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Developing fodder resources on the forest grasslands of tribal areas in Western India: a participatory approach

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DEVELOPING FODDER RESOURCES ON THE FOREST GRASSLANDS OF TRIBAL AREAS IN WESTERN INDIA

- A Participatory Approach

Submitted by

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SUMMARY

The general aim of this research study was to contribute to participatory development knowledge in the area of livestock fodder development in resource poor areas in the vicinity of Dahod, in the semi-arid zone of western India. The specific aims of the research were to:

- characterise existing social structures and fodder resource strategies and assess the efficacy of participatory appraisal techniques in identifying areas of intervention in the cultural setting of the study area;
- investigate a number of agronomic and common property interventions aimed at fodder improvement using a participatory approach.

The techniques used to collect information on social status and present utilisation of fodder ranged from being very useful to being less useful. However, they all did contribute to some extent to helping determine the present state of village fodder

To test a series of hypothesis addressing the aims of the study, farmers participated in the design, implementation and evaluation of research activities relating to the problems associated with inadequate availability of livestock fodder.

Results from experiments conducted on regenerating grasslands showed that significant increases in overall biomass were achievable through protection, but re-vegetation varied within the areas. Crude protein values increased the nutritional value of fodder in the grass sward due to the increased proportion of late succession species.

Supplementing grasslands by direct seeding, sowing grass pellets or transplanting seedlings increased the rate of pasture establishment and enhanced quantity and quality of available fodder grasses. In addition to a high quality fodder from leafy material, woody legumes provided a potential source of fuelwood easily assessable to the village communities in the study area.

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ACRONYMS

AFRI	-	Arid Forest Research Institute
DAS	-	Days After Sowing
DM	-	Dry Matter
CO	-	Community Organiser
CPR	-	Common Property Resource
FD	-	Forest Department
FGD	-	Focused Group Discussions
HHI	-	Household Interview
IGFRI	-	Indian Grassland and Fodder Research Institute
JFM	-	Joint Forest Management
KRIBP	-	KRIBHCO Indo-British Rainfed Farming Project
NTFP	-	Non-Timber Forest Product
PRA	-	Participatory Rural Appraisal
RCBD	-	Randomised Complete Block Design
SSI	-	Semi-Structured Interview
SWC	-	Soil and Water Conservation

CHAPTER 1

INTRODUCTION

The general aim of this research study was to contribute to participatory development knowledge in the area of livestock fodder development in resource poor areas in the vicinity of Dahod, in the semi-arid zone of western India. The specific aims of the research were to:

- characterize existing social structures and fodder resource strategies and assess the efficacy of participatory appraisal techniques in identifying areas of intervention within the cultural setting of the study area;
- investigate a number of agronomic and common property interventions aimed at fodder improvement using a participatory approach.

Before presenting the results of the study in Chapters 2 and 3, with a discussion and conclusions in chapters 4 and 5, issues related fodder development including livelihoods, participation, diagnostic techniques, participatory research and fodder availability in India are discussed in chapter 1. A brief description of the study area is given at the end of the chapter.

1.1 Livelihoods

To help in understanding household needs, an approach, based on the five capital assets[1] upon which individuals draw to develop their livelihoods (Scoones, 1998), has been recently investigated to look at the household environment holistically. The approach aims to improve the well-being of people, particularly of the rural poor, by strengthening the sustainability of their livelihoods strategy and improving household food security (ActionAid, 1999).

The concept of rural livelihoods has gained ground as it has become clear that earlier definitions based on income or on the ability to meet basic needs do not capture the complexities of poverty (Scoones, 1998). Scoones has identified three broad choices of livelihood strategy as being open to rural people:

[1] The five capital assets are: Natural assets, Social assets, Human assets, Physical assets and Financial assets.

- agricultural intensification / extensification (increasing output per unit area through capital investment or increases in labour inputs) / (increasing land under cultivation);
- livelihood diversification (diversification to a range of off-farm income earning activities);
- migration (move away and seek a livelihood either temporarily or permanently elsewhere).

> "*either you gain more of your livelihood from agriculture (including livestock rearing, aquaculture, forestry, etc), through processes of intensification (more output per unit area through capital investment or increases in labour inputs) or extensification (more land under cultivation), or you diversify to a range of off-farm income earning activities, or you move away and seek a livelihood either temporarily or permanently elsewhere. Or more commonly you pursue a combination of strategies together or in a sequence*" (Scoones, 1998).

Interventions to promote fodder and fuelwood improvement could be characterised by a mismatch with livelihood strategies and needs. For example, interventions that have sought to meet subsistence needs have been accompanied by under-estimations of the influence of market demands and a household deficient in fuelwood may result in a fuelwood project initiated simply on the perceived opportunity cost of selling wood to the market (Arnold and Dewes, 1995). Other interventions, because they depend upon credit (or payment by instalment) to cover start-up costs (nurseries, land preparation, etc.), could lead to the encouragement of planting monsoon grasses during the period when fodder is plentiful. Where crude extension targets of forestry services and targets that demand the distribution of a quantity of seedlings, or the meeting of expressed numbers of plantings, contribute to dissemination of inappropriate trees (Arnold, 1991).

Perhaps most importantly, there is a poor level of communication between extension staff and households, due either to a shortage of people trained in participatory skills, or of people with the ability to interpret and adapt these skills to the task of participatory research and selection (Warner *et al.*, 1999). However, if the objectives of the study are clearly stated and their relevance to other factors contributing to the livelihoods strategy appreciated, then the relevance and potential impact of the intervention can be more easily realised in relation to reducing poverty.

Current development thinking focuses particularly on knowledge, empowerment, sustainability, systems and institutions with the concept of sustainable rural livelihoods becoming central to debates about poverty reduction and environmental management in the context of rural development. Promoting sustainability of a rural livelihoods strategy contributes to overall eradication of poverty (Carney, 1998). *Sustainable livelihoods is a way of thinking about the objectives, scope and priorities for development, in order to enhance progress in poverty elimination ... resting on core principles that stress people-centred, responsive and multi-level approaches to development* (Ashley and Carney, 1999).

The sustainable livelihoods approach is not the definitive approach to development issues, but uses tools such as stakeholder and poverty analysis to help provide the basis for design of interventions and an appreciation of links to other sectors to help prioritise the needs of the poor. This is particularly relevant for designing and implementing appropriate research initiatives.

1.2 Participation

As already mentioned, many research projects have lacked client orientation because insufficient attention is paid to farmers' involvement in identifying needs and preferences. With participation of the local communities, adaptive research, particularly in the development context, can increase the chances of change in land-use technologies being adapted to specific regions and adopted by specific user groups.

Although the aims and objectives of participatory approaches have been welcomed, the way in which they are implemented is often questioned. The criticisms include:

- Participatory methods remain peripheral and isolated from conventional development policy (Thrupp *et al.*, 1994).
- Approaches are often techniques for information extraction – an outcome far removed from the goal of empowerment and self-mobilisation first envisaged (Mosse, 1994; Warner and Robb, 1996).
- A wide range of tools and techniques are offered but with very little by way of guidance on how to choose between tools to achieve different ends, or how each is a component of an overall methodology.
- A laudable focus on indigenous technical knowledge (ITK), underpinned by a philosophy of 'farmer knows best', has in some cases led to the neglect of 'outsiders' science, such as the provision of modern crop or tree varieties which better meet people's livelihood needs.

1.3 Participatory Research

Farmer participatory research must be preceded by two basic principles: farmers actively see and test new techniques and ideas; and a potential synergy exists between formal station research and farmer research (Okali *et al.*, 1994). Over the last twenty years, the farmer participatory model has begun to lead current thinking in agricultural and social forestry development in risk prone, low-resource, marginal areas. The shortcomings of the 'top-down' project diagnosis, planning and implementation approach have recently been addressed by implementing participatory approaches to natural resource research and extension (Campbell and Gill, 1991). This may be particularly important at the diagnostic planning stage of the process - the success of the intervention depends on the initial information collected, and the degree of involvement from the participants. To accomplish this, a set of rapid rural appraisal (RRA) techniques has been developed to assess community needs, identify research priorities, determine feasibility of, and monitor interventions (McCracken *et al.*, 1988).

1.3.1 Diagnostic Techniques

Several diagnostic techniques are presently being used in livestock and fodder research and development. These include transects to learn more about the vegetation and land-use, seasonal calendars to identify fodder availability, historical matrices to help understand livelihoods and coping strategies, and ranking diagrams to assess fodder value (IIED, 1994). Conroy *et al.*, (1996) used mapping, seasonal feed diagrams and trend diagrams, among other studies, in a study on small ruminants in Rajasthan to show the importance of variables such as farm size, and livestock numbers. Krishna Barat Co-operative (Kribhco) along with the Indian Grassland Fodder Research Institute (IGRFI) and the Agakhan Rural Support Programme (AKRSP) identified seasonal calendars as very useful in highlighting the diversity of fodder sources used in the villages. A bilateral project between the Government of India and the Netherlands to define recommendations for dairy production systems, found that transects were important for preparing maps and developing a preliminary checklist of issues to be investigated further using other RRA techniques (Turton *et al.*, 1997).

What is important to note in undertaking participatory research is that many of the techniques used today are RRA techniques. Unfortunately, these techniques have been used inter-changeably with the concept of participatory rural appraisal (PRA). The following historical development of RRA and PRA distinguishes the two terms.

Conventional scientific methodologies used in rural development in the past were usually characterised as fixed and formal in structure. This limited the focus of the research to specific issues that relied on assumptions made from data collected using conventional techniques such as statistical and economic analysis, vegetation and soil surveys, social and economic questionnaires, and field experiments. As a result, the linkages to the multi-dimensional aspects of the social and physical rural environment tended to be ignored.

By the 1970s, conventional analytical approaches were in question (Proceedings, 1985). Even though the Green Revolution increased the yield potential of many of the staple cereal crops grown around the world, development programmes were plagued by failure attributed mainly to a poor understanding of the social environment in which they were working resulting in implementation of inappropriate interventions (Cernea, 1985).

To address these shortcomings, several approaches emerged over the next ten years which incorporated social considerations to improve understanding of the system as a whole. Two approaches that emerged as key to stimulating the production of new techniques for cost effective and accurate analysis of farming systems were Farmer Participatory Research (FPR) and Farming Systems Research (FSR) (Proceedings, 1985).

1.3.2 Farming Systems Research

The FPR approach involves participation in the context of social science research. Although it was sensitive to orientation of problems, considerate to people's capacity and ability to produce and analyse information, and recognised that research is an educational process for both the researcher and the farmer, the approach itself varied according to the extent of farmer participation.

The FSR approach increased in complexity and evolved to focus on research conducted not only within the farming system, but beyond. In doing so, it stressed the need to involve and learn from the farmers while conducting research activities (Farrington and Martin, 1993). In the 1970's, FSR concentrated on the cropping system with the performance criteria being 'production' and the target group being simply the 'small farmer'. During the 1980's, it became increasingly complex. Livestock were added to the system studied and performance criteria included 'stability'. During this period the role of women and the need to include them as a target group became clearer. In the 1990's, the complexity increased even more with 'community' and even 'watersheds' included in the system studied. 'Sustainability' was critiqued, and the target groups went beyond the small farmer and women to the 'next generation' (Collinson, 1999).

The systems approach provided methods for investigating and understanding the farming system to help ensure that people destined to adopt the interventions were involved in considering the appropriateness within the social context of their environment.

Another approach used in development of FPR centred on the idea of 'field learning'. This was an applied anthropological approach that stressed the importance of attitude, behaviour and rapport, and emphasised the important contribution that information from indigenous knowledge could make to the development process.

Conway (1985) developed the Agro-ecosystem Analysis approach. This method incorporated a systems approach (sensitive to issues relating to productivity, sustainability and equity), with tools to analyse space (maps and transects), time (seasonal calendars and long-term timelines) and relationships (using flow and Venn diagrams).

By the late 1970s, many of the techniques developed from the different approaches to FPR were grouped into the newly emerging RRA methodology promising to improve the cost-effectiveness, timeliness and quality of rural development-related research (Proceedings, 1985).

The collective heading of RRA encompassing a broad range of methodologies, divided into four modes of approach (Conway and Barbier, 1990):

Exploratory RRA:	techniques to obtain information about a new area and define key questions and hypotheses;
Topical RRA:	techniques to investigate specific areas using key questions or hypotheses;
Participatory RRA:	techniques to involve clients/villagers in the decision-making process based on key questions and hypotheses;
Monitoring RRA:	techniques to monitor changes and determine the implications of change for development.

By the mid 1980s, an ever-increasing number of RRA practitioners had appeared throughout the world. To consolidate experiences and explore the range and limits of the methodology, an International Conference on Rapid Rural Appraisal was held in Thailand in 1985 (Proceedings, 1985). Consequently, emerging principles, methodological and conceptual frameworks, processes and guidelines were discussed in order to begin compiling RRA lessons, tools and techniques that could be used by current and future RRA practitioners (Grandstaff *et al.*, 1990).

Consensus showed that RRA represented a broad spectrum of tools and techniques ranging from formal to informal interview techniques using key informants, semi-structured interviews and focus group discussions, as well as structured observational and survey techniques, that are flexible enough to be easily adapted to many environments and social groupings. Other techniques range from eliciting a response to facilitating problem analysis, and from simple data collection to empowerment of individuals in the decision-making process (Proceedings, 1985).

However, RRA has limitations. If the individuals involved in the process do not represent the balance of stakeholder categories in the village, then the reliability and validity of the information collected is biased to particular individuals or individual groups. Ironically, the flexibility and open-endedness of the techniques which make the methodology so popular, increases the chances of such bias. Aside from that, objectively recording and analysing qualitative data is difficult, and the methods used by practitioners are not standardised (Chambers, 1993, 1997; Cernea, 1985).

By the late 1980s, participation had been embraced by the development community, and the philosophical and perhaps metaphysical concept of Participatory Rural Appraisal (PRA) emerged as the key methodology (Chambers, 1997; Rhoades, 1990). The broad spectrum of techniques covered under the RRA methodologies were encompassed. The role of the researcher was understood as that of facilitator and catalyst. The role of the farmer was that of analyst and decision-maker. The development projects and organisations first using the term PRA (e.g. Mbsuanyi project in Machakos, Kenya (Kabutha and Ford, 1988) and AKRSP in Pakistan) showed the benefits this 'new methodology' had to offer. Other organisations later adopting the approach were said to be '*decisively* *influential through their activities in Africa and Asia, and contributed to the spread and evolution of PRA and its methods through 30 substantial field based training workshops in 15 countries'* (Chambers, 1997). PRA was widely promoted and its popularity gained momentum. The number of training workshops rapidly increased and publications on PRA methodologies and approaches poured from the development sector. The result was radical adjustments in terms of rural development policies of several Governments who adopted the PRA approach for training and management of their extension services.

It became clear that the evolving PRA methodology incorporated varying degrees and levels of participation and the type of methodology employed determined the characteristics of the participation. Biggs (1989) looked at farmer participation in the special case of research in the context of four modes:

Contractual: Farmer is contracted by the researcher to provide a service;

Consultative: Researchers consult farmers, diagnose their problems and find solutions for them;

Collaborative: Farmers and researchers are equal partners and continually interact in the process;

Collegial: Researchers actively encourage farmers to practice informal research and development activities on their own land.

Subsequently, Pretty (1998) looked at farmer participation from a more general point of view and expanded the alternatives to:

Manipulative participation: Researcher has a set agenda (researcher has total control of the research);

Passive participation: People do what they are told (development project goes ahead without listening to peoples' views);

Consultative participation: people provide information only when asked (people consulted not involved in decision-making);

Reward-based participation: People will participate in activities if they receive something in return (objectives pre-determined by the external agency and the decision-making is

	limited to that involved with reaching the objectives);
Functional participation:	A means to fulfil project objectives (interactive and involved in decision-making only to meet predetermined criteria from external agencies);
Interactive participation:	People determine the resources to be used and how to use them (more than just fulfilling objective - uses multi- and inter-disciplinary approaches to provide a range of perspectives to a problem);
Self-mobilisation participation:	People act independent of external agencies providing that they get the framework to enable them to do so (people have full control of decision-making process - empowerment).

Both methods showed the different degrees to which participation influenced the client-researcher relationship. However, unlike the complex categories outlined by Pretty relating more to empowerment issues, Biggs maintained a simpler classification based on the degree of involvement by the stakeholders.

PRA has been defined as *'a growing family of approaches and methods to enable local people to share, enhance and analyse their knowledge of life, and conditions and to plan to act'* (Chambers, 1993). It is said to challenge, question and change aspects of our professional behaviour to a degree where vested interests become demobilised and empowerment along with freedom of choice is given back to the people (Chambers, 1997). The degree to which this occurs will vary with the levels of participation from outside and from within the community. From an operational viewpoint, the techniques used to achieve demobilisation and empowerment are the same as those developed under the umbrella of RRA. Both RRA and PRA are highly dependent on some form of communication medium that helps to develop a common understanding of issues and facilitate discussion.

1.4 Fodder Availability in India

Political changes and population expansion appear to have led to an increase in the rate of depletion of certain natural resources – particularly in the semi-arid areas of India. Unsustainable management practices resulting in extensive deforestation over the last 30 to 40 years have reduced availability of forest resources traditionally harvested by the tribal people, and substantially affected the ability of farmers to maintain a sustainable and viable village livelihoods[1] strategy. In particular, heavy grazing has resulted in a severe shortage of domestic fodder and unsustainable coppicing practices have continued to restrict re-growth and production of household fuelwood.

The cattle population in India increased from 47 million to 144 million between 1951 and 1987, a 206% increase over 36 years (Poffenberger and McGean, 1996). However, recent statistics show that the cattle population has since soared to 281 million (FAO, 1997), a 49% increase in only 10 years. At the same time, due to the opportunities offered by the dairy industry in the peri-urban areas, the buffalo population has increased slowly but steadily to 92 million.

Although there is general agreement between institutions within India that there is a critical shortage of fodder throughout the country, the deficit of components used as fodder varies widely. According to the estimates of the 1993 Policy Advisory Group, Ministry of Environment and Forest, availability in India was 390.6 million tonnes for dry fodder, 573.5 million tonnes for green fodder and 41.9 million tonnes for concentrates. With the requirement for fodder resources at 503.6 million tonnes, 744.7 million tonnes and 79.4 million tonnes respectively, the deficit in India was calculated at 22% for dry fodder, 23% for green fodder and 47% for concentrates (Jacob and Arora, 1997).

Other estimates show a similar overall deficit. The World Bank (1995) estimates a short-fall of 20-30% in the national feed balance. Hazra (1995), on the other hand,

[1] A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover form stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base.

estimates a requirement of 830 million tonnes for dry fodder, 34% more than is available, and a 990 million tonne requirement for green fodder - a 67% deficit with only 370 million tonnes presently available.

Estimates for fuelwood production show that even though the national average consumption has risen by 6% between 1993 and 1997 to 281 million m^{-3}, production has followed suit to keep up with demand (FAO, 1997). This is not, however, true for the rural areas where fuelwood shortages result in communities having to use crop residues and dung as alternative fuel sources (Ravindranath and Hall, 1995).

To help alleviate the fodder deficit, a number of strategies have been implemented and several lessons have been learned. In most marginal areas in India, adoption of improved technologies is slow when it involves new varieties or new production techniques (Pandeya, 1988). This is particularly so for perennial species like grasses and legumes which, unlike seasonal crops, involve significant changes in land-use strategies and management over several years.

Direct introduction of adaptable high yielding bio-types is an efficient method for 'quick gains' in India (Bhag Mal, 1997). This is particularly true for fodder grasses and legumes. In addition to increased nutrition and biomass production through selective breeding of indigenous species (IGFRI, 1998), prolific and nutritious exotic species adapted to the semi-arid and arid conditions of areas from outside India can play a very important role in providing fodder to deficient areas.

