Ecological-Economic Analysis of Grassland Systems: Resource Dynamics and Management Challenges – Kachchh District (Gujarat)

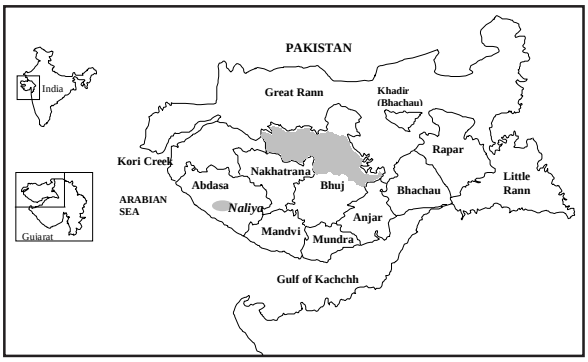
C.P.Geevan, Arun M. Dixit and C.S. Silori

Gujarat Institute of Desert Ecology
Bhuj (Kachchh)

Introduction

About 1,400 km^2 of the grasslands in Gujarat are administered by the State Forest Department and are known as vidis. Of the total vidis in the state, a large proportion (92%) is distributed in the semi-arid and arid regions of Saurashtra and Kachchh. About 44 percent of these are in the Kachchh district. Other than these vidis, there are also large grassland tracts that are open for free-grazing. A significantly large population of pastoral and agro-pastoral communities in these arid/semi-arid regions sustain their livelihoods based on free-grazing livestock. Most of the grasslands of Kachchh are in the Banni and the Naliya regions (Fig. 1). The grasslands are severely degraded through a combination of intensive grazing,

Fig. 1: Location of Study Areas in Kachchh District



changes in institutional arrangements, nature of property rights, illegal encroachments and invasion by the exotic woody species, *Prosopis juliflora*,[1] a mesquite native to South America. The area with the potential for grass cover in Banni is about 1,610 km^2, of which 80percent is at present invaded by the mesquite, leaving only about 350 km^2 with grass cover. Naliya represents a contiguous grassland tract of nearly 160 km^2.

Banni & Naliya Grasslands

Banni represents the case where grassland resources are crucial to the pastoral economy, while Naliya is a case where the biodiversity values are very high. Endangered wild animals like the Chinkara (Indian Gazelle) and Wolf extensively use Naliya, which is also one of the rare breeding areas for the three globally endangered species of bustards – Great Indian Bustard, Lesser Florican and the Houbara Bustard. The property and resource management regimes are in striking contrast in these two regions. The pastoral system dominates Banni, while agriculture is the mainstay of the rural economy in Naliya. Banni is also characterised by the absence of agriculture and non-existence of individual or collective village property rights. Most of the Naliya grasslands are government owned, and much of the village pastures or *gauchars* are also part of the grassland system.

Objectives

The major objectives of the study are to:

- Examine the dynamic links between the economic variables and grassland resources in a system dynamics framework
- Disaggregate income sources and distribution in the context of different kinds of resources

[1] *It is also known by the synonym Prosopis chilensis*

[2] *Adult Cattle Unit (ACU): Numbers of different types of livestock are converted into a uniform number – ACU, based on the biomass requirement, which is determined on the basis of body weight of animal. The conversion units are: One Adult Cattle = One ACU; One buffalo = 1.4 ACU; One sheep or goat = 0.25 ACU, One Camel = 1.4 ACU.*

- Understand the implications of various resource management scenarios on the economic returns and ecological conditions

Methodology

The study focuses on the grassland resource dynamics within an ecological economics perspective. Disaggregating income derived from the different sources and their association with the grassland resources is critical to establish the economic significance of these grasslands, especially in the context of arid and semi-arid tracts where pastoralism/ agro-pastoralism is still an important component of the rural economy. The overall goal of this study is to explore the possibilities for better management of grasslands as an ecological entity, and to study the economic ramifications of various options.

Sampling & Data Analysis

The ecological information was gathered from samples at every kilometre interval (146 sample points in Banni and 28 in Naliya). Several Focused Group Discussions, meetings with village elders and informal group discussions were also held to gather information. The random sample data covers approximately 20 percent of the population in the two study regions. The surveys covered 387 households from 13 out of 51 villages of Banni and 174 households from 9 villages of Naliya. However, for the analysis of data on various aspects, only those sub-samples (datasheets) were considered, which had complete information and were relevant to the theme. In the case of Banni, for example, only a sub-sample of 251 out of 387 had complete responses to the income related parameters, and migration related data was analysed with a sub-sample of 130 families. The relevant sample size is mentioned while describing the results through tables or graphs.

