profitable crop production. Whereas the introduction of cooperative dairy development is responsible for major improvements in milk production and collection, infrastructure and services in the 46 Banni villages remain poor (Bharara 1993). Flooding during the monsoon isolates the Banni from mainland Gujarat.

The principal inhabitants of the Banni (population about 20 000 in 1987) belong to Sindhi Muslim and Rebari communities engaged in raising and breeding large ruminants (cattle and buffalo). About 10% of households herd non-lactating cattle and buffalos owned by non-residents. These livestock are

brought into Kachchh from several regions: from surrounding farming villages in Kachchh, from Rajasthan to the north, and from as far away as Bombay.

Since the 1950s, the Banni has experienced major changes that have largely degraded the quantity, composition and productive potential of its plant populations, having serious repercussions on livestock production. While significant proportions of the Banni were reported to be covered in open savanna in the 1950s, most native trees, and associated native shrubs, forbs and grasses, have disappeared. The compounding influence of climate, grazing, and the introduction of non-native plants have wrought irreversible changes to its plant composition. Loss of plant cover, deteriorated soil structure, and the construction of check dams in Kachchh, used to control flooding and provide drinking water, have curtailed the natural movement of detritus and silt that periodically brought fertility to the Banni (Saxena 1993). Sea water ingress has affected the coastal areas, resulting in loss of vegetation and the abandonment of six villages (Bharara 1993). During 1960-61, following a drought which left pastoralists low on forage and promoted a lack of stability on Banni soils, government foresters introduced mesquite (*Prosopis juliflora*) which spread throughout Kachchh District via the ingestion of its fruit (a pod) by cattle, and the distribution of its scarified seed in faeces. While government forage balance sheets often indicate that Kachchh produces a surplus of forage, Singh et al. (1993) suggest that rangeland forage supply is usually overestimated due to failures to correct for degradation within native vegetation types over the past three decades.

During a 1983 census, there were 9600 cattle and 17 800 buffalos grazing the Banni. In good rainfall years, it has been estimated that over 20 000 small ruminants, principally sheep, are brought into this region from Rajasthan to graze, as well (Bharara 1993). During four consecutive years of regional drought, from 1986-89, large numbers of cattle and migrating small ruminants virtually eliminated many of the scattered pockets of vegetation that remained in Banni. However, the prolonged length of the drought finally resulted in massive livestock die-offs and a general out-migration of cattle during that period (often to South Gujarat, distances of up to 800km; Bharara 1993). Whereas native grasses comprised 8% of ground cover (5 t/ha dried forage) before the drought period (Saxena 1993); studies show that these same species have yet to recover, constituting only 1.5-3.5% of ground cover (0.5 t/ha).

Today, livestock production on the Banni is principally maintained by free grazing among depleted sources of grasses, sedges, and forbs, on the leaves of *Suaeda fruticosa* (a native salt-tolerant tree species), and on the pods and seeds of *Prosopis juliflora* which pastoralists often collect and boil before feeding. During and following the monsoon seasons, livestock are grazed within the Banni, moving between man-made wells and tanks in which freshwater has been trapped during the rains. During the dry season, cattle are moved outside Kachchh District.

Agropastoralism in Gujarat

Galaty's (1992) fear of the impending 'nightmare of landless pastoralism' has, over the past four decades, become a fact of life for Bharwad and Rebari peoples, the principal ethnic/caste groups involved in Gujarati pastoralism. The Bharwads, the largest pastoral group in Gujarat, have historically been associated with grazing grasslands and savannas in Saurashtra, a relatively dry region of the state (400-1000mm annual rainfall). However, with the demise of open grazing land as advancements have been made in dryland agricultural techniques, tube-well technologies, and dam irrigation, these people have (largely since national independence, 1947) settled into hundreds of rural villages throughout north and south Gujarat, the prime agricultural regions of the state.

State land-distribution policies have, in general, negatively affected pastoral access to land. Today, the only remaining common property grazing lands surrounding most villages of Saurashtra are river banks below flood line, hedges that surround fields, the sides of public roads and paths, and severely eroded shrub land.