This can be a controversial issue since introduced species may be considered as harmful to the native environment as when indigenous species are aggressively replaced by an exotic species. However, if the same introduced species is used within the context of a well planned management strategy (e.g. colonising a degraded environment to reduce soil erosion and provide a source of cut-and-carry fodder for livestock), then the same exotic species is considered beneficial. The exotic species themselves are not harmful, but their exclusive dominance and permanency in a given habitat may be (Saxena, 1991). Their appropriateness or inappropriateness for addressing the objective for which it is to be managed should be considered.

Exotic tree and shrub species such as *Prosopis*, *Leucaena leucocephala*, *Eucalyptus* and *Casuarina* have been progressively introduced into India only over the last 150 years (Saxena, 1991). The realisation that fuelwood shortages and environmental degradation were quickly becoming a major problem in many tropical and subtropical rural areas (Arnold and Jongma, 1978: Grainger, 1982), encouraged tree planting activities to supply rural communities with non-industrial wood products such as fuelwood, using agroforestry practices to re-vegetate degraded lands. Fast growing tropical firewood trees, mostly leguminous, are the sorts of species used because they adapt well to degraded sites (Hughes and Jones, 1998). Many countries, including India (Fernandes and Kulkarni, 1983) have initiated programs of social and community forestry with woody legumes as the main component.

Despite the potential benefits of providing fuelwood, fodder, and several other timber and non-timber products as well as ameliorating the soil and microclimate, results from introduction of woody legumes to small holder farms have been disappointing. Several factors including technical problems with propagation, germplasm inappropriate for local conditions, and severity of the environment were cited along with inappropriate choice of species in relation to the perceived needs of the local communities (Hughes and Styles, 1989).

There is also the potential risk that the species will become a weed. But according to Holzner (1982), *'One man's weed is another man's crop'*. For example, the prolific seed production of *Prosopis juliflora*, currently India's primary source of fuelwood for the urban and peri-urban poor, can result in quick establishment over wide areas - a potential weed problem. However, in Rajasthan, rapid establishment on areas lacking natural vegetation not only helped to rehabilitate degraded areas, but provided the much needed livestock fodder and fuelwood required to address the needs of the local communities (Muthana and Arora, 1983).

Leucaena leucocephala is also a potentially weedy species (Hughes and Jones, 1998). However, using the appropriate taxa under the appropriate environmental conditions and considering the relevant social issues (e.g. access to credit, land tenure, scarcity of land and lack of time - Moog *et al*., 1998), *Leucaena* can significantly increase the availability of fodder and fuelwood to local communities. Moog *et al*., (1998) report that adoption remains low: there is poor understanding of farmers'.

Fodder and fuelwood deficit are just two of a myriad of problems and constraints faced by people in the rural areas of India, and the deficit is related to many factors contributing to social, economic, physical and biological interactions within households.

1.5 This Study

In conducting this four-year study, from 1994 to 1998, the information-gathering techniques ranged from subjective interpretations using qualitative research methodologies (e.g. semi-structured interviews (SSI)), to formal objective analysis using data collected from structured experiments (e.g. randomised complete block design (RCBD)) designed to be statistically robust both on-station and on-farm. In doing so, an integrated needs-based research strategy using participatory methods and a process approach was developed using experiments to test hypotheses relating to fodder improvement.

The author lived in the study area for about 100 days per year, but was permanently based in the UK and was limited in the number of times during the year he could visit the study villages. Implementation of experiments and data collection were therefore carried out in: June/July (beginning of the monsoon); September/October (harvest period for *kharif* crop); January/February (*rabi* cropping season). At other times, community organisers working with the study (COs) ensured agreed activities for the participating villagers were monitored.

The study was located in contiguous parts of three districts of three states: Panchmahal (Gujarat), Jhabua (Madhya Pradesh) and Banswara (Rajasthan). Two villages Kadwali Chotti and Potaliya were the main focus but 8 other village communities were involved in parts of the study (Figure 1.1).

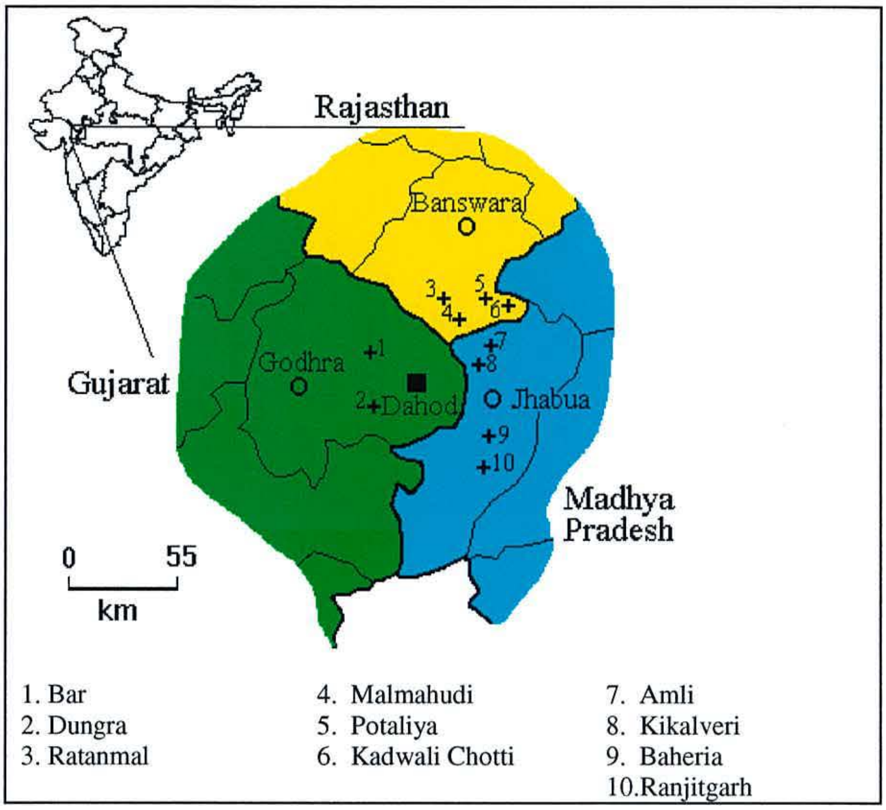


Figure 1.1 Map of the study area in western India showing location of study villages.

Approximately 750 km south-west of Delhi and over 150 km from the nearest city, most of the region is remote with poor communication services and is regarded as among the poorest regions of India.

The Tribal districts in the study are far from the state capitals and are inadequately provided with infrastructure or services. Families of scheduled Tribes make up the majority of the population (75%) in the three districts and include Pateias, Rathwas, Kolis, Nayaks and Minas. Bhil society accounts for the majority (86%) of the Tribal groups in the area (Devendra and Thakur, 1994).

Literacy rates are low, and the distance to access services such as health care, financial credit, transport, electricity and agricultural extension services create difficulties for the tribal farmers.

A large number of marginal farmers – particularly the resource poor, are in a debt cycle where money is borrowed before sale of crops or labour to pay for consumption items and to sustain production capacity. Limited access to financial institutions results in dependence on local money-lenders and traders who act as creditors, middlemen for market products, and contractors for both local and migratory labour.

Rural household livelihoods are rooted in agriculture with plots (0.5–2 ha) of mostly upland rice and maize cultivated on undulating lands under rainfed conditions. Each household is part of a distinct village containing neighborhoods (*faliya*) within which voluntary exchange of goods and services takes place. Since Bhils comprise a single lineage, they are more socially homogeneous then caste villages. The villages in the study area share common livelihood activities under very similar environmental constraints in the semi-arid zones of the three districts studied.

In 1992, a bilateral development project (KRIBP) managed by a national co-operative, the Krishak Bharati Co-operative (KRIBHCO), and funded by the Overseas Development Administration (ODA) at a cost of £3.43 million was initiated. The aim of the project was to *improve the long-term livelihoods of poor farmers in a drought-prone region of western India, through a participatory approach to farming systems development.* The Centre for Development Studies (CDS) in Swansea and the Centre for Arid Zone Studies (CAZS) in Bangor were recruited to consult on the project.

Because of the relative isolation of the Bhil tribal communities in the study area, very little research work had been conducted in the area to address problems relating to the degradation of the local environment, particularly the decrease in availability of fodder and fuelwood. In response, the candidate obtained separate funding from the DFID funded Forestry Research Program in the UK to conduct investigations into possible interventions involving grasses and trees that would help address some of the limitations in and around the study area. The study villages initially selected for the research project were ones in which KRIBP was not working.

CHAPTER 2

PARTICIPATORY APPRAISAL OF THE STUDY AREA

Chapter 2 focuses on characterising the study area in preparation for identifying and implementing interventions. Section 2.1 concentrates on the social aspects of the study villages. Using a range of information gathering techniques (Sections 2.1.1 – 2.1.6), social dynamics and various social groups were characterised. Sub-section 2.2 addresses the bio-physical context – particularly forage and fuelwood. A range of techniques (Sections 2.2.1 – 2.2.4) were used to characterise fodder and fuelwood use and availability in the study villages.

2.1 The Social Context

In the autumn of 1994, two villages, Kadwali Chotti and Potaliya in Rajasthan, were selected for the study by the author with the aid of an interpreter. The main criteria for selection was that the villages must be remote (e.g. no electricity, poor roads), and had forestry department-owned land associated with the village. Other secondary information about the study area was collected from reports and meteorological stations.

Two Community Organisers (COs) (male and female) from the FRP-funded project (R6155) managed by the author were charged with rapport building and initiating dialogue with villagers in Kadwali Chotti and Potaliya. Each had knowledge of the tribal environment and was able to speak the local language.

In the spring of 1995 after several months of interacting with the communities, villagers were asked by the COs if a group of development workers could come and stay in the village, and if so, when the most convenient time would be. It was explained to them that a group will be coming into the village to talk with them to help understand village life and some of the problems they face. At this point, a census was taken by the COs to record the total number of households and individuals within each household.

Three days of meetings were arranged 5-7 days in advance by which time the author, an interpreter, and a team of six persons given formal training from MYRADA in PRA techniques, four males and two females, entered the village.

The first day involved a general meeting to introduce the team members and to answer any questions the community members might have (Plate 2.1).

Plate 2.1 **Meeting held on the first day of a 3-day workshop to introduce the team members and to answer questions the villagers might have for the group (Kadwali Chotti, Rajasthan, 1995).**

Several RRA and PRA techniques were used to help understand the social context in which information was being exchanged, especially between the social groupings, within the study villages.

Secondary sources showed that Kadwali Chotti and Potaliya (*panchayat*: Patan, *tehsil*: Kushalgarh, district: Banswara, state: Rajasthan) are typical of tribal villages in the study area, situated approximately 200 km southwest of the state capital Banswara, 33 km west of Kushalgarh Tehsil headquarters and 2-5 km from the nearest small town of Patan – where the paved road ends.

Kadwali Chotti and Potaliya lack most infrastructure facilities, although a primary school and an Anganwadi Center (government food distribution centre) were built in Potaliya in 1989. The nearest market and sub-primary health centre are situated more that 15 km away in Choti Sarwah and the nearest branch of Bank of Baroda is situated at Patan. Credit facilities through moneylenders are obtained in Bajna, a small town (development block) in Madhya Pradesh 12 km away with larger market facilities. Kadwali Chotti and Potaliya are 2 of 11 villages within the Patan Panchayat, each represented by a ward member and *Sarpanch*. The other 9 villages within the Patan Panchayat are: Patan, Amlia Mal, Saruna, Junapani, Gokulpada, Hatwala Khagra, Badi Kadwali, Gumna Pada and Haldu Pada.

A census of the two villages conducted at the time of the exercise showed that Potaliya village had 75 houses, comprising 77 households (if considered by number of *chullahs* –cooking stoves). The total population was 530, with 132 adult females and 120 adult males (above 14 years of age), and 122 female children and 165 male children. The mean household size was seven. Kadwali Chotti is a much smaller village. There were only 23 households and a total population of 150 (72 male and 78 Female). Mean household size was also seven persons.

Residents in both villages belong to the Bhil tribe group and are members of 6 different clans. The distribution of households by clan in Potaliya are as follows: Munia (65 households), Katara (6 households), Joria (3 households), Kalija (1 household), Bhabhor (1 household), Hingar (1 household). A similar proportion is found in Kadwali Chotti.

2.1.1 Social Characterisation Using Maps

In an attempt to have members from different groups of the community involved in a single activity, a social mapping exercise was conducted. Community members were asked to draw a map of their village using coloured chalk, and to use materials available, such as twigs and stones, to indicate the most important features in the village. This exercise lasted until it was too dark to continue. The team spent the night in the village.

Although most of the village households were represented during the first day at the social mapping exercise, only certain members of the community ended up taking the lead and actively participated in the exercise (Plate 2.2).

Plate 2.2 Social and natural resource mapping exercise used to involve members representing all sectors of the community during the first day of the three-day meeting (Kadwali Chotti, Rajasthan, 1995)

The social mapping exercise was useful in stimulating discussion between the village members, and for project staff to gain a better understanding of the village area. It also provided a forum for discussing issues that arose during the mapping exercises. Aside from that, the information produced on the maps was of limited use. Lack of accuracy for scale and location of households and wells made it difficult to use the maps for any detailed planning exercises.

Since the villagers were already familiar with the revenue maps of their village, they were very useful for collecting accurate location data during FGDs e.g. identifying village plots, individual households and wells (Figures 2.1 & 2.2).

At the start of the exercises when community members were asked to form groups on the second day, the villagers formed into separate groups for men and women. Project facilitators encouraged the villagers to make the groups more heterogeneous by ensuring a mixture of genders within each group. However, this resulted in groups of men and women who were unaccustomed to formal discussions with each other and only the dominant males expressing opinions. The practice of interfering with the selection of members to form a group was later discouraged.

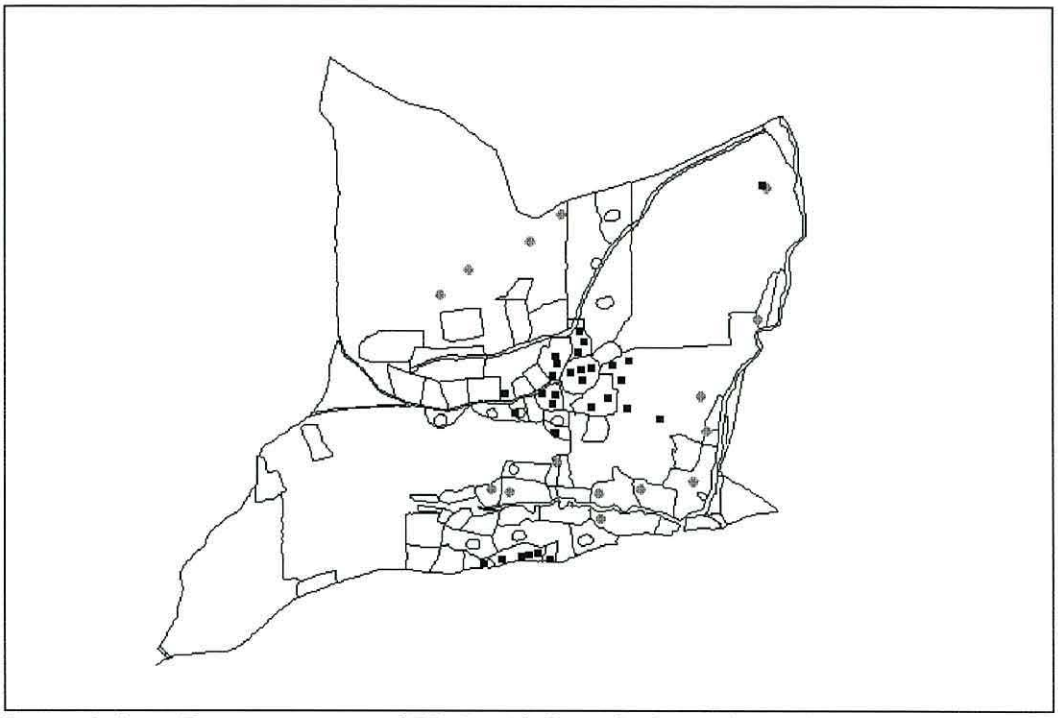


Figure 2.1 Revenue map of Kadwali Chotti village in Rajasthan showing land divisions, and individual households ■ and wells ● (1995).

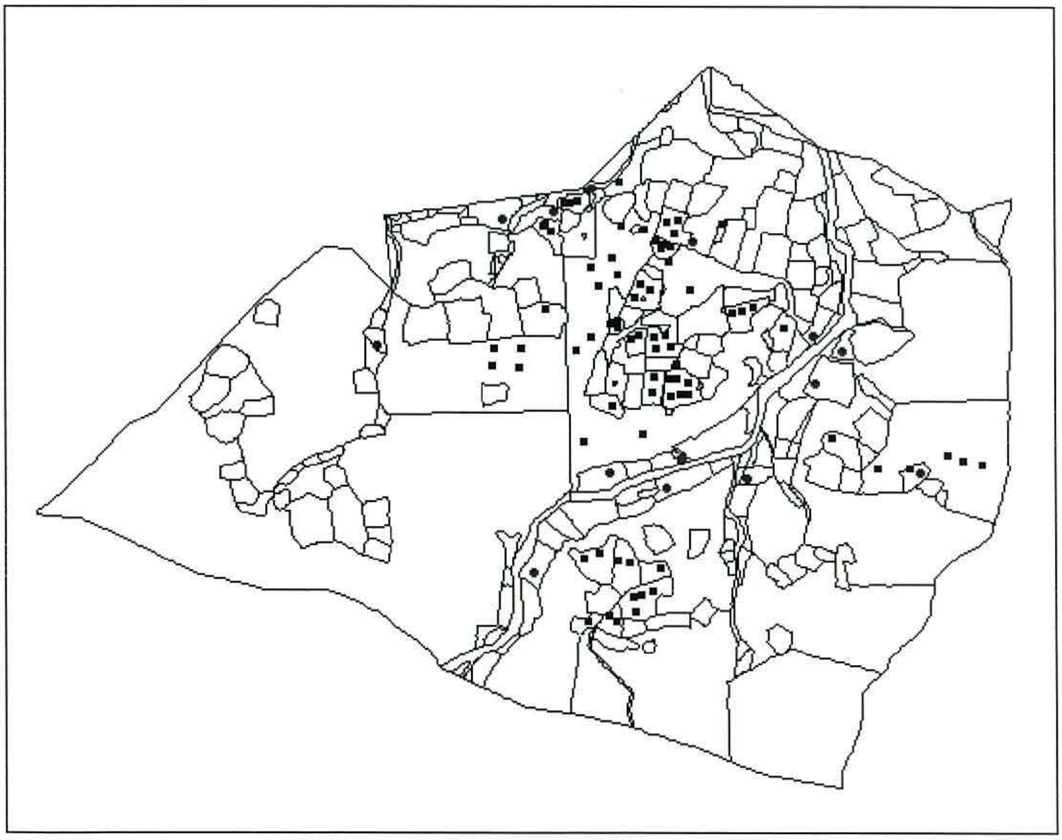


Figure 2.2 Revenue map of Potaliya village in Rajasthan showing land divisions, and individual households ■ and wells ● (1995).

2.1.2 Social Characterisation using Informal Discussion

During casual conversation with a group of 15 to 20 villagers from Potaliya in the evening of the first day, it was suggested by the group that Mr Dhulia son of Kalia, a village member of around 80 years of age, was consulted for information regarding family lines within the village, as he was renowned for being knowledgeable about the village's history and early settlers.

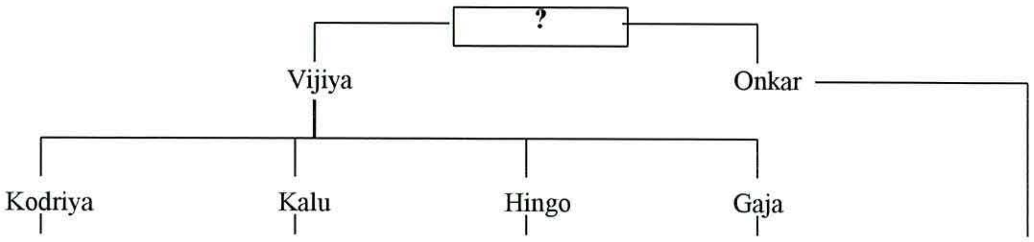
According to the information provided by Mr Dhulia, the village of Potaliya was founded by two brothers, Vijiya and Onkar, who belonged to the Bhil tribe and Muniya clan. Mr Dhulia was not certain who their father was, but thought that he came from village Kadwali Chotti. Vijiya settled permanently at Potaliya, whilst Onkar possibly returned to Kadwali Chotti. Evidence of this is a stone laid in Kadwali Chotti in his memory which was taken to Potaliya some 15-20 years ago by descendants living there. At present, there are few of Onkar's descendants residing in Potaliya.