The statistical methods employed include minimum variance hierarchical clustering, various descriptive statistics, regression analysis – linear, non-linear and logit, analysis of means and decomposition analysis of incomes and inequalities. The inequality measure, CV2, was separated into weighted contribution from the components for the decomposition of inequality. Satellite remote sensing data was used to get a synoptic view of natural resources and to estimate the invasion of grassland by woody cover.

Modelling Resource Dynamics and Economic Returns

We have attempted to understand the dynamics of the ecological and economic linkages by a system dynamic modelling approach. The major steps in this effort are:

- Constructing an ecological model to capture the basics of ecological dynamics that is realistic enough to contain the 'core' ecological or resource degradation problem
- Using the ecological dynamics model to provide the constraints for the renewable resources – grass and wood that are determinants of income in the economic model
- Computer simulations to arrive at inferences on different modes of resource management and policy, based on appropriate choice of parameter values and constraints

Results

Banni Grassland

The available livestock census data for Banni region shows that the livestock numbers, which were about 35,000 in 1957, reached a peak of nearly 49,400 in 1982 and fell to about 30,000 in 1997. The lowest figure recorded in the census is about 25,000 in the 1977 census. The dominant occupation is of livestock rearing (65.4% of total families), followed by wage labour, most of which appears to be linked to illegal wood-charcoal making from the woody species. About 69 percent of those who possess cattle earned supplementary income from charcoal making, while the buffalo owning herders have almost exclusive dependence on livestock based economic activity. Among the major drought coping strategy is the reliance on scarcity relief programs (43.7%). Also, 53.5 percent of households sent their livestock to cattle camps run during drought periods. The tendency to migrate increases with herd size, and smaller herds are less likely to migrate.

- ***Income Decomposition***

The income sources in Banni can be split into livestock and non-livestock based incomes. Agriculture is non-existent due to the absence of the right to own land and the intrinsic difficulties for sustaining agriculture. The existence of a large pool of woody biomass has created a new non-livestock based income (NLBI) opportunity, albeit illegal under the current policy environment, which was almost non-existent till about 1960. The livestock based income (LBI) includes milk-based income, MBI (milk & milk products) and the proceeds from the sale of animals, wool and dung. The miscellaneous category represents all other incomes such as salaries, wages, handicrafts and other sources, such as transfers and trade. The *Prosopis juliflora* based income is disaggregated into returns from wood charcoal and that from non-timber produce (NTFP) such as honey and gum.

Mean annual gross income per household is about Rs.57,000 from livestock, while that NLBI is nearly Rs.23,500. Total extrapolated gross income per year in Banni works out to be about Rs.170 million (Table 1). The extrapolation is carried out by applying the proportion of households deriving incomes from the different sources would conform to the pattern that has emerged from this study. The largest share is from LBI (70.3%) with milk sales alone accounting for 63.6 percent. The share of woody resource based income is 16.3 percent, while sources other than those based on grass and wood account for 13.4 percent.

Table 1: Income from Major Sources in Banni

Source	Households*	Mean GAHI (Rs.)	Extrapolated# (Million Rs.)
Livestock	210	57,150	119
Non-Livestock (i.e., all others)	217	23,550	51
All sources	251	68,175	170

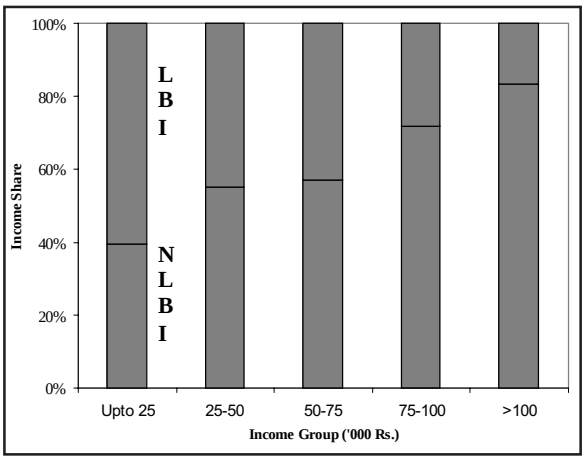
* There are, in general, multiple income streams for each household, and therefore the values in the column do not add up to those given as the total

Extrapolation to nearly 2,500 households (census 1991), based on the assumption that the proportion of households depending on the different resources conforms to the pattern reported here. The extrapolated income = *(total households of census data)**(proportion of households by source)*(mean GAHI by source).