Studies of Bharwad pastoralists (Cincotta and Pangare 1993, Rangnekar 1993, Chen 1991) are illustrative of the changing condition of pastoral production in Gujarat. In interviews with village Bharwads and farmers in villages near Rajkot District in Saurashtra (Cincotta and Pangare in press) respondents suggested that the increased consumption of high-quality crop residue by farmer-owned improved dairy cattle has drastically decreased the supply of nutritious fodder on the local market. This demand has increased local feed prices, making it virtually impossible for village marginal farmers and landless pastoralists to operate in the dairy business. While some Saurashtran pastoral groups appear to traditionally favour sheep husbandry e.g. Motabhai Bharwads, others have adapted to a recent dependence on low quality farm residues by shifting herd composition towards sheep and goats, and marketing manure and wool: animal products that are less nutritionally demanding than milk.

Analyses of economic returns from crop residues suggests that a farmer's benefits from these by-products can be optimised through a mixed strategy (Cincotta and Pangare in press) i.e. by feeding the most digestible, most protein-rich forages to on-farm dairy cattle, and leaving low quality residues for pastoral small ruminants (Fig. 3). Although cooperative dairy managers have tended to believe that additional milch cattle could be maintained at low levels of production if farmers used their 'free source' of low quality residues for feed (Aneja pers. comm.), they failed to account for the fact that low-digestibility feed suppresses forage intake per ruminant animal, as well as production per unit intake. In fact, farm households can best use the increased capacity of the

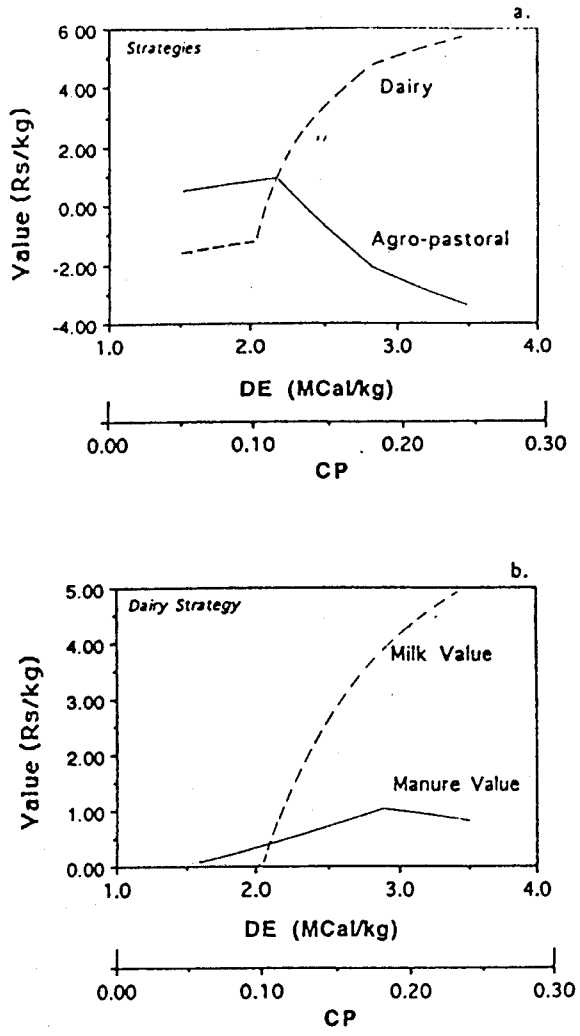


Fig. 3:
Modelled economic returns for farmer strategies of crop-residue use in Sarapdad, Rajkot District, Gujarat (after Cincotta and Pangare, *in press*). Graphs show values of strategies inclusive of opportunity costs, expressed in Indian Rupees (Rs.) per kg feed. Values of strategies are calculated along a feed gradient of both digestible energy (DE) and crude protein (CP), which have been increased simultaneously. Farmers have the option (shown in 3a) to either feed on-farm residue to their own milk cow, or to trade the residue to small ruminant pastoralists for manure, and purchase good quality residues (groundnut hay) for their milk cows. The relationships between components of the on-farm fed dairy strategy and agropastoral strategy (3b) suggest reasons why the strategies show different returns at opposite ends of the forage quality gradient.

'animal production capital' (i.e. the improved dairy cattle in which they have recently invested) by providing these animals with high quality feeds, even when feed must be purchased at relatively high prices. It is most profitable to feed low quality residues, such as wheat and millet straws, to pastoral herds in return for manure, a practice that will likely continue to be profitable as fertiliser subsidies are cut in India. Wherever pastoralists reside, either in permanent village residences or in temporary camps, small ruminants are corralled, manure is collected at central distribution points and traded to farmers by the cartload. Farmers also hire pastoralists to confine pastoral small ruminants within small areas of cropland over night, in order to concentrate faeces and urine on their cropland[7]. Temporary enclosures of steel rods and rope net, designed specifically for this purpose, are now becoming widely used.