Vijiya had 4 sons, Kodriya, Kalu, Hingo and Gaja, and most of the present residents of Potaliya are direct descendants of these 4 brothers. Members of other clans are also resident in Potaliya, and these settled in the village by marrying female members of the Muniya clan (descendants of Vijiya and/or Onkar) (Figure 2.3).

2.1.3 Social Characterisation using Time Lines

An exercise was conducted to learn about the history of the village and discuss changes to the farming system. Members from two of the groups were asked to recall major events in their life and then plot these events on a historical time line. As the period surrounding each of these events was recalled, the facilitator initiated discussions focusing on important assets as identified by the group. These were then recorded in a matrix.

Timeline exercises enabled villagers to give a general overview of the village history in relation to the important physical and natural resource assets selected by them (Table 2.1).



Name	Name	Name	Name	Name
Madia Kamji	Galiya Kaliya	Punja Puniya	Devala Punja	Hawji Dhulia
Mangu Prabhu	Dhulia Kalu	Tita Hamji	Onkar Gaja	Hadia Dhulia
Walji Hawji	Hakru Dhulia	Hadu Hamji	Nathu Onkar	
Narhing Hawji	Laxman Dhulia	Hadia Punia	Narhing Onkar	
Kachru Hawji	Wahling Kalu	Magji Punia	Madia Galiya	
Devji Hawji		Naru Jithra	Raisingh Galiya	
Lalu Prabhu		Jewna Jithra	Ramlal Galiya	
Dolji Prabhu		Kalu Jithra	Hardar Punja	
Bagu Prabhu		Badhru Jithra	Narji Punja	
Indu Prabhu		Madia Jithra	Dipa Gaja	
Bhurji Kamji		Harhing Jithra	Lunja Gaja	
Hurji Radhu		Wala Hamji	Walsingh Wauta	
Rajhing Radhu		Virji Badia	Laxman Gautam	
Nagji Gawji		Hurji Badia	Gautam Gaja	
Kalu Gawji		Kachru Hamji	Ratu Galia	
Dudda Gawji		Bhaudia Hamji		
Laxman Fula				
Dhanji Hukla				
Narhing Dhanji				
Vila Hukla				
Onkar Vila				
Raisen Kanji				
Wagji Fula				
Laxman Fula				
Bhanji Hukla				
Babu Bhanji				

The ancestors of the following households came from other villages and settled in the village by marrying female descendants of the four sons of Vijia.

Nagji Dita	Thavra Hamra
Terhing Madia	Dalji Bijia
	Kachru Rangi
	Rangji Waja
	Vijia Wahling
	Kalu Vesa
	Baddu Gawra

Figure 2.3 **Detailed description of the lineage of village members in Potaliya since 1900 resulting from discussions held with an elder in Potaliya village (1995).**

Table 2.1. Sample of information collected during FGDs used to construct historical timelines (Kadwali Chotti - 1995)

Punja s/o Dharia Dhario	no of HHs[1]	wells[1]	water avail.	forest[2]	crops[2]	cattle[1]	fodder fuel wood[2]
10 year he got married	3	1	whole year	18	16	12	16
16 years wife has 1st child (Karchri)	6	1	whole year	16	16	12	16
18 years wife has 2nd child (Kali)	10	1	whole year	10	15	10	12
20 years wife has 3rd child (Kanji)	13	1	whole year	8	8	8	8
26 years wife has 4th child (Telu)	15	2	less water	6	8	8	8
32 years wife has 5th child	20	3	less water	4	6	7	6
38 years Kachri got married	22	9	less water	3	4	6	4
42 years Kanji got married	24	9	less water	3	4	6	4
52 years	28	10	in 2 wells only 1/2 year	2	3	4	2
62 years	35	15	*	2	2	4	2
problems	lack of timber		little avail. no storage	less avail. often cut by outside use as fuel	low yields	low number per house more disease	lack of fodder

Comment - Total number of animals is increasing, but number of animals per family is decreasing.
[1] number of stones used during exercise relate to actual numbers
[2] number of stones used to indicate relative amounts available during the time period

The trend was the same in both villages. As the number of households (and population) increased, the number of cattle per household decreased (Figure 2.4).

Despite the decrease in the number of cattle owned by individual households, the overall cattle population increased as the village population grew. However, over the last 20 years, the total cattle numbers within the villages remained at a constant level (Figure 2.5).

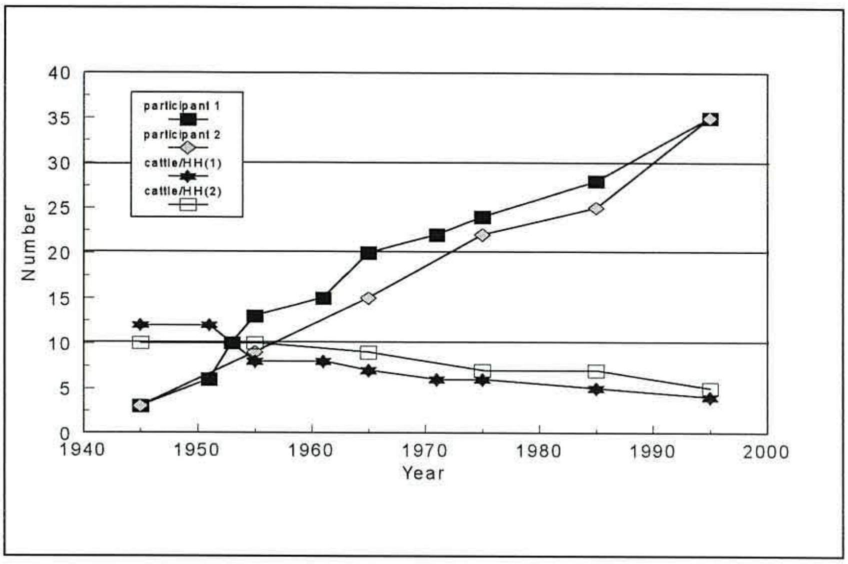


Figure 2.4 Trends showing a decrease in cattle per household as the number of households increase in number over the last 50 years (1995).

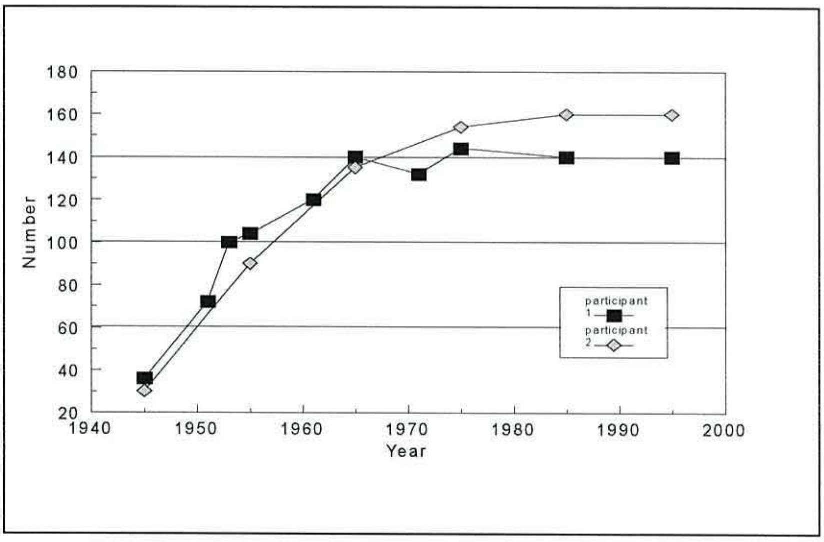


Figure 2.5 Data from timelines during two FGDs showing total cattle population increasing and then levelling during the last 20 years (1995).

2.1.4 Social Characterisation using Well-Being Ranking

A well-being exercise was conducted to identify the different socio-economic groups in the village, and to determine the criteria used in selecting those groups. In Kadwali Chotti and Potaliya, the well-being ranking was conducted with a mixed group of 21 women and men in Potaliya and a mixed group of 17 women and men in Kadwali Chotti.

Groups of villagers were asked to select the most well-off household in the village and to give their reasons why they thought they were the richest. They were then asked to select the poorest household and then asked their reasons for the selection. Each of the remaining households in the village were then compared to each other to determine their relative well-being compared to the richest and poorest. Initially five groupings were identified but after discussions regarding selection criteria, these were then summarised into three groups - resource-rich, moderate and resource-poor.

Household interviews were then conducted in the village households in each of the wealth ranked groups to prioritise selection criteria. Although each well-being ranking was specific to each village, similarities in ranking criteria emerged between villages (Table 2.2).

In Kadwali Chotti and Potaliya, the physical and natural assets categorised into land, food, and livestock were ranked as the most important criteria for assessing the well-being of individual households. The more any household possesses relative to the neighbouring households in the village, the higher the well-being category of that household. Housing was given a high priority for the resource-poor households as was clothing that was not considered in the moderate or resource-rich categories.

2.1.5 Social Characterisation using Semi-Structured Interviews

This exercise was conducted to learn more about the components involved with functioning of the household. In particular, resource flow into and out of the household. Groups were asked about important activities in the household, and the major influences on those activities.

The household cycle in these two villages is typical for the study area. Using semi-structured interviews, the key components of the cycle were identified as: assets; income; expenditure; credit. Using a seasonal calendar, some of the important issues were discussed in more detail during FGDs.

Table 2.2 Well-being ranking of households in Kadwali Chotti and Potaliya villages (April 1995).

socio-economic category	criteria	no of households in Kadwali Chotti (%)	no of households in Potaliya (%)
resource rich	· **food** available for the whole year · 15 to 20 *bighas* of **land** (can sow 60 kgs. of paddy and 40 kg of maize seeds), partially irrigated · adequate and healthy **livestock** (4 bullocks, 2-3 cows, 1-2 female buffaloes and goats and poultry) · cash availability in hand · receive Rs. 10,000-15,000 in ***Nothra*** ceremony · **migrate** for only 2 months · Possess or have free access to a water well · well structured **house** (with beams and connectors) · articulate and well behaved · able to present the village situation to outsiders and also can understand the purpose of outsiders coming into the village · lend money and food grains to the other villagers · access to governments, **credit**, etc	5 (22%) *3 * surveyed*	17 (22%) *3 surveyed*
medium	· 8-10 *bighas* of **land**, of average quality · **food** availability for 8 months (until *Holi*) · 2-3 members from a household **migrate** for 4-6 months · own **livestock** (2 bullocks, sometimes 1 buffalo, 1-2 cows & some goats) · **house** structure moderate · receive Rs.5,000-8000 in **Nothra** ceremony · get **credit** from others easily · maintain good relations with others · little **cash** available in hand	12 (52%) *3 surveyed*	33 (43%) *7 surveyed*
resource poor	· 5-6 bighas of **land** · do not have **livestock** all year · poor clothing · poor **housing** condition (made from hand made tiles and pigeon pea stalks) · **migrate** for 8 months · **food** availability for 1-2 months · unable to perform do agriculture operations on time · receive Rs. 2,000-3,000 in ***Nothra*** ceremony · unable to get **credit** easily from the money · unable to pay back the credit amount on time · earnings from migration spent on paying off debts · usually depend on others support	6 (26%) *3 surveyed*	27 (35%) *5 surveyed*

** Number of households surveyed in each well-being category*

Income: The important seasonal activities that earn the household both cash and non-cash income are agriculture and migration. (Table 2.3). All households practise agriculture on their own land and communal land with the aim of producing sufficient food for subsistence though this is not fulfilled for most of the households. The opportunities of work nearby are very limited and villagers have to depend heavily on migration (Tables 2.3 and 2.4) to the nearby cities of Ratlam, Kota and Indore and stay away 2 months to 8 months in a year depending on their socio-economic status. Livestock including poultry may be sold to meet cash needs but draught animals are retained as long as possible.

Expenditures: Expenditures are concentrated on agricultural inputs and festivals (Table 2.3). The highest expenditure is just before and during the monsoon season when fertiliser, seed and medicines are in great demand. *Holi* and *Diwali* festivals are prominent in March and November respectively, but the greatest monthly expenditure is for marriages particularly during January/February.

Credit: Debt is incurred for a range of reasons, which vary according to socio-economic classes. Poorer households are more likely to borrow for necessities such as food, emergencies or agriculture inputs, but wealthier households often incur debt to pay for wedding or celebrations. Money is borrowed mainly from merchant money lenders, who reside in Bajna and Patan. Sometimes family friends and relatives are also the source of credit. The rates of interest charged by the money lenders are high and usually 40-50% for the sum which is given against some mortgage of silver ornaments and nearly 100% for the sum which is taken for a season and supposed to be paid at the end of the season.

Assets: Most households have ownership of some assets whether they are physical (e.g. shelter) natural (grasses from open grazing), financial (e.g. access to credit), social (e.g. part of a network within their community) or human (e.g. skill to do labour during migration). However, the value of the asset depends upon the wealth of the individual household and is reflected partly by the well-being category to which the household is allocated.

2.1.6 Social Characterisation using Monthly Activities

Based on information gathered during group discussions, a seasonal calendar was constructed to help understand some of the issues identified as important to the village household (Table 2.4). Details on migration activities and cropping patterns on a monthly basis were easily recorded providing a quick reference to when these activities were prominent during the year. The pattern that emerged was similar for all groups within the village.

Table 2.3 Monthly expenditure, prevalence of disease and general cropping and migration activities for Kadwali Chotti and Potaliya villages (April 1995).

	Baisakh *April-May*	**Jeth** *May-June*	**Ahad** *June-July*	**Sawan** *July-Aug*	**Bhado** *Aug-Sept*	**Kuwar** *Sept- Oct*	**Kartic** *Oct-Nov*	**Ahgan** *Nov-Dec*	**Po** *Dec-Jan*	**Magh** *Jan-Feb*	**Phagun** *Feb-Mar*	**Chait** *Mar-April*
expenses	*Akateez* custom	fertilizer & seed	fertilizer seed & medicine	fertilizer seed pesticides & *Dewasa* festival	pesticides & *Rakhi* festival	*Navratri* festival marriage	*Diwali* festivals & disease	medicine	marriage	marriage	*Holi* festival & *Dasa* custom	medicine
disease	dysentery influenza malaria	dysentery	malaria and cattle disease	malaria fever	malaria cattle disease	--	fever swelling of eyes	cough	cold cough	--	dysentery cough	cough malaria
cropping work	-	-	sowing (if rain come in time)	sowing (*kharif*) Inter cropping operation	cropping operations	harvesting	sowing (*rabi* crop)	cropping operations	winding	harvesting	-	-
migration	1/2 time	1/2 time	no	no	no	no	1/2 time	yes	yes	return	return	1/2 time
rainfall pattern	dry	dry	monsoon begins	heavy rain	moderate rain	light rain	little rain	dry	dry	dry	dry	dry

Table 2.4 Detailed monthly migration patterns and cropping activities for Kadwali Chotti and Potaliya (April 1995).

Baisakh *15 April to 15 May*	**Jeth** *15 May to 15 June*	**Ahad** *15 June to 15 July*	**Sawan** *15 July to 15 Aug*
In this month people work on their own farms for 5 to 10 days, and then migrate to cities e.g. Ratlam, Neemaeh and Mandsaur. Old people do not migrate. Type of work includes: agricultural work, road and house construction	In this month the decision to migrate depends on whether the rains have started or not. If the rain has started, then the villagers will stay to plow the fields and repair the thatch roofs of their huts. If the rains have not started, then they will go outside the village to work.	In this month crops are sown including *jawar* (5 days), maize (10 days), cotton, green gram (5 days) and rice (5 days). The seed is obtained from the nearby markets.	No migrate in this month due to preparations for the *kharif* crop.
Bhado *15 Aug to 15 Sept*	**Kuwar** *15 Sept to 15 Oct*	**Kartic** *15 Oct to 15 Nov*	**Ahgan** *15 Nov to 15 Dec*
No migration due to *kharif* cropping activities. If free time is available, villagers travel to the areas close to the village in search of work.	No migration due to cropping activities e.g. harvesting, threshing and winnowing. If time is available, fields are prepared for *rabi* crop e.g. wheat and gram.	50% of villagers migrate for 10-15 days after *Dewali* celebrations. If rain fall and soil moisture is adequate, crops such as gram, chick pea and wheat are sown.	In this month most of the people migrate to the city e.g. Ujain, Nagda and Mandsaur (MP) as agricultural or construction labourers. Someone is usually left in the household to maintain livestock and the *rabi* crop
Po *15 Dec to 15 Jan*	**Magh** *15 Jan to 15 Feb*	**Phagun** *15 Feb to 15 Mar*	**Chait** *15 mar to 15 April*
Most people migrate to cities during this period e.g. Neemah, Ratlam and Mondsaur. At least one person will stay at home to maintain livestock and the *rabi* crop	The first 15 days of this month will be spent outside of the village working as labourers after which all villagers will return for arrangement of marriages. For the rest of the month, time is spent on household activities such as collecting wood for fuel and maintaining the wheat and gram crop.	Most villagers migrate but some return for the *holi* festival. Half of the time this month is spend harvesting wheat and gram while the rest of the time is spent in post harvest activities.	Half of the time this month is spent in post harvest crop activities of wheat and gram. The rest of the month is spent in search of work in the nearby villages and cities.

Note: Similar wages are received throughout the year.

2.2 The Fodder and Fuelwood Context

A range of information gathering techniques was used to characterise fodder and fuelwood use and availability in the study villages. This included secondary source information on physical aspects of the area such as rainfall and temperature.

The village area is subject to a unimodal monsoon climate (Figure 2.7) with a long-term average annual rainfall of 750 - 1000 mm. Data collected from four meteorological stations in the Banswara district where Kadwali Chotti and Potaliya are located, indicated that the rainfall is highly variable from year to year and droughts are common as are years of exceptionally heavy rainfall (Figure 2.6). Monthly means of daily temperature maxima vary from 28°C (January) to 40°C (May).

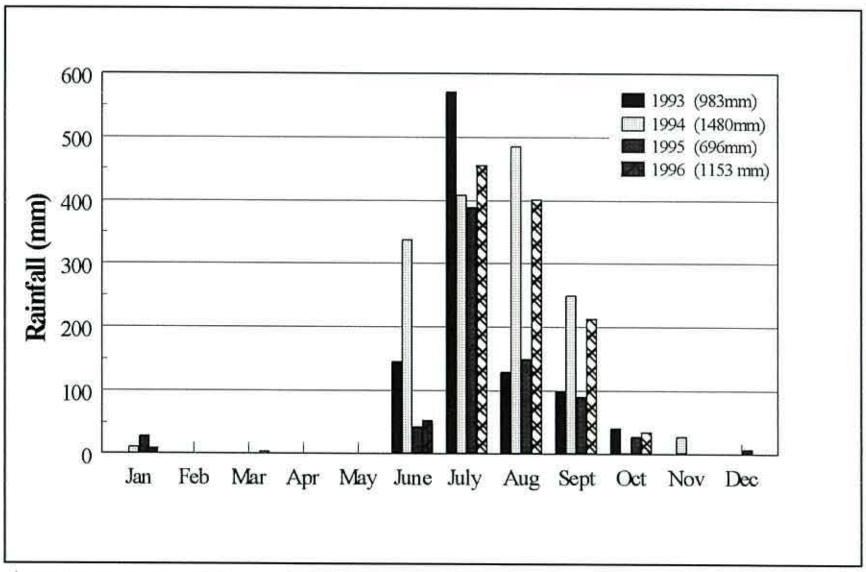


Figure 2.6 Average monthly rainfall pattern calculated from daily rainfall data collected by four meteorological stations over four years in the Banswara district, Rajasthan (1993-1996).