Resource Dependency

The income distribution is highly skewed with 20 percent of families in the low-income group (0 to Rs. 25,000/yr) and 16 percent in the high-income group (above Rs. 1 lakh/year). The share from LBI is more in the richer households, while poorer families have heavy reliance on NLBI, derived mostly from Prosopis juliflora (Fig. 2).

Fig. 2: Income Share from LBI and NLBI



The inequality was much lower in the non-herder category than among herders, where there are very large differences (Table 2). Although a large part of the inequality within non-herders comes from woody resource, the disparity tends to get evened out by the income from other sources. The woody resource based income has only a negligible role in altering the overall inequality, which is determined by the dominant share of LBI in the total income. A buffalo herder is able to generate about 74 percent more net income than a cattle herder. It is also seen that there is significant dependence of the poorer herders and those without livestock on the woody resource, despite the illegal nature of this commercial activity. The analysis shows that the higher the non-livestock-based income, the less is the probability of a household to migrate.

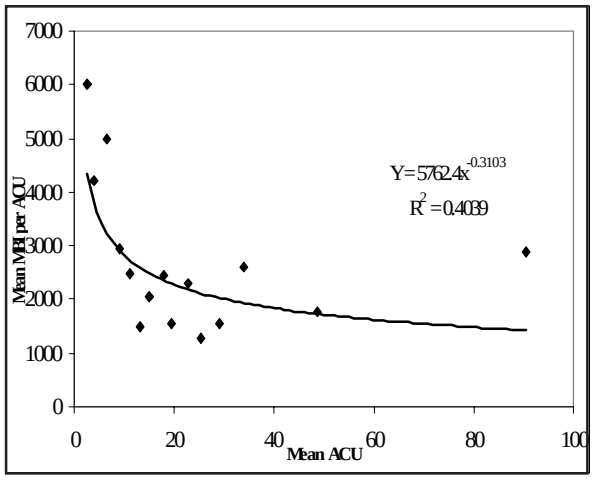
Table 2: Income Inequality- Herders vs. Non-herders

Parameters	Herders	Non-Herders	All Families
Mean GAHI (Rs.)	76,731	24,261	68,175
Gini Coefficient	0.44	0.35	0.46
CV^2	1.13	0.39	1.28

Returns per Animal and Open Access Resource

In order to analyse the pattern of LBI per Adult Cattle Unit[1] (ACU), we grouped the buffalo herds into various size classes, and then computed different parameters of income and herd size. The milk-based income (MBI) per animal turns out to be a slowly declining function of herd size (Fig. 3) that follows a power law function ($Y = a*X^b$, where the constants, $a>0$; $-1<b<0$) and the total return $X*Y$ will naturally increase with herd size. In other words,

Fig. 3: Relationship of herd Size and MBI in Buffalo Group



the utility per animal declined with the addition of one animal, if the asset value of an additional animal is not considered. Regression analysis also showed that the mean livestock maintenance cost per ACU also followed a similar power law function, declining with increasing herd size. The net return per unit maintenance cost obtained from these two is a slowly declining power law function, falling very slowly with herd size. The nature of this function implies that a strategy to maximise returns from grassland resources would be for each herder to go for larger herd size, which will yield greater incomes, even though the return per animal may decline with herd size. This is consistent with conditions of open access involving zero costs. It may also be noted that owning a larger herd amounts to possessing greater wealth as well as larger productive assets. A strategy to extract the maximum of freely available grass resource and the drive to increase assets will in combination give rise to a functional relationship that is revealed by the data. The declining power law function for MBI per animal naturally raises the question of the economy of scale in such an economy. As a corollary, it may also be inferred that the conventional economy of scale do not appear to be valid if we consider only a single output such as milk. However, if all the benefits are fully accounted for, the apparent diseconomy of scale may disappear.

- ***Dynamic Model of Resources Economics***

The resource dynamics were modelled using a system dynamics approach with three state variables:

- Livestock expressed in ACU
- The grazing potential or the maximum cattle that the rangeland can support
- The area invaded by woody species displacing grass cover