Pastoralists generally trade goat and sheep manure to farmers for a variety of commodities and privileges, in nearly every possible combination (Kavoori no date). Returns from manure include payments in cut crop residue feeds; access to standing residues, fallow weeds and water sources; foodstuffs for human consumption; and cash. In South Gujarat, informants described negotiations between Bharwads and a *panchayat* (local government) in which the *panchayat* offered a group of Bharwads common land on which to build houses at the edge of a village, conditional upon the payment of an annual rent in manure. In Rajkot District, Bharwads sell their own labour for forage and cash, although Bharwads of other areas are often reluctant to participate in the agricultural labour market (see Chen 1991). Although we observed several Bharwad families who contributed milk to the local cooperative, these producers complained of low returns. Small ruminant milk production, both because of the low overall quality of available feed and the low dairy fat production (a parameter upon which milk is priced by cooperatives, George 1985) characteristic of native breeds (around 3% milk fat), is not particularly profitable (Cincotta and Pangare 1993); though certainly an important subsistence product (see Ahuja and Rathore 1987).

As is the case in other agropastoral systems, there is a net export of nitrogen (N) from common sources onto cropland (Powell and Williams 1992). Because of the low crude protein (CP) content of the straws (<4.5%) that make up 30-40% of the small ruminant diet in this system, we estimate that around 80% of the digestible N necessary to maintain these animals (assuming 6-8% dietary CP for rumen maintenance) originates from grazing rather than residue feeds. In a study area near Sarapdad, in Rajkot District, Cincotta and Pangare (in press)

[7]Similar relationships exist between farmers and pastoralists in many regions of India. On cropland in Maharashtra, we have personally observed Dungar pastoralists retaining about three hundred sheep and goats within rope enclosures of 10 by 5 metres.

found Bharwad pastoralists keeping small ruminants within pens until late in the morning, between 9.30 and 10.30am, to return in the early evening, around 6.00pm (~8 hours). Interviewed pastoralists explained that they were trying to capture the most they could from the faecal output of their sheep, without negatively affecting herd reproduction and health. Thus, assuming constant faecal output, at least 67% of faecal N is destined for cropland[8].

Although small ruminant pastoralists in this position seem precariously dependent on their ability to trade manure for crop residue, the proliferation of irrigation schemes and increase in cropping frequency have actually augmented demand for manure in Gujarat (Rangnekar 1993). A survey of Bharwads in Rajkot District suggested that larger herds, generally those of over 100 animals (see Fig. 4), are regularly taken on migration during dry seasons of normal

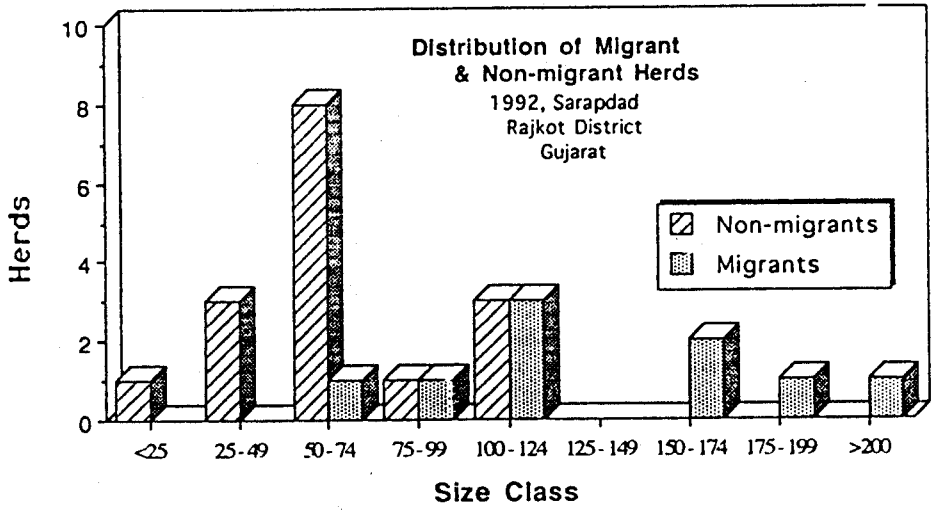


Fig. 4: **Size distribution of migrant and non-migrant small ruminant herds among a group of Bharwad pastoralists in a rain-fed agricultural area in Saurashtra. Larger herds (>100 animals) appear more likely to migrate during the dry season (after Cincotta and Pangare *in press*).**