2.2.1 Resource Characterisation using Transect Walks

Transect walks were used to help project staff better understand the village area, and give the villagers the opportunity to raise and discuss issues important to them. The villagers were asked to select five directions radiating from the meeting area on the village map. Each of five groups (consisting of 7 to 10 persons) along with two of the project staff with three of the groups, and one staff member with each of the other two groups, were assigned to each transect. Discussions were held with the group members at various points along the walk.

A general profile of the village area was developed from the information collected during the five transects in each village. Information on the local environment was easily obtained (Figure 2.7). Transect walks also provided villagers the opportunity to discuss problems and propose possible solutions.

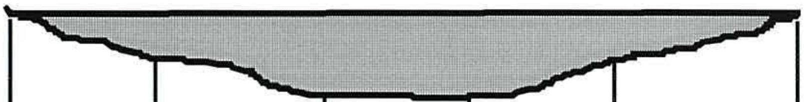
e.g. landscape of transect - important issues farmers included					
land - ownership - use - topography	panchyat sloping pasture	private cultivated /open grazing	private cultivated	private cultivated /open grazing	government forest but used by village
soil - colour - texture - depth	red (stoney) depth 6 inches	red depth 6 inches	black fertile depth 12 inches	black fertile depth 9 inches	red (stoney)
trees - timber - poles - fuelwood - fruit	teak, khejra, kherio	bamboo	--	khakhro, kad	teak khakhro neem
grass - cut & carry - grazing	*Boreria Tephrosia*	--	--	--	*Sehima, Dichanthium*
crop - both kharif and rabi	--	maize, pigeon pea, black gram	maize, pigeon pea, black gram	rice, cotton, chick pea (depends on rainfall)	some maize and black gram in cleared areas
water - ownership important	rainfed	rainfed	well Hukla Punja	irrigated	rainfed
village members of transect team - mostly men	Nathu Barsing Nanji Narsing Kanji	--	--	--	--
problems - related to land use	no grasses after rabi	no irrigation	poor yield during summer droughts	limited water in rabi	no grasses after rabi; no fuelwood
solutions - related to land use problems	plant grasses that would grow after rabi	well construction	dig well deeper	dig well.	plant grasses fodder and fuelwood trees

Figure 2.7 Example of the types of information collected during transect walks through Kadwali Chotti and Potaliya (1995).

As a general rule, descriptions under the category of **land** given by the villagers included elements of ownership (e.g. private, government, panchayat), land-use (e.g. pasture/open grazing, cultivated for crops), and topographical features (e.g. sloping, uplands, hilly).

The main elements used to describe **soil** during this exercise were colour (red, black, black/brown), texture (sandy, stoney), and soil depth. The degree of stoniness was usually only associated with red soils and sandy was used to describe colour as much as it was used to indicate texture.

The **trees** that were prominent in the area included *Eucalyptus spp.*, *Tectona grandis*, *Acacia catechu*, *Dendrocalamus strictus*, *Azadirachta indica* and *Ficus religiosa*, along with some fruit trees including *Mangifera indica* and *Ziziphus mauritiana*. The overall trend during transect walks was that the trees most frequently pointed out were first those that were important for timber or house construction, followed by those considered important for fuelwood and fruit. Only after further discussions with staff did the villages mention other uses of the selected trees and their components such as leaves of *Acacia catechu* for fodder and those of *Azadirachta indica* for medicine, and branches of *Tectona grandus* for agricultural tools.

The main **grasses** referred to were described as either cut & carry (*Heteropogon, Themeda and Sehima*) or grazing (*Dichanthium, Digitaria, Boreria and Tephrosia*). It was necessary for staff to ask specifically the names of other grasses found in the area.

The **crops** mentioned were not only those that were presently in the fields (*rabi* season), but also the crops, particularly maize and rice, grown in the *kharif* in each village. Other crops included millet and blackgram during the *kharif*, and wheat and chick pea in the *rabi*. One of the key factors determining which crop was grown was the source and availability of water. Rainfall was of particular significance.

When availability of **water** was discussed, access to water and ownership of the wells were the key issue.

Problems were discussed at each point related to land-use issues. For example, lack of water for irrigation was the main problem for cultivated crop lands, lack of fodder grasses during the *rabi* was the problem on pasture lands, and scarcity of timber and fuelwood was mostly associated with government forest land. The **solutions** proposed related directly to those problems.

2.2.2 Resource Characterisation using Matrix Ranking

During discussions, a matrix ranking exercise was used to collect information on the importance and the availability of local tree and grass species.

Results from the ranking exercise showed that there are several tree species that are used in the villages for different purposes (Table 2.5). The ranking of the trees proved difficult as different people had ranked the trees based on individual access to the tree species and/or the product obtained from the tree. However, 12 of the tree species were selected by the participants as the most important species in the area (Table 2.5).

Results from the matrix ranking exercise on grasses indicted that importance was related to availability and that *Heteropogon* and *Themeda* were the most important grasses in the villages due to their availability particularly for cut & carry during the *rabi* season (Table 2.6). Other grasses were ranked lower which was related to limited availability, especially after the *rabi* season.

At the end of the appraisal period, the information collected was reviewed and discussed by all of the village members represented by all prominent groups in the village (Plate 2.3).

Within the next few months after conducting the three-day exercise in Kadwali Chotti and Potaliya, seven other villages were selected where a team, many of the members of which were those in the original team, continued with the workshops similar to the one held in the first two villages.

Table 2.5 Results of matrix ranking exercise on important trees and their uses in Kadwali Chotti and Potaliya (1995).

local name	botanical name	uses
Kheria*	*Acacia catechu*	1, 2, 3, 6, 7
Teak*	*Tectona grandus*	1, 2, 3, 6, 7, 11 (plates)
Dhawada*	*Anogeissus latifolia*	1, 2, 3, 7 (spade), 8
Bor*	*Zizyphus mauritiana*	1, 2, 3, 4, 6, 7
Neem*	*Azadirachta indica*	1, 2, 3 (camels), 4, 6, 9, 11 (sell seed)
Khakhro*	*Butea monosperma*	1, 2, 3 (buffalo), 11 (plates)
Mango*	*Mangifera indica*	2, 4, 6
Nilgari*	*Eucalyptus*	1
Bamboo*	*Dendrocalamus strictus*	2, 6
Umry*	*Ficus racemosa*	2, 3, 4, 7
Bavlia*	*Acacia nilotica*	2, 3 (goats), 6, 7, 8
Peeplo*	*Ficus religiosa*	1, 10
amli	*Tamarindus indica*	1, 2, 3, 4, 5
royan	*Soymida febrifuga*	1, 2
behdo	*Terminalia bellirica*	1, 2, 3, 7 (cart)
hadyo	---	2, 3, 6, 7 (hoe)
mooni	---	2
palbada	---	3 (pods)
tahniyo	---	2, 3, 7 (harrow)
hegi	---	1
tijru	---	1, 3
billi	*Aegle marmelos*	1, 2, 3, 5, 10
kajlipo	---	1
gundi	*Cordia gharf*	1
himlo	---	
khakra	*Butea monosperma*	1, 3
gular	---	1, 4, 5
sader	*Terminalia arjuna*	1
wadam	---	1, 3
haler	---	1
kegario	---	1

1. wood
2. fuel
3. fodder
4. Fruit
5. Flowers
6. Furniture
7. Tools
8. Gum
9. Medicine
10. worship
11. other

* one of the 12 most important species

Table 2.6 Results of matrix ranking exercise to collect information on fodder grasses, in Kadwali Chotti and Potaliya (1995).

local name	genus species	avail	animal preference	found in village	found in common land	found on other land	manage
lamp	*Heteropogon*	2 (1)	2 (3) dry	x	x	hillocks and forest	cut and carry
haran	*Dichanthium*	2 (4)	1 (1) green	x	x	hillocks and forest	open grazing
gunda raro	*Themeda*	1 (2)	(4) only buffalo dry	x		in nalla and waste land	cut and store
hichal	*Digitaria.*	5 (5)	(2) green	x		in fields	cut and store
toko	*Sehima*	3 (3)	2 (2) dry			in nalla	cut and store
gatio	*Boreria*	6	3 green		x	forest	open grazing
papdi	*Tephrosia.*	7	3 green		x	forest	open grazing
hamo		4		x		in nalla	open grazing
baru	*Sorghum*	13		x			
dhakani	*Cynodon*	11			x	forest	
kalo	---	10		x		in nalla	
kahaio	---	9	4			in nalla	
garko	---	8				in nalla	
dairio	---	12			x	forest	

Plate 2.3 **A review of the discussions was convened at the end of the appraisal period in each village (Kadwali Chotti, Rajasthan, 1995).**

2.2.3 Resource Characterisation using Ranking and Scoring

Ranking and scoring exercises were conducted in ten villages of the study area to categorise land-use and soil type in the project area. A group of 10 to 15 persons in each village listed the land-use types in order of size, and then placed stones (1-100) next to each category representing the percentage of land. The same was done for the soil types in each land-use category.

In addition, composite soil samples (each composed of five samples of soil each dug from an area 1 m x 1 m x 0.15 m) were taken from two, Kadwali Chotti village and Dahod, and analysed by a soils laboratory in Morningside, Queensland, Australia (Incitec Analysis Systems Ltd). They were found to be highly variable being shallow on the hills and moderately deep in the valleys, and ranged in texture from sandy to clay loam. Results from laboratory analysis showed that the soils have high pH (7.0 to 7.6), low nitrogen content (4.4 to 5.8 mg/kg) and are low in potassium (0.25 to 0.38 meq/100 g) (Annex 1). Electrical conductivity tests show no evidence of salt problems (0.3 to 1.0 s/m) and the ESP (0.4 to 2.36%) indicates no structural problems to impede drainage in the soils tested.

Results from transect walks around Kadwali Chotti and Potaliya, and later through the other study villages, indicated that the soils in and around the village comprised of four main soil types: red, black, brown/black and sandy. Further scoring exercises showed land-use divided into four main categories: forest land; pasture land; cultivated land and uncultivated land (Figure 2.8).

A significant proportion of village land in the project area is classified as *forest* land (36%). The soil types within the *forest* areas are predominantly red (19%), with significantly less area covered by brown/black (9%), sandy (5%) and black soils (3%).

Almost half (46%) of the total land area is classified as *cultivated*. The amount of red soil (14%) is similar to that found in the *forest* lands, but significantly higher than found on *pasture* (6%) or *uncultivated* lands (4%). The equal proportions of black (15%) and brown/black (16%) soils present on the *cultivated* lands are significantly higher than in any of the other land-use classifications.

Pasture land (10%) and *uncultivated* land (8%) encompass significantly less of village areas and in each the proportions of soil types are similar.

2.2.4 Resource Characterisation from Specific Issues using FGDs

During the period when workshops were being held in the other villages, the author and a translator returned to Kadwali Chotti and Potaliya one month after the initial meetings were held, and with the help of the two COs, followed-up on information obtained during the previous meeting.

Focus group discussions were used to collect and record more detailed information on the importance and use of fodder resources among the village groups. Specific issues selected for discussion were:

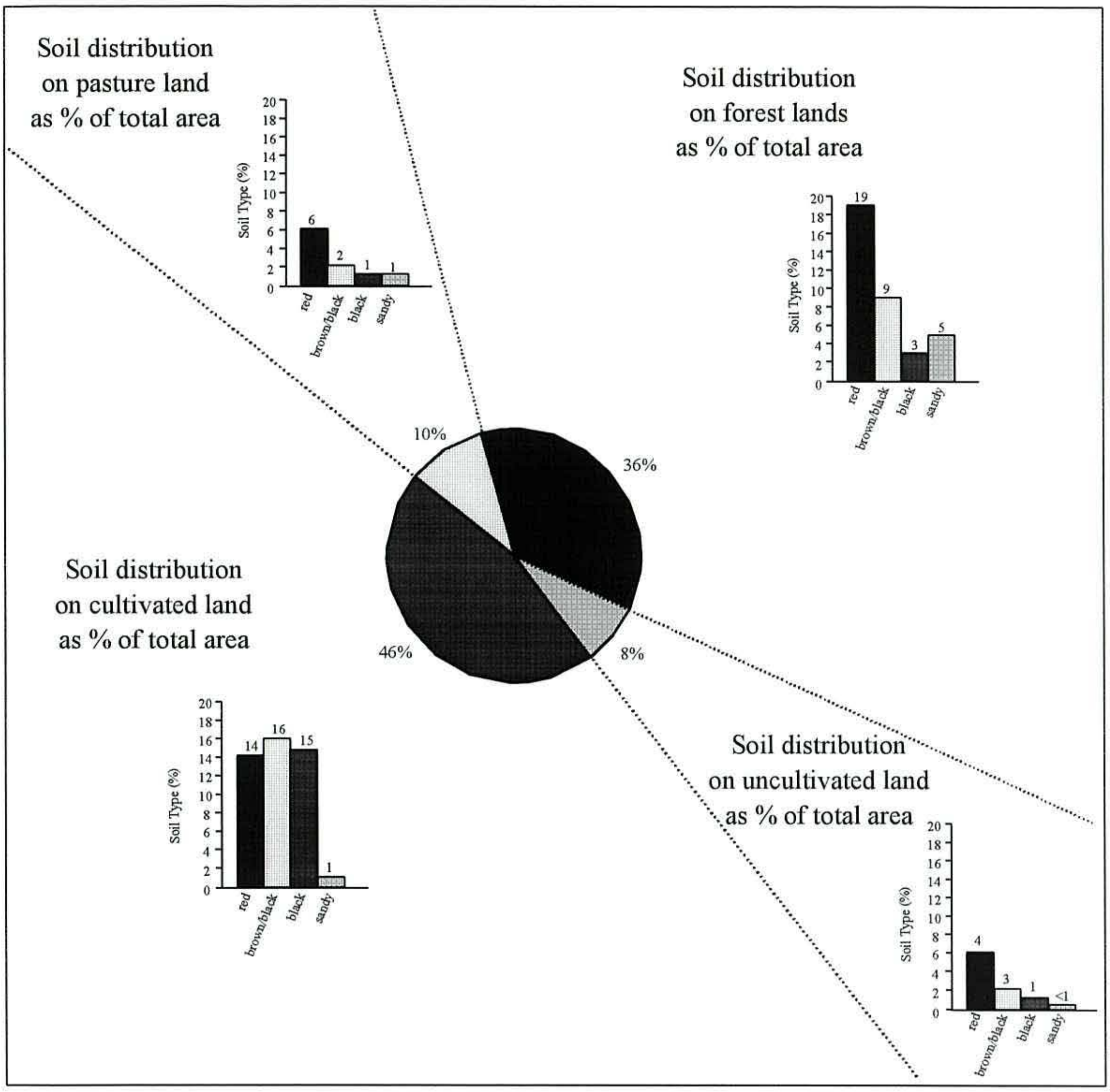


Figure 2.8 **Distribution of soil types within each land-use category found in ten villages of the study area (1995).**

- present availability and use of fodder resources in the village;
- importance of grasses and legumes as a fodder in the community;
- importance of grasses collected from forest land.

Meetings were held during daylight hours lasting 4 to 6 hours in each village. Villagers were informed of the investigative team's visit 3 to 5 days prior to the meeting – the exact day depended on when the community was free to participate in the discussions.

Exercises during focus group discussions (FGDs), including yearly time lines[1] and

[1] *Time line: A line was drawn on a large piece of paper with the 12 months of the village calendar year written along the bottom of the line. Livestock grazing patterns and fodder harvesting strategies during the year were allocated to each month.*

matrix ranking were conducted with villagers to collect information on activities relating to seasonal grassland fodder use. Sixteen groups of farmers (10 to 20 participants per group) in 10 different villages were involved with discussions. Six of the village groups in six villages included only women, and the other four villages included groups with both men and women. The rest of the groups involved only men. This opportunity was also used to record information on fuelwood collection and use in Kadwali Chotti and Potaliya.

2.2.4.1 Present Availability and Use of Fodder Resources in the Village

Results from the FGDs conducted to help characterise monthly/seasonal access to and use of fodder resources amongst village groups indicated that grazing and harvesting timings were similar in all ten of the villages in the study (Table 2.7).

Table 2.7 Results from focus group discussions conducted in ten study villages showing similar timing for grazing and cut-and-carry in each village during the year (1995).

village	restricted grazing	partial grazing	open grazing	cut and carry
Kadwali Chotti	July to Sept	Oct to Feb/Mar	Mar/Apr to June	Aug to Mar/Apr
Potaliya	July to Sept	Oct to Feb/Mar	Mar/Apr to June	Aug to Mar/Apr
Bar	July to Sept	Oct to Mar	Apr to June	Aug to Mar
Dungra	July to Sept	Oct to Mar	Apr to June	Aug to Mar
Ratanmal	July to Sept	Oct to Feb	Mar to June	Aug to Mar
Malmahudi	July to Sept	Oct to Feb/Mar	Mar/Apr to June	Aug to Mar/Apr
Amli	July to Sept	Oct to Feb	Mar to June	Aug to Mar
Kikalveri	July to Sept	Oct to Feb/Mar	Mar/Apr to June	Aug to Mar/Apr
Baheria	July to Sept	Oct to Feb/Mar	Mar/Apr to June	Aug to Mar/Apr
Ranjitgarh	July to Sept	Oct to Feb/Mar	Mar/Apr to June	Aug to Mar/Apr

Detailed information collected during household surveys in Kadwali Chotti and Potaliya indicated fodder availability and use throughout the year revealing slight variations between well-being categories (Figure 2.9).

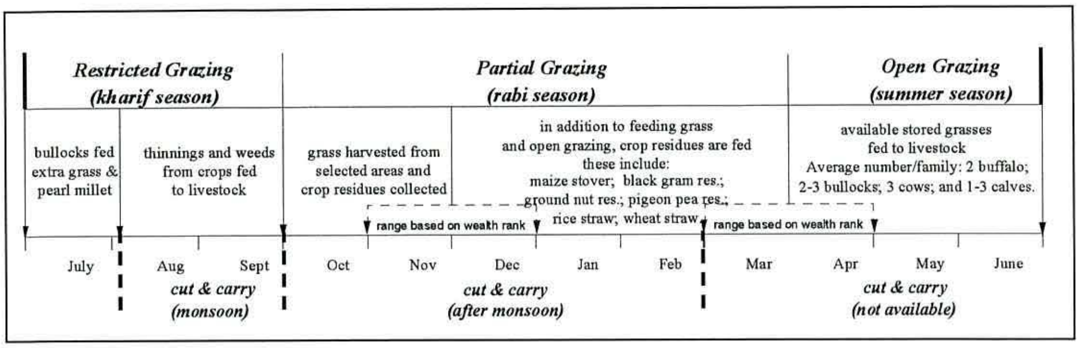


Figure 2.9 Household surveys from Kadwali Chotti and Potaliya in Rajasthan show similar grazing patterns and fodder utilisation both between villages and between the wealth-ranked categories within each village (1995).

Grazing is generally restricted to designated pasture areas or open forest areas during the monsoon (*kharif*) season when most of the other land in the village is cultivated. To allow draught animals to regain strength before they are required to pull ploughs for cultivating cropping areas, it is common practice to save good quality fodder over the summer season and then feed it to the draught animals for the few weeks leading to the beginning of the monsoon. During the rest of the monsoon period, there is an abundance of grasses and weeds cut-and-carried from the cultivated areas, and regenerating grasses and legumes growing in pasture lands and open forest areas.

During the *rabi* season, grazing is extended to the areas where the *kharif* crop (June/July to September/October) has been harvested but no *rabi* crop (October to March) has been planted. Specific grassland areas are protected toward the end of the monsoon and native grasses are harvested and stored at the beginning of the *rabi* season in October/November. During this period, livestock benefit from foraging on crop residues that have been left in the field, and the weeds that survived the *kharif*. Availability of fodder quickly diminishes as the *rabi* season ends and the summer season (April to June) approaches with decreasing soil moisture and increasing temperatures. After the *rabi* crop is harvested, livestock are allowed access to most areas including open forest, pasture and cultivated lands.