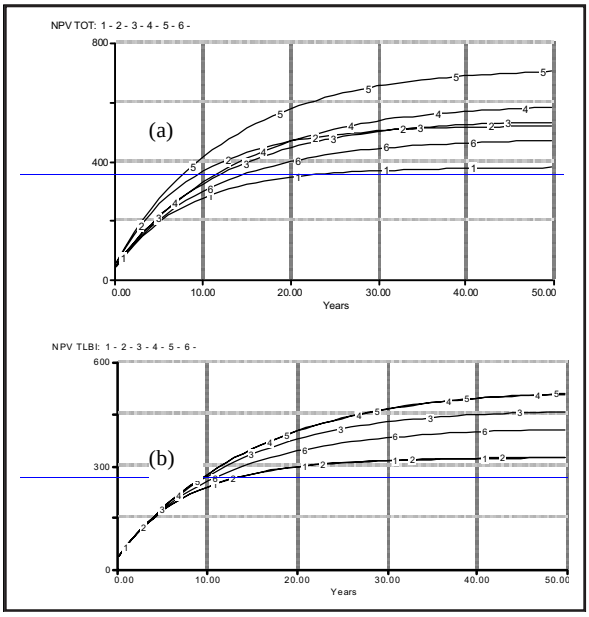
The grazing potential is treated as a state variable that varies both with time and stocking level, since stock of livestock alters the grazing potential.

The key elements for the specification of the dynamics of a pastoral-economy and ecology in this manner are:

- Current state of the variables such as herd size will affect the future rangeland carrying capacity.
- High degree of variance determines the evolution of the system and such variation randomises the trajectories of all variables over time.
- Very high degree of uncertainty that are attached to the future value of state variables.

The total area that can be covered by grass and woody species is constant, while the grazing potential is both a function of livestock levels and extent of woody invasion. The growth rates for livestock and the regeneration rates for grass were treated as normally distributed random variates to incorporate the stochastic effects of rainfall variability. The utility function includes returns from both grass and wood-based economic activity. The short and long-term fate of the grassland is assumed to be irrelevant to the utility maximising decisions of livestock owners. The Net Present

Fig. 4: Net Present Values of (a) Total and (b) LBI over a 50-year Period



Value (NPV) of various income streams and total income from all are computed over a 50-year time horizon assuming a discount rate of 10 percent. The parameter sensitivity analysis was also carried out to determine the response of the system when parameters are varied.

Computer simulations were carried out to examine different resource management scenarios. The Business-As-Usual (BAU) scenario, predictably leads to progressive decline of the grassland. The second case is one of removing all restrictions on wood charcoal making and opening up economic opportunities of the woody sector. This would naturally increase the incomes from woody resource, without making any significant change in the livestock sector, as can be seen from the comparison of Fig. 4(a) and 4(b). Scenario 3 represents the situation where there is a state sponsored effort for removal of woody areas, without attempting to put in place any institutional arrangements or resource management regimes that can check re-invasion of the areas cleared. This case will naturally increase the returns from the grasslands, without any substantial increase in earnings from woody resource. In the long-run, this does not change the fate of grasslands, since all of woody cover cannot be removed in a short period and at low rates of removal, there is enough woody cover left, which can invade the grassland areas. The 5th scenario is of considerable interest, because it envisages woody removal, change in policy environment to alter resource management regime to ensure that re-invasion is checked and legalizing wood charcoal making under a quota based system. The 6th scenario mimics the current efforts involving NGO's to regenerate small grassland plots, which can only lead to a marginal improvement from the current situation.

As it stands, major investments are not needed in the total removal of woody cover as all expenses can be recovered through the sale of wood charcoal in the same year with a net gain. Already 80 percent of grassland is invaded and the task of complete removal in a short time is extremely difficult. Simulations show that even with a removal plan of 5 to 10 percent of invaded area per year and recovering it - as good grassland brings dual economic benefits: increased incomes from grassland regeneration and the returns from wood charcoal produced from the area cleared (scenario 5). All this is subject to the caveat that there is a policy change, altering the management regime to check re-invasion by legalizing the economic stakes. The simulations are over a 50-year span and these economic benefits are sustainable over such a long term. Scenario 5 represents a workable framework, which places certain responsibilities on the Forest Department (i.e., of designating areas for removal of woody cover and auctioning of woody areas for charcoal making). The area from which woody cover is removed will be placed under a joint resource management framework, with well-defined entitlements and usufruct rights to the herders for the use of those grassland tracts. It ensures that they have the incentive to check reinvasion of the grassland tracts on which they have the usufruct rights.

Naliya Grasslands

- ***Income Decomposition***

Most of the households in Naliya are agro-pastoral. The distribution of income from each source and their relative contribution in the total economy of the region is very uneven (SD = Rs.97,247/-). About 77 percent of the total income of the households studied belongs to the richer quintiles, while only about 4 percent income is with

the poorest quintile. Table 3 shows that, of the total average annual income, the largest share comes from agriculture (46.5%), followed by livestock (37.2%) and other sources (16.3%). In the poorest group, the largest share of income is derived from grassland dependent livestock (42.9%), and is thus very crucial for their subsistence.