[8] In addition there is the faecal and urine N deposited on cropland while grazing crop fallow and when penned in fields overnight. The frequency of these activities varies seasonally and between pastoral herds.

rainfall years (Cincotta and Pangare 1992a, in press). According to interviewed pastoralists, households with large herds migrate from dry season village residences to irrigation projects in the north in response to:

1) the economy of scale inherent in manuring irrigated cropland, a service remunerated on a per animal basis; and
2) the diseconomies of scale involved in remaining in a non-irrigated village, where herders must provide scarce forage and water using a fixed household labour supply.

On average, the local veterinarian's survey showed that around 25% of pastoralist-owned sheep and goats migrated to irrigated areas during the dry season.

Other Pastoral Systems in Gujarat

Certain Gujarati pastoral populations, including local populations of Bharwads (Salzman 1988[9]) and Rebaris (Seth 1990[10]) have depended, sometimes completely, on forest grazing. Renewed interest in forest protection, afforestation and conservation of wildlife habitat has made it difficult for these pastoralists to maintain their livelihood. Many pastoralists who depended upon these few remaining forests have been resettled, granted title to revenue lands, and have taken to farming on afforesting village common lands. Nonetheless, grazing of afforested plots and reserve forests, especially by migrating pastoralists, is still considered to be a significant impediment to the sustainable management of remnant forests in Gujarat.

In Gir Forest, a forest remnant containing the last known population of Asian lions, local Rebaris have raised buffalo (which herders claim to be the only livestock capable of defending themselves against these predators). In the interest of protecting forest regrowth and the re-establishment of native herbivorous wildlife, the Forest Department has attempted to settle Rebaris on surrounding deforested lands. The Aga Khan Rural Support Project (India) has provided sustained technical assistance and training to the resettled pastoral community in agriculture, intensive livestock production, water catchment, and tree planting (Seth 1990).

[9]Salzman analysed a case of voluntary settlement of landless Bharwad cattle-keepers who took up residence in Surat, South Gujarat, and whose settlement was facilitated by their organisation as a cooperative dairy society supplying milk to Surat Milk-Producers Union, Ltd. (Sumul).

[10]Seth describes a case where Maldharis within the Gir Forest (a wildlife sanctuary) in Saurashtra were persuaded to relocate outside the forest boundary and take up farming activities. Their conversion to farmers, and their management and reclamation of community property was aided by a community-based self-help programme supported by the Aga Khan Rural Support Group, India (AKRSP-I).

Another group, the Banjara pastoralists, who principally herd donkeys, are most often associated with urban construction sites, where they rent their animals and herding services to haul building materials. Banjaras set up campsites along roadsides and on vacant lots within urban areas from which they rent their labour and that of their donkeys. Although there is little data available concerning Banjara pastoralists (D.V. Rangnekar 1993, S. Rangnekar 1993), it is worth noting that these pastoralists reside, at least intermittently, in nearly every urban centre in Gujarat. While the Banjara are principally donkey herders, families generally keep small herds of goats, cattle and buffalo for subsistence. Donkey herds are principally herded by adult women.

SUMMARY

In this analysis we have assumed that, to realistically consider the future of Gujarati pastoralism, one must work within a theoretical framework. To this end, we have asserted that a) Boserup's model of population growth and agricultural succession provides insight into empirical patterns of pastoral change under conditions of agricultural expansion, and b) it is most useful when the observational focus of the theory is switched from the farmer to the natural resource user. In this analysis, we have called attention to several differences between classical expectations of the theory when farmers are the principal focus, and expectations generated when pastoral interests and on-farm livestock intensification are considered. The differences are:

1) agricultural expansion generally constrains pastoralists to confine grazing (at least seasonally) to a smaller, more intensely-utilised set of vegetation;
2) privatisation of the commons by farmers precipitates a loss of pastoral control over the ecosystem capital (land, water sources, and vegetation) that provided inputs and options to their production system;
3) technological intensification of livestock production, which shunts the highest quality forages to on-farm livestock, further restricts pastoral access to forage nutrients.