Similarities were also found in fuel sources used during the year between Kadwali Chotti and Potaliya as well as within the three well-being groups. Fuelwood is the major fuel source during the three-month monsoon and dung, along with some crop residues and tree branches, is the main source during the rest of the year (Figure 2.10)

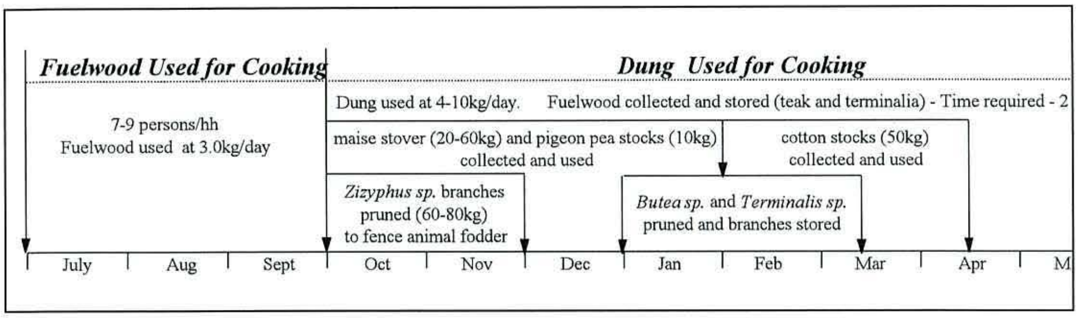
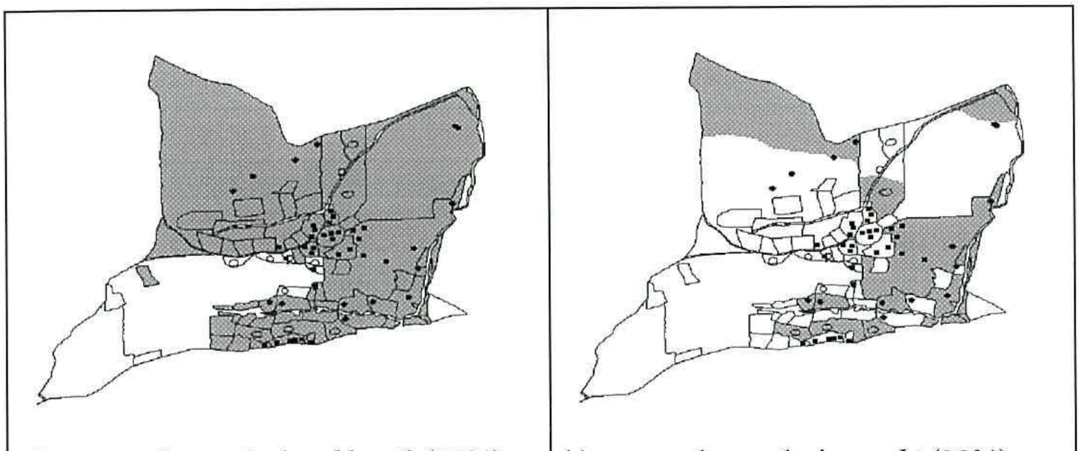


Figure 2.10 Fuel sources collected and used during the year in Kadwali Chotti and Potaliya villages, Rajasthan (1995).

To provide a more detailed analysis of cropping patterns, seasonal grazing patterns, fodder and crop residue availability and land ownership, a detailed household survey was conducted in Kadwali Chotti and Potaliya to obtain more detailed information on availability and use of fodder, and land-use between well-being categories throughout the year. Limited information was also collected on fuelwood since tree fodder was a consideration in the research strategy. A random sample (>20%) of households within each of the well-being categories was surveyed. In the case where the number of households within a category was low (<15), a minimum number of three random households were questioned. Revenue maps were used during each exercise to help determine ownership and management of land within each of the villages. The maps were then digitised by the author with the aid of a colleague back in the UK using GIS software, and the information collected was stored in an associated database.

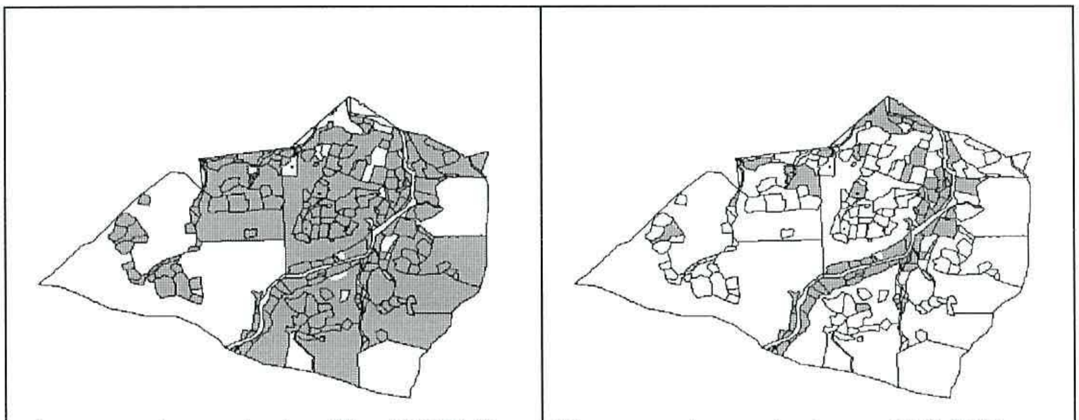
Seasonal cropping patterns – Results from FGDs conducted in Kadwali Chotti during the 1995/96 cropping season indicated that 75% of the village area was cropped during the *kharif*. Almost 30% of this area was again cropped during the *rabi* season (Figure 2.11).



a) cropped area during *kharif* (75%) b) cropped area during *rabi* (29%)

Figure 2.11 Shaded area indicates the high proportion (% of total) of Kadwali Chotti village cropped during the *kharif* compared to the low proportion during the *rabi* season (1995). (Dots indicate location of individual houses).

In Potaliya, over 60% of the land was cropped in the k*harif* season. Almost 20% of the cropped area again was cropped in the *rabi* season (Figure 2.12).

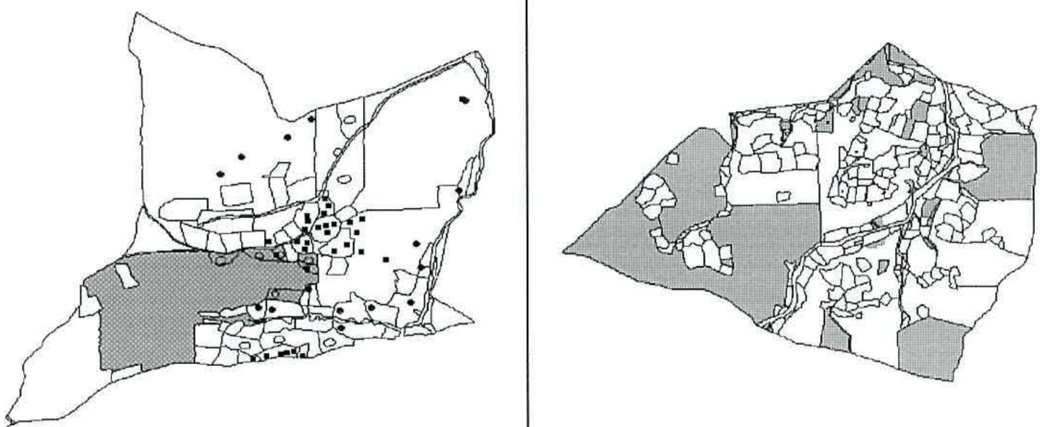


a) cropped area during *kharif* (63%) b) cropped area during *rabi* (18%)

Figure 2.12 Shaded area indicates the high proportion (% of total) of Potaliya village cropped during the *kharif* compared to the low proportion during the *rabi* season (1995).

In both case studies, similar proportions of land were cultivated in the *kharif* (Kadwali Chotti 75% and Potaliya 63%) and *rabi* (Kadwali Chotti 29% and Potaliya 18%). Timing and amount of rainfall, infestation of pests and disease, and market prices determined the amount of land area cultivated, and the type of crop planted. This in turn determined the type and amount of crop residues available for feeding livestock during the *rabi* and summer season.

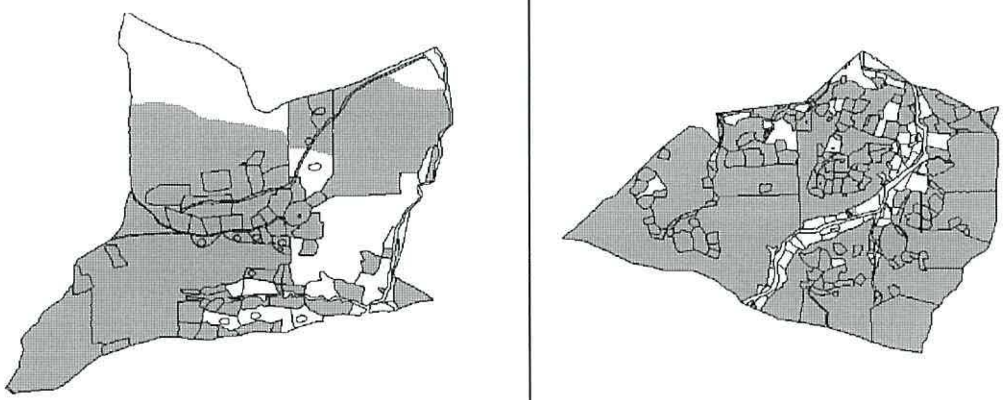
Seasonal grazing patterns - During the monsoon season in the *kharif*, grazing is usually restricted to specified pasture areas (usually common property resource areas) inside the village (Figure 2.13 & 2.14). If carrying capacity is inadequate, grazing usually extends to open forest land outside the village boundaries.



a) grazing area during *kharif* in Kadwali Chotti (17%)

b) grazing area during *kharif* in Potaliya (25%)

Figure 2.13 Shaded area indicates similar proportion (% of total) of (a) Kadwali Chotti and (b) Potaliya used for grazing during the *kharif* season (1995).



a) grazing area during *rabi* in Kadwali Chotti (72%)

b) grazing area during *rabi* in Potaliya (87%)

Figure 2.14 Shaded area indicates similar proportion (% of total) area (a) Kadwali Chotti and (b) Potaliya used for grazing during the *rabi* season.

After the *rabi* harvest (March/April) and until the onset of the monsoon (June/July), very little vegetation is available for grazing. During this period, livestock depend on additional fodder supplied from grasses that were cut-and-carried at the beginning of the previous *rabi* season (October/November), and from crop residues stored after the previous years harvest.

Fodder grasses and crop residues - The land area designated as pasture in Kadwali Chotti (*kharif* 17% and *rabi* 72%) and Potaliya (*kharif* 25% and *rabi* 87%) is similar in proportion. The main differences within each village and between villages were the type and amount of fodder available per household (Figure 2.15).

The 'resource-poor' group in each village harvested significantly less grass than the corresponding 'moderate' and 'resource-rich' groups. Differences were also indicated in the amount of crop residues available for livestock during the year. Maize stover was the main crop residue used by 'resource-poor' farmers. Several other types of crop residues were used as livestock feed by 'moderate' and 'resource-rich' farmers.

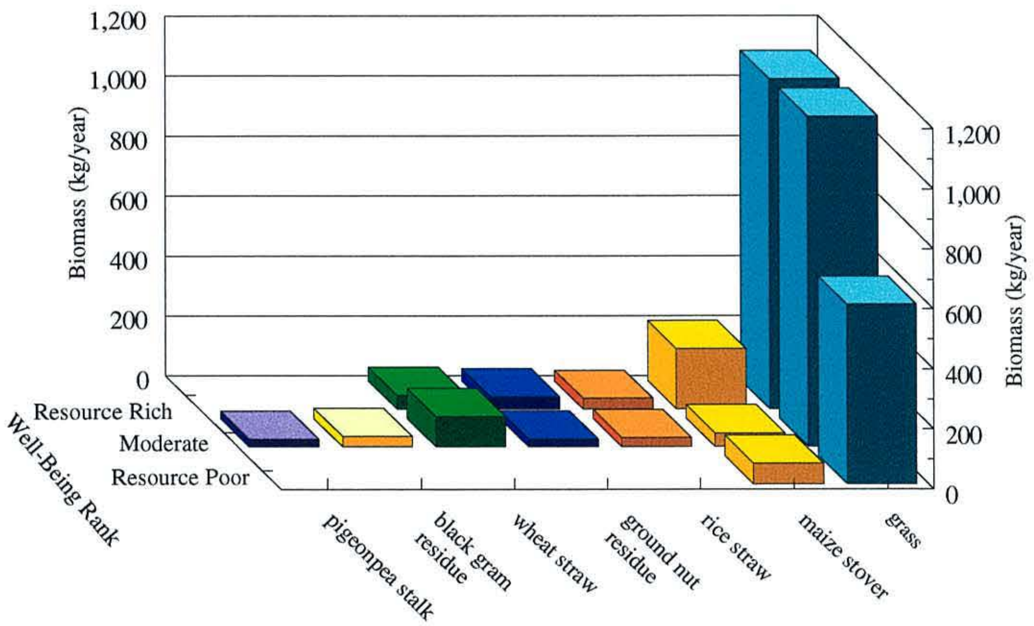
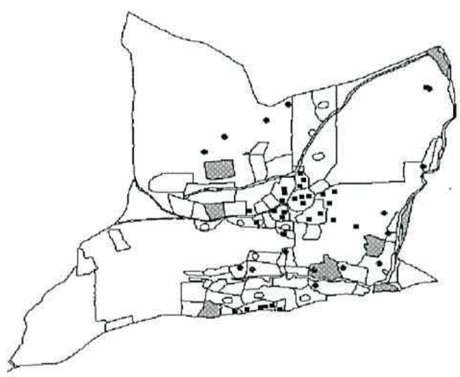


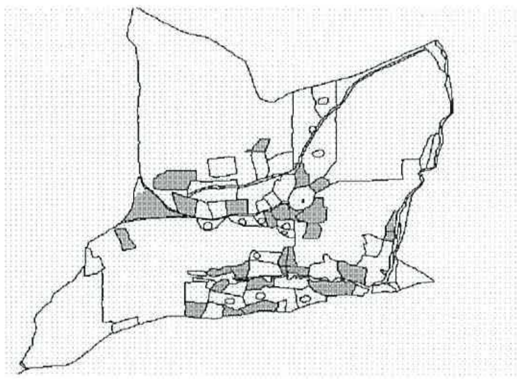
Figure 2.15 Range and amount of fodder used per household within each wealth ranked group in Kadwali Chotti and Potaliya villages, Rajasthan (1995).

The proportion of land designated for specific crops determines the type and amount of crop residue available to be stored and fed to livestock during the *rabi* and summer seasons. Survey information from Kadwali Chotti showed that maize (35%) or pearl millet (15%) and rice (36%) during the *kharif*, and wheat (12%) during the *rabi* cover the largest proportion of land area and provide the majority of crop residues for animal fodder. Black gram and chick pea supplement the diet after maize stover is depleted and before wheat straw is available.

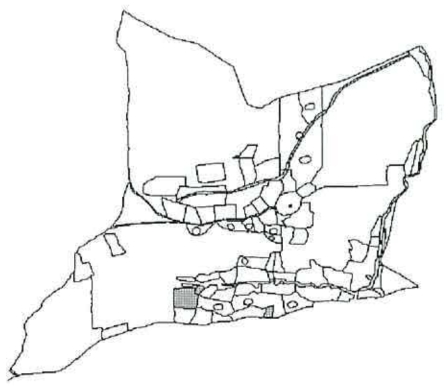
Land ownership - The difference in type and amount of livestock fodder used by farmers in each wealth rank group is related to the area of cultivated land available for cropping, as well as accessibility to resources from forest, pasture and uncultivated land.



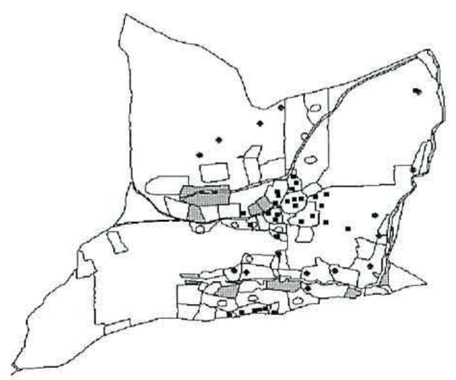
a) owned by resource rich farmers (3%)



b) owned by medium farmers (10%)



c) owned by resource poor farmers (1%)

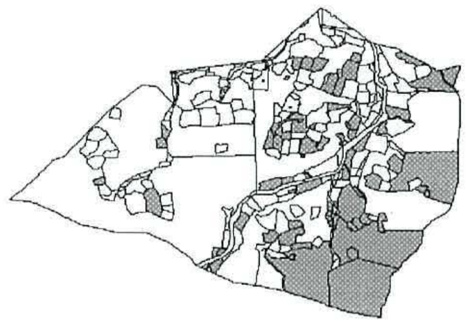


d) owned by outsider (3%)

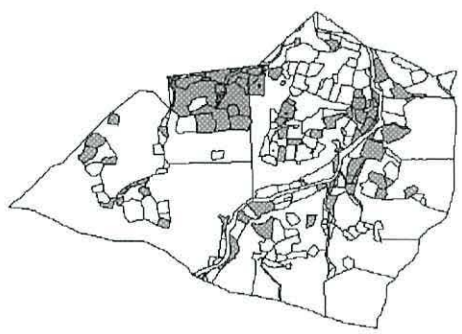
Figure 2.16 Shaded area indicates low (17%) proportion (% of total) of area in Kadwali Chotti managed privately by single households for all well-being groups (1995).

In Kadwali Chotti, the proportion of land owned and managed by individuals within the village is small compared to the total land area cultivated in the village (Figure 2.16 a-d).

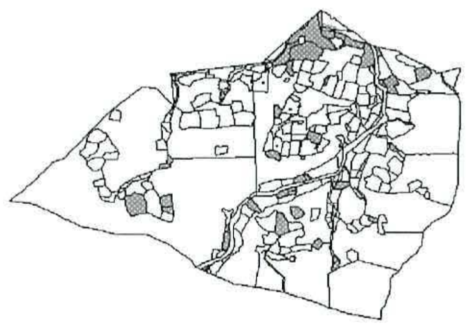
In contrast, a high proportion of Potaliya village is privately owned and managed by individual households (Figure 2.17a-d).



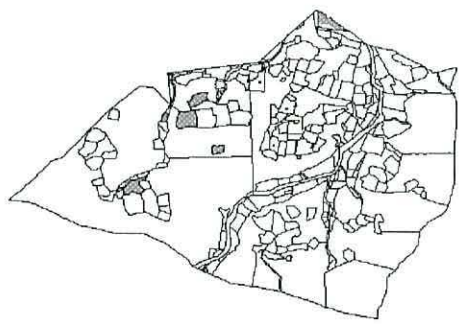
a) owned by resource rich farmers (25%)



b) owned by medium farmers (14%)



c) owned by resource poor farmers (6%)



d) owned by outsider (2%)

Figure 2.17 Shaded area indicates a higher (47%) proportion (% of total) of area in Potaliya managed privately by single households within each wealth rank group (1995).

The management of a large proportion of village land is shared between two or more households in Kadwali Chotti (Figure 2.18), where as in Potaliya, a much smaller proportion of the land area is managed by village groups consisting of two or more households (Figure 2.19).

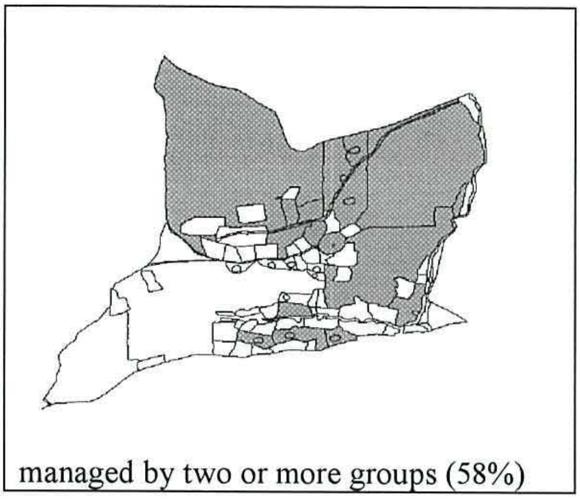


Figure 2.18 Shaded area indicates a high proportion (% of total) of area in Kadwali Chotti managed jointly by households within or between different groups (1995).