Table 3: Income Share (%) from Various Sources across Different Income Groups

Income Quintile	Mean GAHI (Rs.)	Share of income by source		
		Farm-based	Livestock-based	Miscellaneous
Poorest	12239	19.0	42.9	38.1
Second	24029	27.9	32.8	39.3
Third	35421	30.6	35.5	33.9
Fourth	60099	34.8	48.4	16.8
Richest	186009	57.1	34.3	8.6
Total	**64,275**	**46.5**	**37.2**	**16.3**

The richer section also derives quite a substantial income from the livestock sector, and given their large livestock holdings (mean ACU per household of 19.4 as compared to 1.6 in the poorest), these returns go beyond subsistence. Both farm and livestock based incomes are positively correlated with landholding size. Mean gross annual FBI per household is about Rs.39,500, while that from LBI is about Rs.29,000. Total extrapolated gross income per year for the nine sampled villages is about Rs.48 million (Table 4). It can be seen that about 93 percent of total LBI is derived from milk and milk-based products.

Table 4: Income from Different Sources in Naliya

Source	House-holds*	Mean GAHI (Rs.)	Extrapolated Income# (Million Rs.)
Farm-based	129	39,578	22.3
Livestock-based	140	29,238	17.9
Others	89	20,136	7.8
All Sources	**171**	**64,275**	**48.0**

* There are, in general, multiple income streams for each household, and therefore the values in the column do not add up to those given as the total.

Extrapolation to nearly 750 households (census 1991), based on the assumption that proportion of households depending on the different resources conforms to the pattern reported here. The extrapolated income = *(total households of census data)**(proportion of households by source) *(mean GAHI by source).

- ***Unpaid Costs of Open Access***

The cost of open access to grassland resources, or the unpaid cost of grassland resources used was inferred by the use of imputed values of the fodder consumed from pastures. Only 11.6 percent of the fodder demand is met from the *gauchar* lands during summer, while the same grassland fulfils nearly 86 percent fodder demand during the rainy season. There is a marked variation in the seasonal dependency across different income groups (Table 5). The livestock units were converted to ACU and consumption estimated using the norm of 7 kg intake per ACU per day. The data on seasonal variations in the dependency on pastures was used to estimate the total quantum of fodder extraction in the year from the *gauchar* lands. The total cost of such dependency was arrived at using a notional cost of 50 paise per kg of grass. The unpaid cost incurred by the poorest and richest are about Rs.38,800 and Rs.360,700 respectively. The total unpaid cost per year for the sampled households is about Rs.0.95 million. The extrapolation based on the 1991 census data of the nine villages in the study area works out to be approximately Rs.4.75 million. Analysis shows that the bulk of social cost for the year is accounted for by the richest quintile (38%), while poorest benefits by a mere 4 percent, although the poorest extract higher benefits per animal per year.

Table 5: Annual Social Cost (Rs.) of Free Grazing Across Income Quintiles

Quintiles	Total	%	Per HH	Per ACU
Poorest	38801	4.1	1141	719
Second	179981	18.9	5294	577
Third	144924	15.2	4262	609
Fourth	227471	23.9	6690	589
Richest	360,679	37.9	10305	530
Total	**9,51,856**	100.0	**5,566**	**570**

Convergence Despite Contrasts

Banni and Naliya grasslands provide an unusual study in contrasts, despite the similarities of *de facto* open access resource management regimes. The lack of alternate

economic resources such as agriculture and absence of property rights, force the people of Banni to be dependent on the market for their subsistence needs. The case is somewhat different in Naliya, where in view of alternate resource availability for livestock, migration is almost non-existent, while in the case of Banni, migration to other areas, including Naliya, is common. The grasslands of Naliya serve as a refuge for the livestock of Banni during periods of resource scarcity, as was confirmed by the surveys in Naliya. The fallow agriculture fields also offer grazing opportunities for the in-migrant livestock, and even a symbiotic relationship between herders from outside and the farmers: some farmers allow livestock into their fallow fields and use the dung in return. There is no practice of collecting any grazing fee or rent from the migrant herders. Extrapolations show that the milk production of Banni is worth more than Rs.100 million annually, which is likely to be a conservative estimate, since the data of this study is more representative of a dry period, and not of a normal year. The milk production in Naliya, on the other hand, is more for its own consumption than for the market. Nevertheless, it forms an important component of the household budgets of the agro-pastoral communities.