Such differences are the result of:

1) the marginalised social and political position of pastoralists;
2) pastoral adaptability in the face of narrowing production options and lack of control over forage sources; and
3) the positive feedback process that impedes the ability of vegetation and soils in natural resource ecosystems to renew themselves as 'fallowed grassland' and pastoral livestock populations continue to survive and grow in an agricultural economy.

Whereas a decision tree is commonly generated to plot the path of options accessible to a decision-maker, our presentation of this graphical device is an historical dichotomous key (Fig. 5): the points of articulation representing

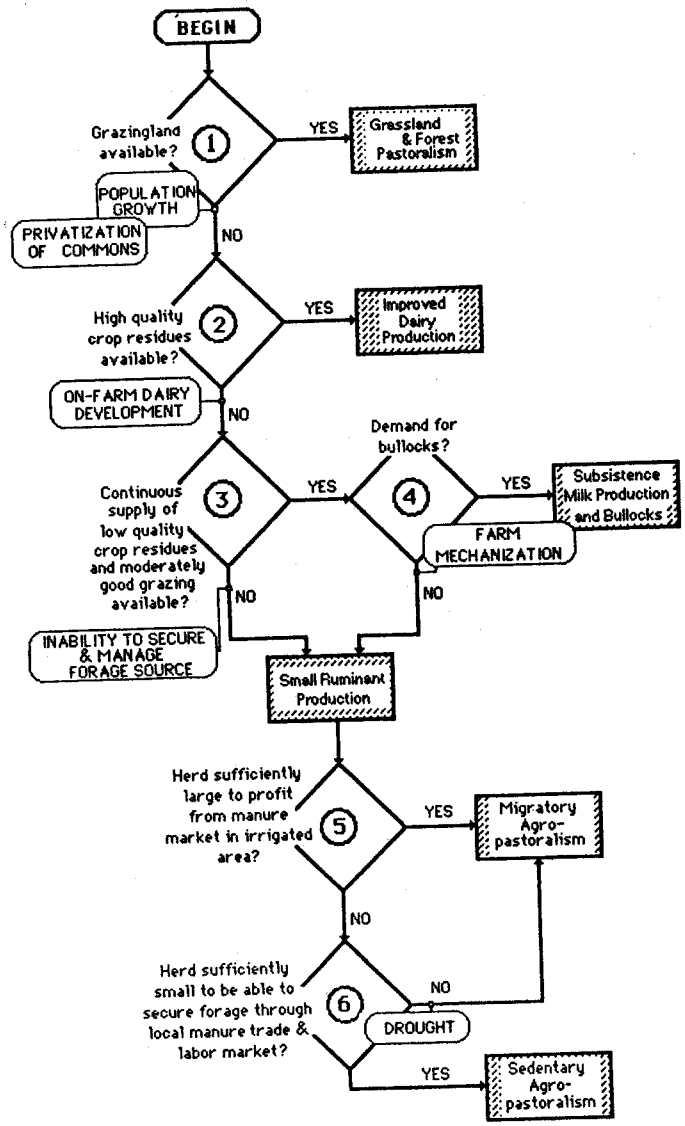


Fig. 5: Decision tree describing the historical evolution of constraints that have been imposed upon pastoralism, and the strategic adaptations to livestock raising within those constraints (after Cincotta and Pangare *in press*).

constraints in control over resources and capital that circumscribe systems of livestock production in Gujarat. An increasing number of pastoralists are, quite rapidly, being confined to the lower extremes of this decision tree, where constraints on resources are most numerous and difficult to alleviate.

The decision tree begins by acknowledging the historic conversion of common land to agriculture (Fig. 5, Decision 1) during this century. Grassland and forest pastoralism still exist in Gujarat, but only in the Banni Grasslands of Kachchh (Bharara 1987, 1993, Saxena 1993) and among small groups of forest graziers. Yet even these systems rely on crop residues during some parts of the dry season (Singh et al. 1993).