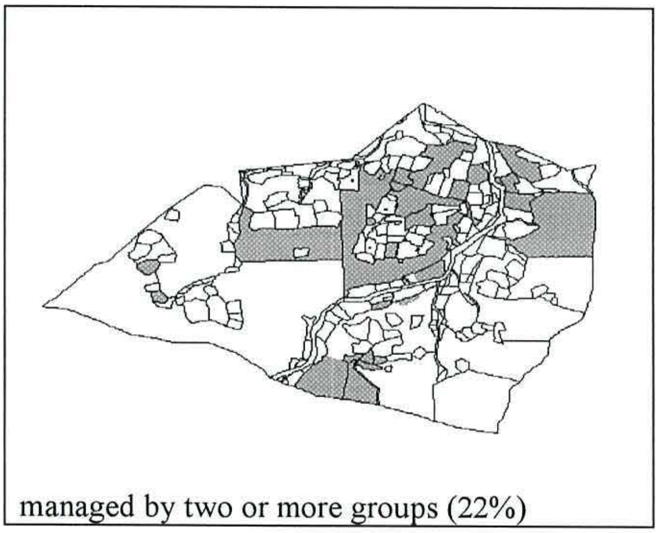


Figure 2.19 Shaded area indicates the comparatively low proportion (% of total) of area in Potaliya managed jointly by households within or between different groups (1995).

2.2.4.2 Importance of Grasses and Legumes as a Fodder in the Community

To determine the importance and use of grass as a fodder among the village groups, focus group discussions were conducted outside the two main study villages and involved 16 groups of farmers from a mixture of wealth-ranked groups in ten study villages. Topics for discussion related to importance of species within each of the three fodder categories previously identified according to harvesting method and fodder availability. A matrix ranking[2] was use to determine preference of each species selected by the villagers relating to its importance for utilisation.

FGDs were conducted to determine the importance of grass as a fodder among the village groups concluded that the most preferred grasses for cut-and-carry during the monsoon was *Echinochloa* without exception (Table 2.8).

Table 2.8 Species preference by sixteen focused groups for cut-and-carry grasses during the monsoon in the study area (1995).

	preference (% of groups)		
species	**1st**	**2nd**	**3rd**
Echinochloa	100	--	--
Digitaria	--	38	31
Others*	--	62	69

* including *Dichanthium*, *Cynodon* and *Tephrosia*

Three main reasons were given for its high ranking: high nutritional value and good palatability; early plant growth at the beginning of the monsoon; high production of biomass due to high regeneration capacity. *Digitaria* was the second and the third most preferred species depending on the group involved in the discussions.

After the monsoon and during the *rabi* and summer seasons, two species: *Heteropogon* and *Themeda* were selected as the most important fodder grass species (Table 2.9). *Heteropogon* was considered important because of its availability and nutritional value, and *Themeda* was considered important only because of its availability during this period. Nutritional quality of *Themeda* was considered poor.

Among the 16 separate focus groups, *Heteropogon* was selected as 1st preference by 69% and the remaining 31% selected it as 2nd choice identifying *Themeda* as preferred. Preferences for other species depended on regional availability.

[2] *matrix ranking involves asking the groups to list grass species in order of preference along the y-axis of a grid, and then asking them to select the preferred grass in order of importance along the top of the grid.*

Table 2.9. Species preference by sixteen focused groups for cut-and-carry grasses after the monsoon in the study area (1995).

	preference (% of groups)		
species	1st	2nd	3rd
Heteropogon	69	31	--
Themeda	31	44	19
Sehima	--	13	31
Dichanthium	--	6	19
Others	--	6	31

Several native grass and legume species that were grazed by livestock during open grazing periods were identified (Table 2.10).

During the *kharif*, livestock are restricted to grazing uncultivated lands not set aside for production of cut-and-carry grass. Several species, particularly *Heteropogon, Dichanthium*, *Sehima* and *Digitaria* produce a flush of re-growth as soon as the monsoon begins.

Shortly after the monsoon ends when grasses have been harvested and stored, livestock are allowed to graze residual vegetation in the previously restricted area. In addition to crop residues left in the field after the harvest, grasses such as *Digitaria* and legumes such as *Tephrosia* are grazed. For the rest of the year, open grazing is practised with few restrictions.

2.2.4.3 Importance of Grasses Collected from Forest Land

In May/June, 1995, a total of 12 groups of mixed well-being ranking were involved in FGDs in five villages. Two groups in each of three villages: Malmahuri (Rajasthan), Katarani palli (Gujarat), and Palasia pada (Madhya Pradesh); and three groups in each of two villages: Umarjhokha (Rajasthan) and Kompura (Rajasthan).

Table 2.10 Native grass species available to livestock during open grazing periods in the study area.

botanical name	local name	utilisation
Grasses		Many of these grasses are used for cut-and-carry but all are grazed by livestock in open grazing areas.
Heteropogon contortus	*lappo*	
Themeda quadrivalvis	*gundrari*	
Dichanthium annulatum	*kad*	
Sehima nervosum	*haran*	
Chrysopogon fulvus	*barevo*	
Digitaria sp.	*tikol*	
Coix lacryma-jobi	*kahi*	
Cympogon martinii	*rohya*	
Sorghum halepense	*baru*	
Apluda mutica	*tatyapeda*	
Cynodon dactylon	*dravni*	
Iseilema laxum	*kadwali*	
Legumes		Most are considered weeds and are only grazed by livestock throughout the year.
Cassia tora	*kuad*	
Indigofrea sp.	*pappdhi*	
Melilotus indica	*chara*	
Tephrosia sp.	*papdi*	
Others		
Euphorbia hirta	*dudhi*	
Boerrhavia diffusa	*takani*	
Tridax procumpens	*pilwa*	
Celosia argentea	*gaharea*	
Cocculus hirsutus	*lasedi*	
Borreria hispida	*gathio*	
Borreria stricta	*gadhio*	
Amarantus sp.	*khatti bhaji*	

Villagers were informed that a team would be visiting their village several days prior to the meeting to ensure that the community was able to participate in the discussions. All meetings lasted six to eight hours during daylight. Non-timber products regularly harvested from the forest areas were ranked in order of importance, and each product was discussed in detail with facilitation from project staff. A total of 357 households were represented in the discussions covering a total forest land area of 678 hectares.

The forest land in the project area is of major importance as the source of a variety of products considered essential components to the livelihoods strategy. Among these, grasses are considered as the most important product (Table 2.11).

All 12 groups selected grasses as either their first (75%) or second (25%) preference of importance[3]. Leaves, seed and medicines were also selected as important by every group. Fruit was important to 11 groups, and gums were selected by 10 groups, 25% selecting this resource as their second preference. Fuelwood was first preference for 2 groups, second preference for 1 group and third preference for 3 groups. However, 33% of the groups did not consider fuelwood an important forest product and did not include it in their list. The remaining products selected are presently of lesser importance. Nevertheless, the potential for improving production/processing techniques or marketing strategies may significantly increase the ranking of these products.

Table 2.11 Forest products ranked in order of use and importance during 16 separate focus group discussions in ten villages (1995).

important forest products (number of groups)	1st (%)	2nd (%)	3rd (%)	4th (%)	< 4th (%)	not important (%)
1 grasses (12)	75	25	---	---	0	0
2 leaves (12)	8	42	33	8	8	0
3 seeds (12)	---	---	25	58	17	0
4 medicine (12)	---	---	8	17	75	0
5 fruit (11)	---	---	---	8	83	8
6 gum (10)	---	25	0	8	50	17
7 fuelwood (8)	17	8	25	0	17	33
8 honey (8)	---	---	8	0	58	33
9 vegetables (5)	---	---	---	---	42	58
10 rope (4)	---	---	---	---	33	67
11 *lac* (3)	---	---	---	---	25	75
12 flowers (3)	---	---	---	---	25	75

Grasses are considered the most important product collected from the forest areas. All 12 groups use grass collected from the forest areas for both household use and for sale. Among the species selected, *Heteropogon* and *Themeda* dominate as being most important (Table 2.12).

[3] Importance here was related to the benefits obtained by the household.

Table 2.12 Groups (%) preference for selected grass species considered as important assets collected from forest lands (1995).

grasses (% based on 12 groups)	1st (%)	2nd (%)	3rd (%)
Heteropogon contortus	67	33	---
Themeda quadrivalvis	33	50	17
Sehima nervosum	---	---	50
Dichanthium annulatum	---	8	17
Digitaria ciliaris	---	8	8
Tephrosia spp.	---	---	8

Trends indicate that since initiation of the JFM scheme in the forest areas, there has been an overall increase in production of grass biomass by 30 to 50%. However, it is expected that over the next five years, there will be a significant reduction in *Heteropogon* (50 to 75%) and *Themeda* (50 to 90%), while at the same time, the availability of *Sehima* and *Dichanthium* will increase if light is not restricted.

Fuelwood is an important resource for over 60% of the groups. Branches and shoots from a number of species are used as fuel by several groups. One species in particular, *Holarrhena antidysenterica*, is the preferred source of fuelwood collected from the forest areas (Table 2.13).

Availability of fuelwood has increased significantly over the last few years. Protection of the forest areas has facilitated regeneration of indigenous root stocks, and increased availability of branches for fuel. With proper management of trees, including proper pruning regimes and selective coppicing, availability of fuelwood and leaves that could be used as a source of fodder will continue to increase over the next few years.

Table 2.13 Groups (%) preference for fuelwood collected from forest lands (1995).

fuelwood (% based on 8 groups)	1^{st} (%)	2^{nd} (%)	3^{rd} (%)
Holarrhena antidysenterica	75	13	---
B. monosperma	---	38	38
(Kakria)	---	25	13
T. grandis	13	13	25
Prosopis juliflora	13	---	---
Wrightia tinctoria	---	---	17
B. sarrata	---	13	---

After jointly developing the study area profile and characterising fodder resources presently used, discussions were held at community meetings with regard to implementing interventions that would potentially increase fodder availability and improve fodder quality in the study villages. Village groups were elected by the community to oversee project activities, and village areas allocated by the villagers for testing interventions.

CHAPTER 3
TEST INTERVENTIONS AND TRIALS FOR GRASSLAND IMPROVEMENT

Chapter 3 focuses on a series of test interventions and experimental trials conducted over a period of three years after the initial appraisals had been conducted. Three main options to improve grasslands in the study area are presented:

The first option presented investigates changes in the management of grasslands (3.2). Three activities are presented.

(i) Results from an intervention to protect openly-grazed grasslands highlight the potential benefits on biomass production and succession of native species (3.2.1).

(ii) The benefits that changes in the harvesting time would have on the quality of native grasses obtained from and experimental trial (3.2.2).

(iii) Results from a laboratory experiment looking at seed germination and how it relates to the seed bank potential along sloping lands (3.2.3).

The second option investigates introduction of germplasm for grasses (3.3). Again three activities are presented.

(i) An investigation into direct seeding of several grass species in protected areas (3.3.1).

(ii) An experiment to test germination of seed contained in earthen pellets (3.3.2).

(iii) The perceptions of villagers on producing grasses in village nurseries before outplanting in the monsoon season (3.3.3).

The third option explores introduction of germplasm for woody legumes, specifically *Leucaena* species (3.4). Both on station and on-farm trials are presented comparing tree growth, as well as woody and leafy biomass between different taxa.

3.1 General

Group discussions proved to be invaluable for involving of villagers in issues raised during the appraisal period. Using this approach continued to benefit the exchange of ideas during design and implementation of interventions and trials using a range of group techniques including non-focus group discussion interviews, but the most productive in identifying practical methods for interventions were FGDs. Interactive discussions based on a series of open-ended questions during the FGDs relating to the agreed topic of increasing availability of and improving access to fodder resources, resulted in a range of possible interventions.

In the first year, the interventions for potentially increasing fodder availability and improving fodder quality in Kadwali Chotti and Potaliya were narrowed down to the three main activities. These were: by changing current management practices but without specific enrichment measures; by supplementing existing regeneration with improved grass species; by introducing woody legume species to provide a high quality forage.

All of the options involved protection of village plots used for the study, particularly from grazing livestock as this was one of the most important criteria to satisfy before any experimental intervention could be initiated. On private lands, individual households that chose to plant woody legume species agreed to use the branches of thorny tree species (e.g. *Ziziphus*) to fence and protect the study areas throughout the year. The branches used were usually ones collected from trees the household already possessed, and were used as a fuel source after being replaced each year. On forest land in villages other than Kadwali Chotti and Potaliya, communities established management plans in collaboration with the state forest department to protect and manage large tracts of land (50-150 ha) following government guidelines set out under the Joint Forest Management (JFM) scheme (SPWD, 1992).

With other common property areas, such as community-owned open grazing lands, procedures were developed with the communities in Kadwali Chotti and Potaliya to select and establish suitable common property resource (CPR) areas for regeneration of local species and establishment of introduced species. Securing protection of planted areas was a major limitation in establishing vegetation in the village areas.

Experimental plots were planted at the beginning of the monsoon in June/July 1995. Subsequent experiments were included in 1997 and 1998 to address issues arising during discussions and evaluation of interventions.

3.2 Management Options

As previously mentioned, one of the major limitations to vegetative re-growth in the semi-arid areas of India is the unrestricted grazing which has lead to degradation of grasslands containing unpalatable weedy species (Pandeya, 1988). One of the most effective methods of facilitating regeneration is by protecting areas from livestock grazing using the most cost-effective physical fencing such as cattle trenches or stone walls (Kanodia and Patil, 1982), or a social fence where the community agrees to protect the selected area by vigilance (Singh, 1994). In reality, a certain degree of both are usually required to ensure adequate protection.

In addition to increased production of herbage yields (Tandon *et al.*, 1982), protection has resulted in an increase in forage quality by the increase in the number of palatable grasses and reduction in the amount of undesirable forbs (Trivedi and Kanodia, 1982). The extent to which this occurs will depend on the regeneration capacity of the area which includes density of perennial rootstocks and the viability of soil seed.

During discussions pertaining to information on fodder availability obtained during the appraisal period at Kadwali Chotti in April 1995, villagers were asked for suggestions on how interventions to develop fodder resources discussed earlier could be implemented in the village. The question was left with the villagers to discuss among them selves. After returning to the village a few days later, the research team found that the villagers had selected a portion of land within the village, commonly used for open grazing, to protect and use for growing grasses and trees. The study was concerned that with the resulting decrease in the area for grazing, the cattle would not have enough fodder, particularly during the *kharif*. However, the villagers had already considered this and had selected another part of the village to take their animals for grazing during this period in question. Even though the amount of fodder would be insufficient for cattle during the first year, the potential benefits of protection were realised for the following season.

The group agreed that half of the wages paid to the villagers for work done in establishing the CPR area was deposited into a CPR bank account. This money was used to pay for the *Chokida* to help watch over and protect the area. During a village meeting, five members of the village were appointed as the CPR executive body whose main responsibility was to manage the CPR area on behalf of the village.

The committee opened a bank account into which half of the payments for work done establishing the area were deposited. The account was operated by two signatories from the village executive committee along with a member of the research staff.

The cost for establishment of the protected area (5 ha) totalled Rs15,000. This included Rs12,000 for digging a cattle trench around the perimeter, and Rs3,000 for planting *Prosopis juliflora* seedlings on the bund beside the trench for additional protection. A similar approach was used in Potaliya.

Three aspects of management practice were investigated:

- Protection measures;
- Harvesting times;
- Seed bank potential in relation to topographic position.

3.2.1 Protection Measures

Common property resource areas, including the panchayat land, the revenue land and forest land of the study area, have proven to be a major source of fodder grasses for livestock throughout the year. However, severe grazing has resulted in replacement of the natural *Sehima-Dichanthium* grass cover by *Chrysopogon* and *Bothriochloa*, and subsequently by the present day *Heteropogon* and *Themeda* community (Dabadghao and Shankarnarayan, 1973).

To increase availability of fodder grasses, priority must first be given to improving land-management of production areas - the main strategy being exclusion or controlled grazing of livestock. Methodologies for activities promoting protection and development of common property resource (CPR) areas have been developed to provide pragmatic ways of implementing this strategy (Singh, 1994), but practical issues, particularly with regard to groups actions, are less understood.

The predicted outcome of protecting an area from open grazing gave a mixed response from villagers in Kadwali Chotti and Potaliya. Some thought that the dominant *Heteropogon* would continue to dominate, while others insisted that the more nutritious species such as *Sehima* and *Dichanthium* would take over. It was agreed that villagers and staff would monitor regeneration of the CPR areas to determine which was correct.

Protected CPR areas were established (Plates 3.1, 3.2, 3.3 and 3.4), and a study conducted in Kadwali Chotti over three years to determine the extent to which protection of grasslands dominated by these species facilitated re-growth from rootstocks and soil seed banks, increasing fodder grass production and availability. Changes in grass composition were also monitored.

3.2.1.1 Experimental procedure

Hypotheses: If livestock are restricted access to common property open grazing areas:

- re-vegetating local grasses could be used to increase available animal fodder within the first year;
- composition of regenerating vegetation will change in subsequent years to include a higher proportion of primary succession species.

Design: Two protected grassland areas each covering five ha (one dominated by *Heteropogon* in Kadwali Chotti, and one dominated by *Themeda* in Potaliya) were protected from grazing livestock beginning in June 1995. At the end of the monsoon (August) in the first year, a starting point was randomly

Plate 3.1 **Common grazing area selected by villagers for protection before monsoon in Kadwali Chotti, Rajasthan**

Plate 3.2 **Regeneration of vegetation in CPR area after 6 months of protection during and after monsoon.**

Plate 3.3 **Boundary area of CPR after 8 months of protection planted with caster bean (*Ricinus communis*)**

Plate 3.4 **Boundary area of CPR showing drought tolerant vegetation growing in conjunction with caster bean at the beginning of the monsoon in the second year of protection**

selected at the edge of the plots, and a quadrat (1 m^2) made from a 0.1 m x 0.2 m wooden stake was placed on the ground around the existing vegetation (Figure 3.1). Local villagers selected by the villagers for their knowledge of grasses were asked to identify the grass species within the quadrat. The accompanying villagers were then asked to estimate the proportion of ground covered by each of the selected species within the quadrate. After the information was recorded, the team walked for another 15 meters and followed the same sampling procedure. A total of 12 quadrats sampled every 15 meters in a straight-line direction.

In the second and third year after protection (1996 and 1997), quadrat data was taken from approximately the same location as in the previous year. The same sampling procedure was used for each of the 12 quadrats sampled every 15 meters along the same direction as that of the first year. Group discussions were held with the villagers after each sampling period and the grass composition of the different species in the protected area was discussed.

Away from the village, arc sine transformation for proportions was used to transform the percentage of area covered by each species within each quadrat each year and to ensure that extreme values ($30<x>70$) are a closer fit to the normal distribution. Transformed data were then subjected to analysis of variance to compare the significance of the mean for each area covered by each species within and between years.

3.2.1.2 Results

Results from ANOVA showed that there was a significant difference in the proportion of ground covered by species within each year. More importantly, however, the proportion of ground cover for some of the species changed in subsequent years.

Heteropogon dominated grasslands - During the first year of sampling, the area covered by four of the main species identified in the quadrats were of similar proportion except for *Dichanthium* which covered significantly less of the ground area (Figure 3.2).