The ability of the herders in Banni to diversify their income sources is controlled by variables like heterogeneity of ecosystems (grasslands) or socio-economic differentiation among the communities. The present study suggests that the rich and poor herders (or owners of different herd types) pursue diversification differently, as different groups do not perceive risks in the same way. Obviously, in the risk management strategies of Banni pastoralists, the income opportunity from the mesquite (realised at present through charcoal and NTFP) plays an important role. Despite the economic significance of woody resource, the Banni herders still prefer grassland-based pastoral mode of income generation. In fact, this study suggests that the management of mesquite is needed, not only to improve the grazing potential of the Banni, but also as an alternative income channel to support the herders during periods of acute scarcity.

The overwhelming perception of the local people point to the possibilities for participatory management of both grass and woody resources (i.e., treat it as an economic resource) in the Banni region. On the other hand, in the case of Naliya, the pattern of resource dependency indicates that there is considerable scope for enhancing the economic outputs from the grassland. The findings clearly point to the need for a strategy to improve the synergy between agricultural and pastoral activities in Naliya. The local people extract the maximum resources during the post-monsoon season, when the area is full of green grass. Incidentally, this is also the breeding season for rare and endangered birds. Therefore, the management goal here becomes one of ensuring the availability of suitable habitats for the wildlife and of rational use of the grass resources by domesticated livestock.

The situation in both Banni and Naliya require innovative and pro-active approaches that will not only regenerate the grassland system, but also rationalise the economic activity based on woody resource in Banni. The approach must also improve the grassland system of Naliya for both livestock and endangered wildlife. In both cases, the management strategy needs to be informed by the recognition that the key stakeholders have crucial economic interests in the resource regeneration, and that the stakeholder involvement can be realised only by altering the open access regimes into one based on legitimate entitlements and for collective usufruct rights. Despite the contrasts, there is a convergence in the management goals because of the sound economic and ecological rationale for grassland regeneration.

This study estimates that the gross output per year from grassland and woody resources of Banni is about Rs.120 million and Rs.28 million, respectively. The estimated social cost of grassland use per year by all the agro-pastoral households in Naliya would be about Rs.4.75 million, without accounting for the benefits enjoyed by in-migrant pastoralists. All indications point to the increasing demand for milk and milk products, and consequently the potential for a vibrant livestock-based economy.

The feasible approach in both cases converges on the need for a very proactive and dynamic joint management framework, in which various stakeholders can be partners who can negotiate their competing claims. Given the current property rights regime, the Forest

Department will have to play a key role in making this possible. This cannot be accomplished by a mere replication of the lacklustre Joint Forest Management (JFM) approach currently implemented in degraded forests; but will have to be based on the recognition that these grasslands are of enormous direct economic values and the joint management has to facilitate efficiency in the economic activity based on the grasslands.

Policy Recommendations

Certain policy initiatives and institutional strengthening will help to realise some of the possibilities for developing models of the stakeholder-driven regime of resource management. The suggestions presented here emerge not only from the data analysed, but also from the extensive consultations carried out as part of the study. It is also enriched by the study of people's perceptions.

The major policy issues that emerge from the study are:

- Need for a three-pronged approach to grassland management: – a) protecting the livelihoods of pastoral communities; b) controlling the woody invasion of grasslands (applied largely to Banni), and c) addressing biodiversity conservation goals (Naliya)
- Restructuring the property and/or resource management regimes and administrative approaches, so as to bring about greater economic efficiency in the grassland resource use through higher stakeholder involvement in the control and economic use of woody biomass
- Need for a critical reassessment of the management of grasslands under the provisions of the Forest Conservation Act (1980) and the approach adopted by the Forest Department for this
- Review of biodiversity conservation strategy for grassland systems, so as to bring about sharing of conservation responsibilities between the Forest Department and local communities in place of excessive reliance on the Protected Area approach in regions like Naliya with extensive dispersal of biodiversity values

Two of the major policy and legal changes relate to: (a) alterations in the resource management regime in Banni, and (b) biodiversity conservation strategy in Naliya. The policy initiative needed in the former case is one of adapting the JFM approach for grassland regeneration, with due recognition of the usufruct rights of the stakeholders. The later case requires the shaping of a participatory biodiversity conservation program, in which the roles, duties and responsibilities of the community and the Forest Department are properly defined. Such policy changes are a pre-requisite for any meaningful and sustainable resource management in the prevailing conditions.