The next tier of constraints (Decision 2) is associated with the availability of an adequate and continuous supply of high quality forage for milk production, from grazing, on-farm or commercial sources. Deprived of high quality forage, milk production decreases rapidly and non-linearly because low forage quality results in both a decreased supply of nutrients per kg ingested, and suppresses total feed intake. However, (following the path of Decision 3 and 4) pastoralists have previously been able to use combinations of grazing and low quality residues to raise strong, slow growing bullocks (especially of the Kankrej breed) to be marketed for pulling and ploughing. While bullock raising continues among some ethnic/caste groups in Gujarat, especially in Kachchh (Mittal 1993), demand for high quality traction animals has substantially decreased with farm mechanisation (see Chen 1991).

For those pastoralists who cannot obtain continuous affordable supplies of good quality forage, small ruminant production is the only remaining pastoral option. Seasonal migration appears to be an economically viable activity for households with large herds (Decision 5), whereas smaller herds (Decision 6) are likely to be maintained in the local area unless drought forces migration (e.g. during the latter years of the 1986-89 drought). In Gujarat, future remittances and caste political protection for trade may prevent the loss of ownership of herds by pastoralists (especially during drought) and prevent the wholesale conversion to the herding of livestock for absentee owners, a trend seen among sub-Saharan and North African pastoral households (e.g., Galaty 1992, Little 1987, Utah State University 1986), as well as in the Banni Grasslands.

Of course, this simple graphical theory cannot explain the evolution of the many production scenarios manifested among pastoral communities in Gujarat, especially those influenced by the rapid growth of urban centres and industry. Banjara donkey pastoralists have historically worked their animals in trade and construction, and many will remain associated with small building sites and excavations. In addition, pastoral milk cooperatives are being successfully organised near urban centres around the purchase of affordable, manufactured, composite feeds (Salzman 1989), prepared largely from agribusiness industrial

residue such as cotton-seed meal. Perhaps more profound will be the long-term effects on village livestock husbandry by remittances from pastoral household members drawn to manufacturing jobs in the many urban centres of Gujarat.

However, the effect of the emergence of agricultural production for Gujarat's industries on pastoral livestock systems is also difficult to determine. Large scale shifts toward oil seed production and other non-food crops that leave crop residues that are unpalatable to livestock (such as tobacco) are predicted (Phansalkar and Pandey 1991), while percentages of area under the traditional food grains, jowar and bajra millet, have been drastically reduced (>65% in Saurashtra since independence).

Conclusion

In closing, we submit that the example of pastoral production systems in Gujarat is a general model for the evolution of similar systems that lie within the margin of technically-driven agricultural expansion, where there are impediments and lags to transitions, i.e. out-migration and non-pastoral employment. This model predicts the persistence of pastoral systems geared toward outputs that are not highly demanding of nutrients, such as manure and wool. The continued existence of commercially-viable, extensive livestock systems that are milk and meat-oriented (rather than manure-oriented) will depend largely on their ability to:

1) maintain grazing land beyond the political dominion of potential agricultural and urban users (e.g., Juul 1992);
2) limit their own human population or the population given use-rights to that resource; and
3) closely manage the frequency, timing, and location of livestock grazing; or
4) secure political or economic leverage over supplementary, good quality feeds and residues.

Examples where graziers have succeeded with a common land agenda, or have created successful institutions to do so, are few. Even in the US, where graziers (western ranchers) were instrumental in creating a system of institutionalised grazing access to federal rangelands under rules that limit users and control animal use (Liebecap 1981), the political priorities of environmental and urban constituencies are rapidly displacing those of the grazier.

The populations of most developing countries, which are rapidly urbanising, are predicted to more than double their 1992 levels and some will triple before 2025 according to the UN Population Divisions medium projection. The enormous pressures to increase intensive food production and to expand crop land (Brown 1994), to harvest water and provide recreation, will undoubtedly impinge upon pastoralists who are now near the margin of crop production defined by rainfall, temperature and soil conditions. For the pastoralist, the

world community has learned too late the connections between natural resource dependent livelihoods and the most fundamental problems of sustainability: land use politics, population growth, and economic growth and change.

What can social and natural scientists whose careers are invested in pastoral systems do about this trend? Probably very little. Ultimately, the production relationships of many pastoral peoples in energy and land-poor societies will be similar to that of pastoralists throughout Gujarat: their livelihood will be sustained through servicing agricultural systems as agents for rapid nutrient cycling and nutrient transport. Should we not, then, apply our energies to this problem? In the final tally, we believe that the concept of a sustainable, highly productive pastoralism is likely to prove as meaningless as most developing country governments already believe it is.

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