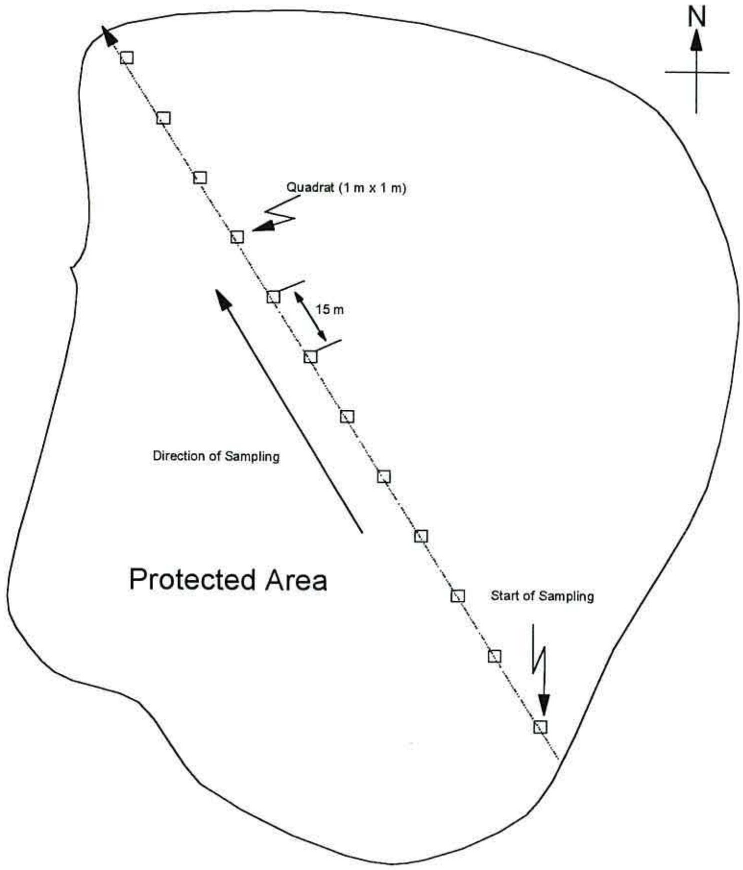


Figure 3.1 **Map of protected area (Kadwali Chotti – five ha) sampled for changes in species composition using quadrat method.**

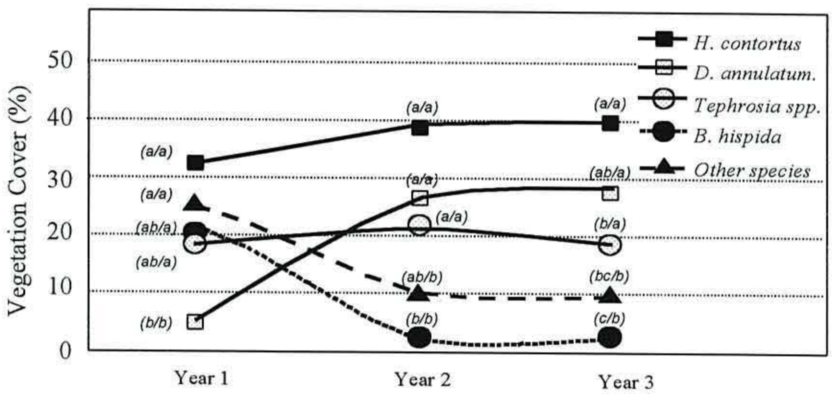


Figure 3.2 **Succession of grasses and legumes in a five-hectare *Heteropogon* dominated area protected from grazing livestock.**
(Note: different letters in the first column of the brackets indicate significant differences between species cover within each year; different letters in the second column of the brackets indicate significant differences for each species between years).

In the second year, two of the species, *Heteropogon* and *Tephrosia* remained unchanged, but *Dichanthium* cover increased significantly while *Borreria* and many of the other annual weedy species decreased from the previous year.

In the third year of the study, natural succession of the grasslands resulted in a stand comprising largely of the grasses *Heteropogon* (40%) and *Dichanthium* (27%) along with the legume *Tephrosia* (18%). The remainder of the stand comprised of small proportions of other grass species including: *Digitaria*, and common weeds such as *Borreria* and *Celosia*

Themeda dominated grasslands - During the first year, *Themeda* dominated the area. *Dichanthium*, *Sehima* and several other species, mostly annual weeds, covered the remaining area (Figure 3.3).

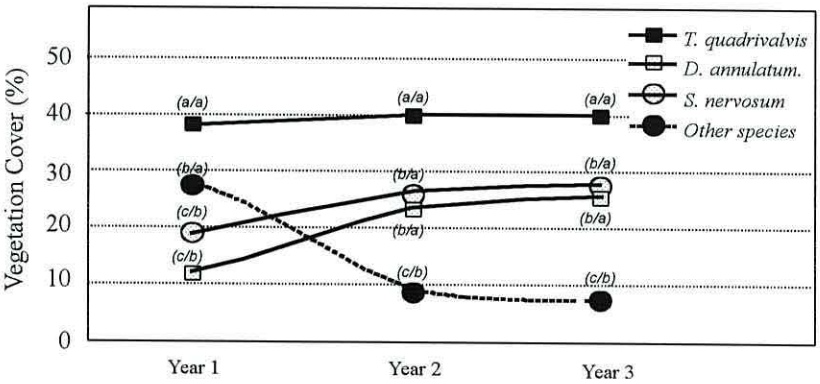


Figure 3.3 Succession of grasses and legumes in a five-hectare *Themeda* dominated areas protected from grazing livestock.
(Note: different letters in the first column of the brackets indicate significant differences between species cover within each year; different letters in the second column of the brackets indicate significant differences for each species between years).

In the second year, the proportion of *Themeda* remained the same. However, proportion of ground covered by *Dichanthium* and *Sehima* increased significantly from the year before to equal that of *Themeda*. The area covered by *Borreria* and the other annual weedy species decreased.

In the final year, the protected area was dominated by a stand of grasses comprising equally of *Themeda* (40%), *Dichanthium* (26%) and *Sehima* (28%). The other species, covering significantly less ground than in the first year, comprised 4% of the area.

3.2.1.3 Conclusions

Detailed analysis confirmed that *Heteropogon* dominance persisted throughout the experimental period. However, the percentage *Dichanthium* cover increased significantly while the percentage of cover by weeds such as *Borreria*, and other grass and legume species fell significantly over the three years of protection from grazing livestock.

Themeda was the dominant species and showed no significant changes in the proportion of the area covered during the study period. However, the proportions of both *Sehima* and *Dichanthium* showed significant increases while the percentage of cover by other grass and legume species fell.

3.2.2 Harvesting Time

Detailed information from FGDs conducted in the study villages showed that traditional cutting regime for harvesting and storage of cut-and-carry grasses involves just one cut per year after seed-set at the beginning of the *rabi* season (October/November) (Table 2.7). This is at the stage when the nutritional value of the grasses is at its lowest. As physiological age of a plant will usually determine its nutritional status, the older the plant is, the more lignin is deposited and the lower the nutritional quality of the plant for livestock (Heady and Child, 1994).

Improving quality of fodder grasses can be achieved simply by adjusting the traditional management regime and harvesting the grasses at the vegetative stage before flowering when nutrient content is high. By cutting the grass earlier in the season, an additional benefit may be obtained by taking advantage of re-growth and increasing biomass availability by harvesting the grass a second time (FAO, 1989).

The possibility of a second cut was discussed during group discussions. Although it was generally agreed that the younger grasses were more palatable before they maturing the general impression was that the biomass of the grasses would be much higher after flowering compared to before flowering. There was also some uncertainty as to the difference in nutritional quality and some doubt as to whether there would be sufficient re-growth in the season for a second cut. To investigate the effect changes in the cutting regime have on the quantity and quality of the local grasses, villagers from Kadwali Chotti and Potaliya participated in tests on cutting frequency of local species. Since *Heteropogon* and *Themeda* are the dominant grass species in the area and considered important as cut-and-carry fodder grass, experiments were conducted in areas dominated by these two species.

3.2.2.1 Experimental procedure

Hypothesis 1: If grasses are harvested before flowering, than the quality of the fodder grasses collected and used for livestock will be higher than if collected after flowering.

Hypothesis 2: If cut-and-carry grasses are cut twice in a season, then the total biomass and nutritional quality of the fodder grasses harvested will be higher than if harvested using the traditional practice of only one harvest per season.

Design: To compare the amount of grass biomass cut twice in one season with that cut only once, two locations were selected: an area dominated by *Heteropogon* in Kadwali Chotti, and an area dominated by *Themeda* in Potaliya. Experimental plots were established at the beginning of the monsoon in July 1996 in each of the areas. Each plot (11 m x 16 m) was divided into 6 equal sections each measuring 4.0 m x 4.0 m (Figure 3.4).

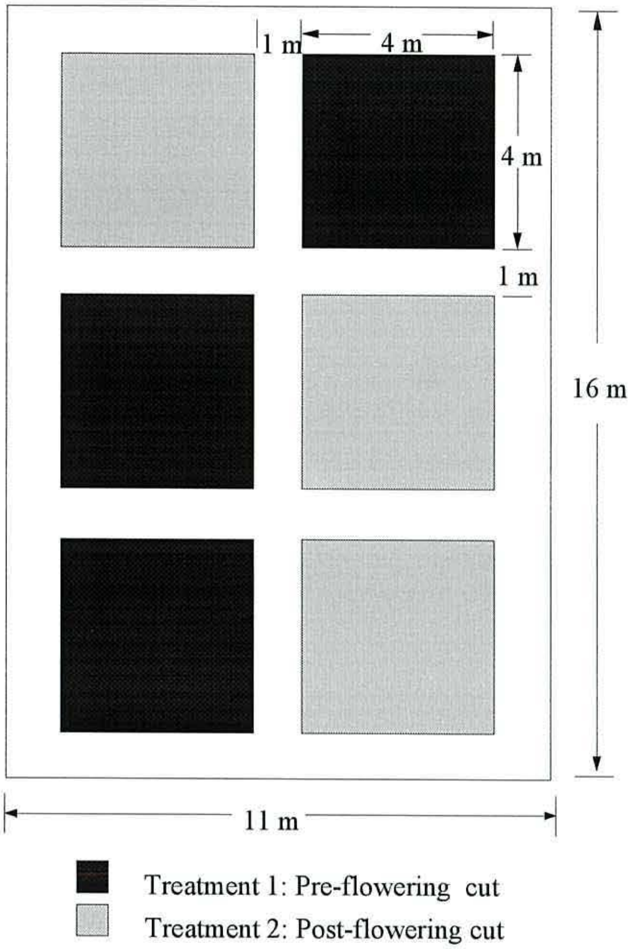


Figure 3.4 Layout of experimental plots used to measure differences in biomass and crude protein of grasses under two cutting regimes.

One of two treatments was randomly assigned to each of the experimental plots: 1) Pre-flowering - cut at the vegetative stage in September, and 2) Post-flowering - cut after seed dispersal in November, with three replicates each.

Before flowering after the *kharif* season (September), a 1.0 m^2 quadrat frame was placed at random within the designated $4m^2$ area for each of the three replicates of Treatment 1. The grass was then cut by one of the villagers using a hand sickle, a traditional harvesting tool, in Treatment 1 blocks in the three replicates of both experimental plots. As the grass was cut, each species was identified and separated before weighing.

The fresh biomass of each species was weighed immediately after collection, and then sun dried for three days before being weighed a second time. A sample (500 g) of each species of sun-dried grass was then stored in sample bags and sent for protein analysis using ammonium nitrogen digestion - Kjeldahl method (MAFF, 1985).

At post-flowering at the beginning of the *rabi* (November) when villagers traditionally cut grass for storage, the grass in Treatment 2 blocks were cut using traditional harvesting methods in all replicates in both experimental plots. Sampling and recording procedures were followed as in Treatment 1. At the same time, vegetative re-growth in Treatment 1 blocks was cut again and biomass measured.

Analysis: ANOVA was used in a 2 x 3 factorial design to compare differences in biomass and changes in crude protein within species between cutting treatments within each of the experimental plots. One-way ANOVA was used to determine significance between treatment means.

To illustrate changes in quantity and quality from pre- to post-flowering periods, biomass measurements and crude protein % for each species was extrapolated from the experimental results and reported as kg per ha.

3.2.2.2 Results

Hypothesis 1 - Statistical analysis showed that total biomass harvested from the two experimental plots in Kadwali Chotti and Potaliya was less at the post-flowering stage than at the pre-flowering vegetative stage (Figure 3.5).

Detailed analysis of the *Heteropogon* dominated plots showed that while biomass remained the same for both Treatments, there was a significant decrease in *Dichanthium* biomass at post-flowering in Treatment 2 (Figures 3.6).

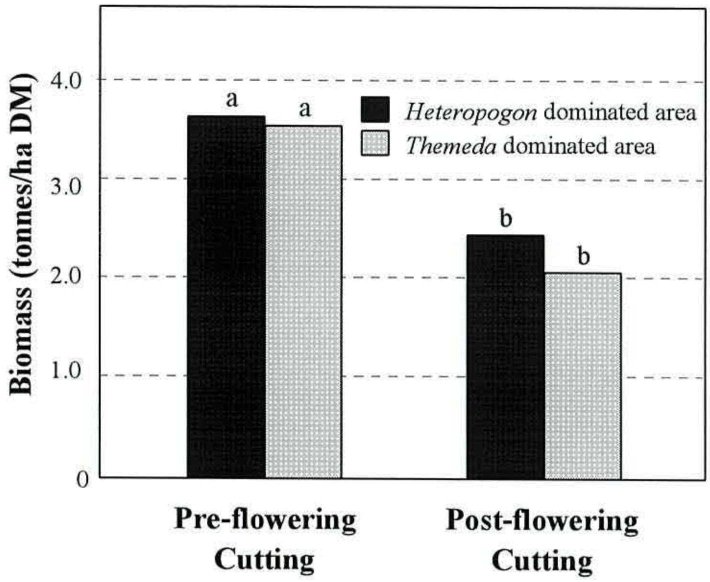


Figure 3.5 **Total biomass of grasses under two Treatments (pre- and post flowering) harvested from two experimental plots.**

Analysis of the *Themeda* dominated plots also showed that there was no difference in biomass between pre- and post-flowering *Themeda*. However, both *Dichanthium* and *Sehima* provided significantly less biomass post-flowering (Treatment 2) compared to pre-flowering in Treatment 1 (Figure 3.7).

Crude protein content decreased significantly between the pre-flowering and post-flowering Treatments for both *Heteropogon* (Table 3.1) and *Themeda* (Table 3.2).

Calculated on a per ha basis, analysis showed that total crude protein harvested from the two experimental plots in Kadwali Chotti and Potaliya was less during post-flowering than at the pre-flowering vegetative stage (Figure 3.8).

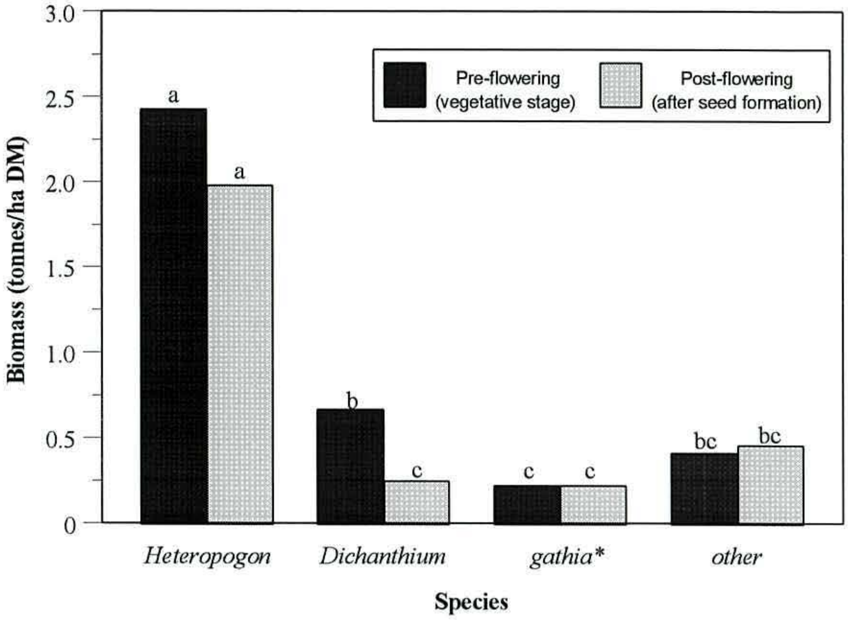


Figure 3.6 **Changes between plant biomass harvested before flowering and after seed formation in *Heteropogon* dominated grasslands.**
(Note: different letters indicate significant differences within and between species at p<0.05).

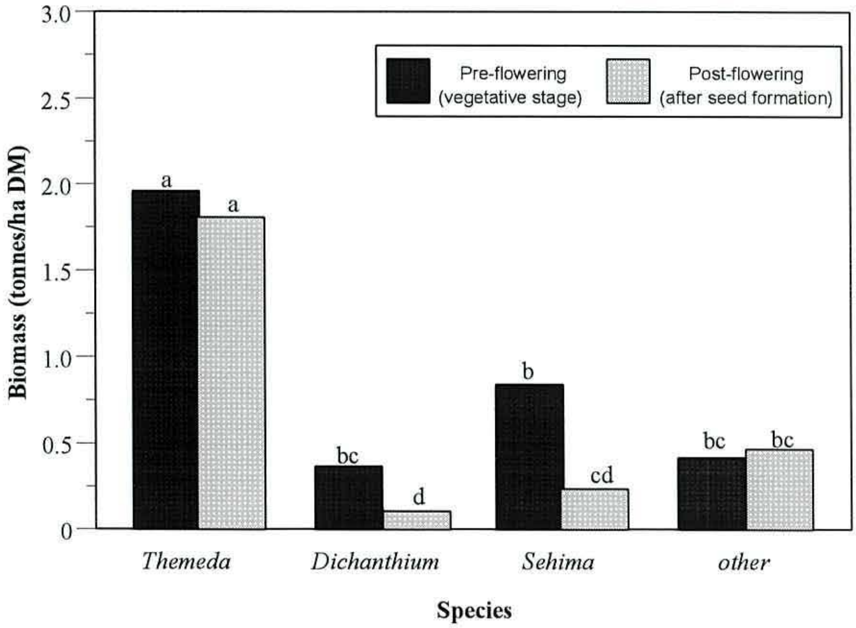


Figure 3.7 **Changes between plant biomass harvested before flowering and after seed formation in *Themeda* dominated grasslands.**
(Note: different letters indicate significant differences within and between species at p<0.05).

Table 3.1 **Changes in crude protein for *Heteropogon* harvested pre- and post-flowering.**

species	Treatment 1 (pre-flowering) (CP%)	Treatment 2 (post-flowering) (CP%)
Heteropogon	5.2	2.8
Dichanthium	6.4	2.7
Gathia	--	--
Other	--	--

Table 3.2 **Changes in crude protein for *Themeda* harvested pre- and post-flowering.**

species	Treatment 1 (pre-flowering) (CP%)	Treatment 2 (post-flowering) (CP%)
Themeda	4.3	3.7
Dichanthium	6.9	3.1
Sehima	5.5	2.0
Other	--	--

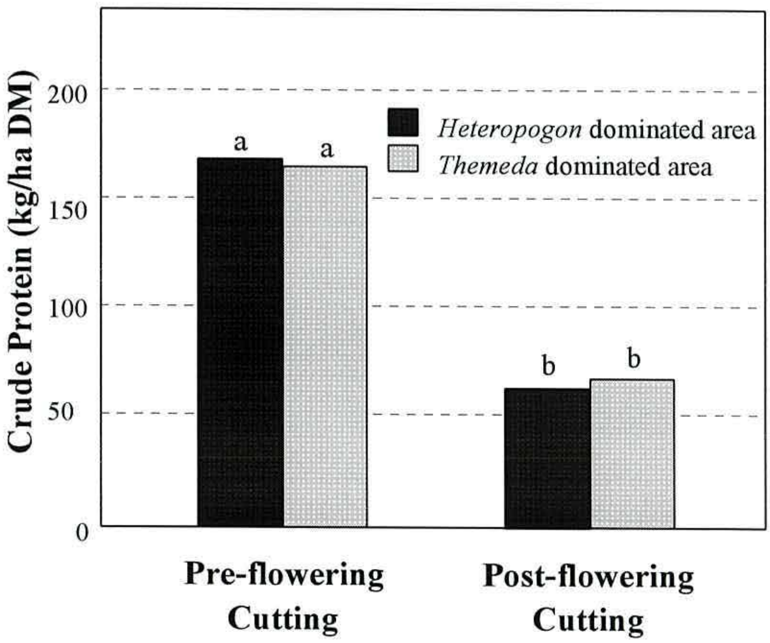


Figure 3.8 **Total crude protein harvested from two experimental plots (one dominated by *Heteropogon* and one dominated by *Themeda*) for two Treatments (pre-and post-flowering).**

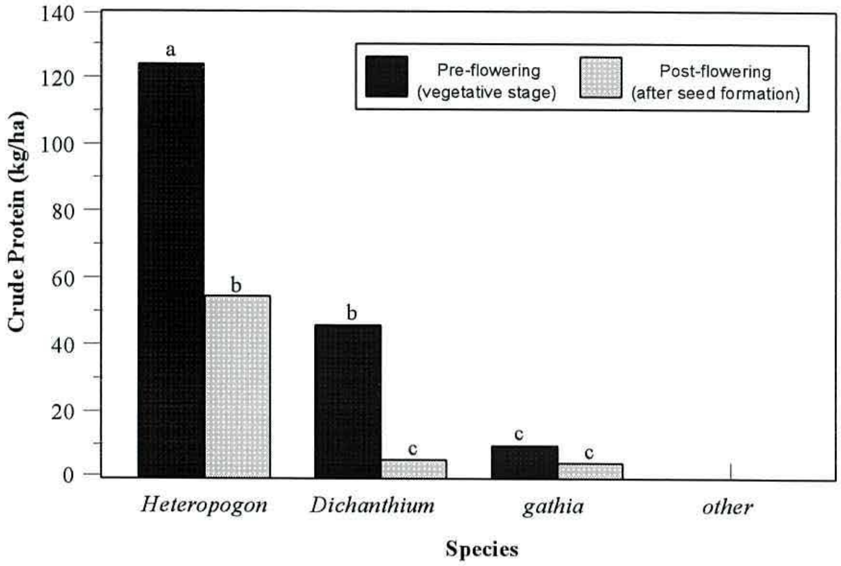


Figure 3.9 **Changes in crude protein content for *Heteropogon* dominated grasslands under two cutting regimes.**
(Note: different letters indicate significant differences within and between species at p<0.05).

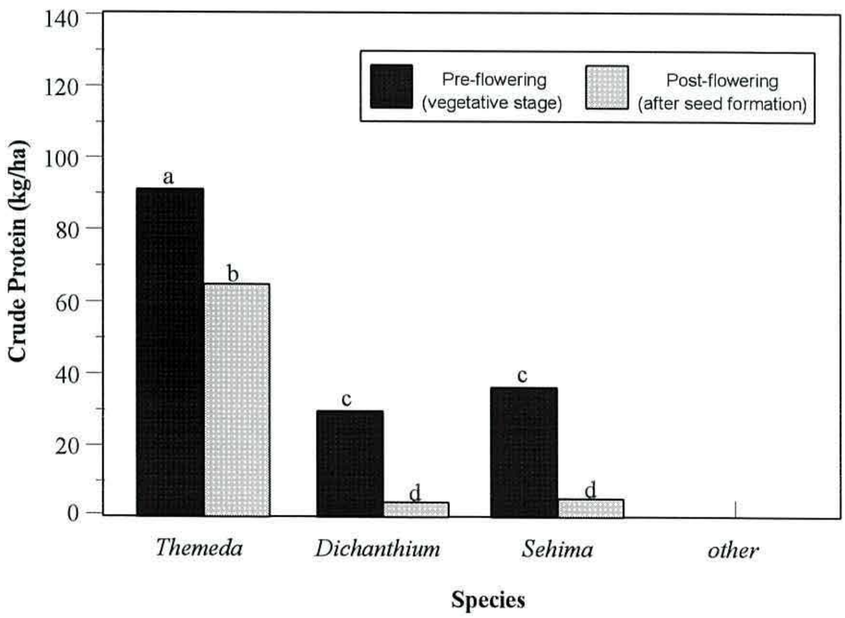


Figure 3.10 **Changes in crude protein content for *Themeda* dominated grasslands under two cutting regimes.**
(Note: different letters indicate significant differences within and between species at p<0.05)

All the main grasses harvested between the pre-flowering vegetative growth stage at the end of the *kharif* (August/September), and the post-flowering stage at the beginning of the *rabi* (October/November) showed a significant decrease in the total protein content on a per ha basis (Figures 3.9 and 3.10).

3.2.2.2 Results

Hypothesis 2 - Statistical analysis showed that biomass samples harvested (2nd cut during post-flowering period) from re-growth of grasses was significantly less than the biomass harvested earlier in the season (1st cut during pre-flowering period) for both *Heteropogon* and *Themeda* (Figure 3.11).

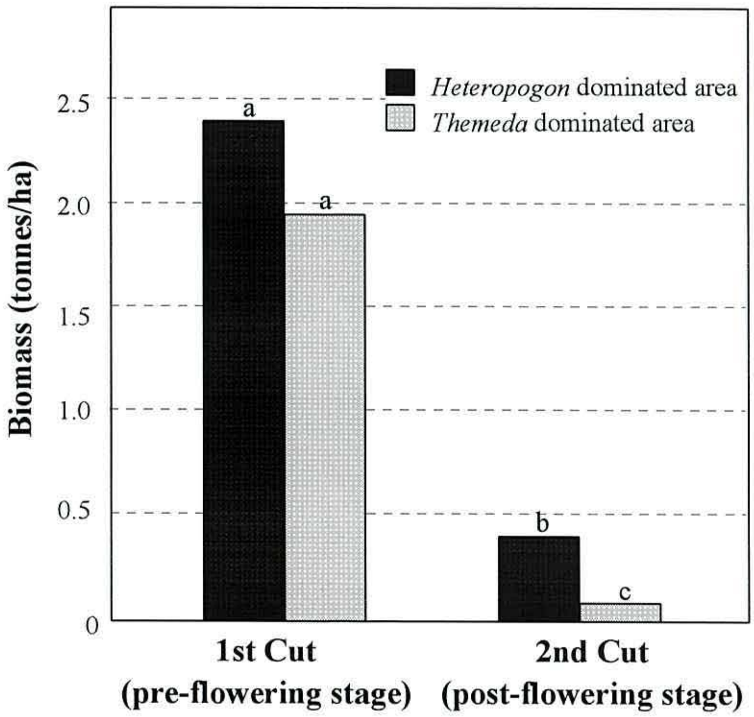


Figure 3.11 Biomass produced from two dominant grass species (*Heteropogon* and *Themeda*) cut before flowering, with re-growth cut again during the traditional harvesting period two months later.

(Note: different letters indicate significant differences within and between species at $p<0.05$).

3.2.2.3 *Conclusions*

Detailed analysis indicated that nutritional quality of the biomass harvested showed protein content to decrease significantly over time for both *Heteropogon* and *Themeda*, as well as for the associated grasses within each grass community. The result was a decrease in harvest of total crude protein per ha.

3.2.3 Seed Bank Potential in Relation to Topographic Position

Regeneration of grasses was relatively uniform in both the gently undulating CPR areas of Kadwali Chotti and Potaliya providing evidence that protection of village grasslands can facilitate significant regeneration of grasses from rootstocks or seed from the soil seed bank. However, in JFM areas of other study villages where the difference in elevation of the forest land ranged from 50 to 100 meters, villagers considered that there was less re-growth on the upper slopes than on the lower areas.

If rootstocks or seed stored in the soil have low viability, or are not available in sufficient quantities to restore the area's potential, then enrichment planting may be used to accelerate natural grassland regeneration in association with protection (Garwood, 1989; Bazzaz *et al.*, 1992).

To help identify if the viability of the seed throughout the protected area, a study was conducted to compare the regeneration capacity of soil from two elevations in undulating protected areas - upper part of the slope and lower part of the slope.

3.2.3.1 *Experimental procedure*

Hypothesis: There is a difference in the regeneration capacity of the soil seed bank at different elevations along a slope ranging from 50 to 100m in elevation in protected village areas.

Design: JFM areas previously used for open grazing were selected in each of five villages. Four of the villages were not part of the original study, but since plans were being made to protect the common property areas in each of the new villages, it was decided to include them for this study. In May 1997, soil was collected from the top 10 cm of soil in two locations: Treatment 1 - upper slope and Treatment 2 - lower slope. Five soil samples each from an area of 0.5 m x 0.5 m x 0.1 m were collected and a composite sample taken from each village to be used to test seed germination.

Villagers were asked to keep the some of the soil samples in earthen dishes, three with soil from the upper slope and three with soil from the lower slope, water them each day and then to observe what seeds germinated.

Under more controlled conditions, three replicate soil samples for each Treatment were held in 175 cm^3 germination plates in a controlled environment with artificial lighting and a constant temperature of 28-30°C. Samples were watered two times per day. The number of seeds that had germinated in the plates was recorded on a daily basis for a total of 21 days.

Analysis: The data was structured in a randomised complete block design (RCBD), and ANOVA was used for the analysis.

3.2.3.2 Results

At first, villagers did not see much difference between the two treatments. However, after they were encouraged to count the number of seedlings that emerged from each soil sample, participants in Bijori, Bijori Chotti and Shobhabati concluded that there were more seedlings germinating from the soil collected on the lower slopes than there was from the soil from the upper slopes. There was no difference in the other two villages.

A more detailed analysis from the controlled study confirmed the findings of the villagers. It showed a significantly higher number of grass seedlings germinated on the lower slopes (Treatment 2) than on the upper slopes (Treatment 1) within four of the five villages in the study (Figure 3.12).

Further analysis showed that the germination rates also varied significantly between villages.

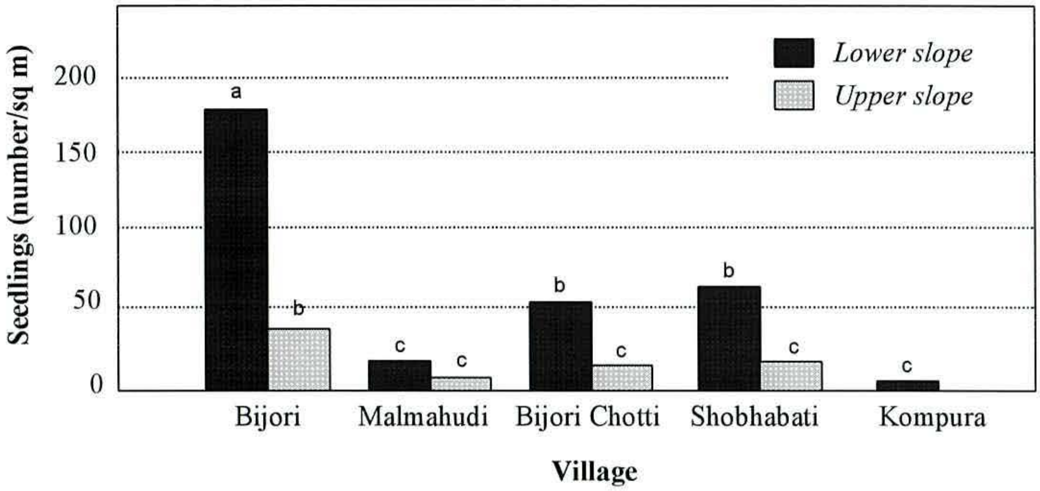


Figure 3.12 Number of plants germinated from soil seed collected from five village JFM areas at the beginning of the monsoon - 1996. (Note: different letters indicate significant differences within and between villages at $p<0.05$).

3.2.3.3 Conclusions

Both, the observations of the villagers in three of the villages and detailed statistical analysis of data collected from under controlled conditions, showed that the number of seedlings germinating on the lower slopes was much greater than seedlings germinating on the upper regions. This shows that although the amount of soil seed may be adequate for some of the village areas, viable seed and therefore regeneration capacity of vegetation in the upper soil regions of the villages is considerably limited throughout the study area.

3.3 Germplasm Options with Grasses

Protection of heavily grazed areas will facilitate regeneration of ground vegetation from existing rootstocks and buried seed. Earlier results from this study have shown significant increases in biomass production and gradual changes in species composition resulting in early succession plants being replaced by late-succession species (Chapter 3.2.1). However effective, natural regeneration and species succession can take a long time, particularly in areas where grass rootstocks or soil seed viability are low such as areas on the upper slopes of regenerating grasslands (Chapter 3.2.3).

Group discussions with villagers focused on supplementing areas with improved grass varieties to help reduce the time required for establishing grassland sward composition. One simple but potentially effective option that arose was to directly sow seeds from grasses and legumes which are native to these, or similar sites. As several species have already been identified by national research institute scientists (IGFRI, 1995) as suitable for reseeding in the project area (Table 3.3), a selection of were chosen for testing.

Table 3.3 Example of Grass and Legume Species Identified by IGFRI as Suitable for Study Area.

grass species	conditions
*Sehima nervosum** *Pennisetum pedicellatum** *Cenchrus ciliaris* *Cenchrus setigerus* *Bothriochloa intermidia*	red/gravely soils
*Dichanthium annulatum**	black soils
*Chrysopogon fulvus**	sloping lands
Panicum maximum *Dichanthium annulatum* *Cynodon dactylon*	field bunds
Iseilema laxum *Brachiaria mutica* *Brachiaria decumbens*	along nallahs
legume species	**conditions**
*Stylosanthes hamata** *Stylosanthes scabra**	cut and carry
Macroptilium atropurpureum *Atylosia scarabaeoides** *Clitoria ternatia** *Lablab purpureus*	moist areas/field bunds

* *Species selected for testing in village fields.*

Further discussions focused on identifying methods to help supplement regeneration of protected grasslands. These included:

- direct seeding of supplemental grasses and legumes;

- pelleting of seed before sowing;
- establishing grass seedlings in village nurseries and transplanting onto protected grassland areas.

3.3.1 Direct seeding

The easiest and perhaps least expensive method of planting grasses (assuming that the quantity of seed required is available and land preparation costs are not unreasonable) is by sowing seed directly on to the area selected for establishment (FAO, 1989).

During group discussions, villagers were certain that if quality seed were supplemented in areas protected from grazing livestock, the time required for establishing grasslands would be reduced resulting in a significant increase in availability of good quality fodder.

To test establishment and production of grasses and legumes in protected areas under village conditions, a selection of species was planted by direct seeding in six of the study villages

3.3.1.1 Experimental procedure

Hypothesis: Sowing supplemental grass and legume seed into open grazing grassland areas protected from livestock will increase availability of cut-and-carry fodder compared to the dominant local species.

Design: Four grass species and four legume species (Table 3.4) were selected by project staff in consultation with participating villagers and IGFRI at the beginning of the monsoon in July 1996 and were planted in a complete randomised design (CRD) in protected grassland areas in six villages. The villages were Bar and Kikalvari (Gujarat); Kadwali Chotti, Ratanmal and Malmahudi (Rajasthan); Amli (Madhya Pradesh) (Plates 3.5 and 3.6).

Table 3.4 Grass and legume species tested for germination and production in the study villages – 1996-97.

grass species	legume species
1. *Sehima nervosum*	1. *Stylosanthes hamata*
2. *Chrysopogon fulvus*	2. *Stylosanthes scabra*
3. *Pennisetum pedicellatum*	3. *Clitoria ternatia*
4. *Dichanthium annulatum*	4. *Atylosia scarabaeoides*

Planting density was 250 seeds/m^2 for each species. Each of the two replicate blocks (2 m x 10 m for grasses which includes a control Treatment for local grasses, and 2 m x 8 m for legumes) was replicated six times (once in each village). Treatments (seeded species) including the control for grasses (native species) were randomly assigned to a plot (2 m x 2 m) within each block (Figure 3.13).

At the end of the monsoon (September 1996) in the first year, the total number of seedlings that germinated in both the grass and legume plots were counted in each of the 2 m x 2 m Treatment plots.

After the end of the monsoon (September 1997) in the second year, all of the Treatment plots, including the control, were harvested. The biomass was then weighed after drying in the sun for three days. Native *Heteropogon*, regenerating from rootstocks already present in the study area in the control Treatment plots, was measured for biomass and compared to the other Treatments.

Analysis: One-way ANOVA was used for the comparison of germination and biomass between villages and species.

Plate 3.5 **Joint forest management area (left) protected from open grazing by stone wall in Malmahudi, Rajasthan - 1996.**

Plate 3.6 ***Chrysopogon* and *Pennisetum* surrounding introduced 1 year old *Gliricidia sepium* sapling in CPR area of Malmahudi, Rajasthan - 1997.**

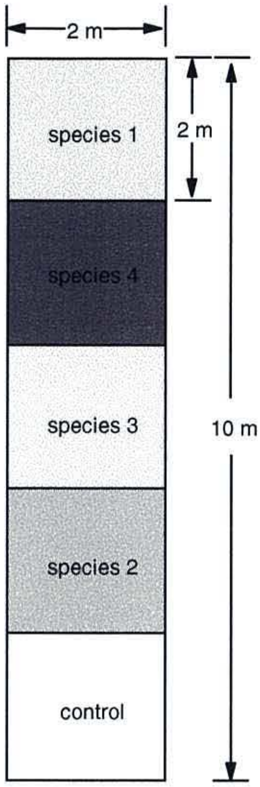


Figure 3.13 **Layout of one of the grass plots established in each village to test establishment of directly sown recommended grass species - 1996.**

3.3.1.2 Results

Germination counts after the first monsoon showed a wide variation between grass species in the number of seedlings emerging after direct seeding on to the experimental plots (Figure 3.14).

Germination and emergence rates of the grasses were significantly higher for both *Chrysopogon* and *Pennisetum* than for *Sehima* and *Dichanthium*.

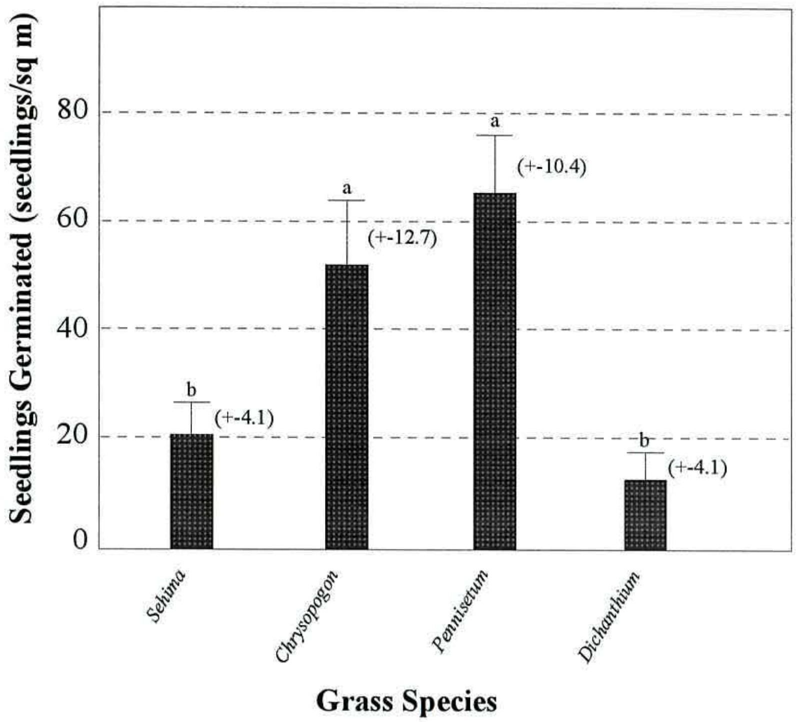


Figure 3.14 Comparison of seed germination between grass species directly sown in the study village plots (1996). *(Note: SE=(+-) and different letters indicate significant differences between species at p<0.05).*

Germination counts varied widely between legume species that were directly seeded on to the experimental plots as well (Figure 3.15).

For the legume species, *Stylosanthes scabra* and *Clitoria* showed the highest emergence rate with a significantly lower number of *Stylosanthes hamata* and *Atylosia* seedlings germinating compared to the other treatments.

Even though experimental plots were selected on the basis of soil type (all red soils), grass seedling establishment varied significantly between the six villages (Figure 3.16).

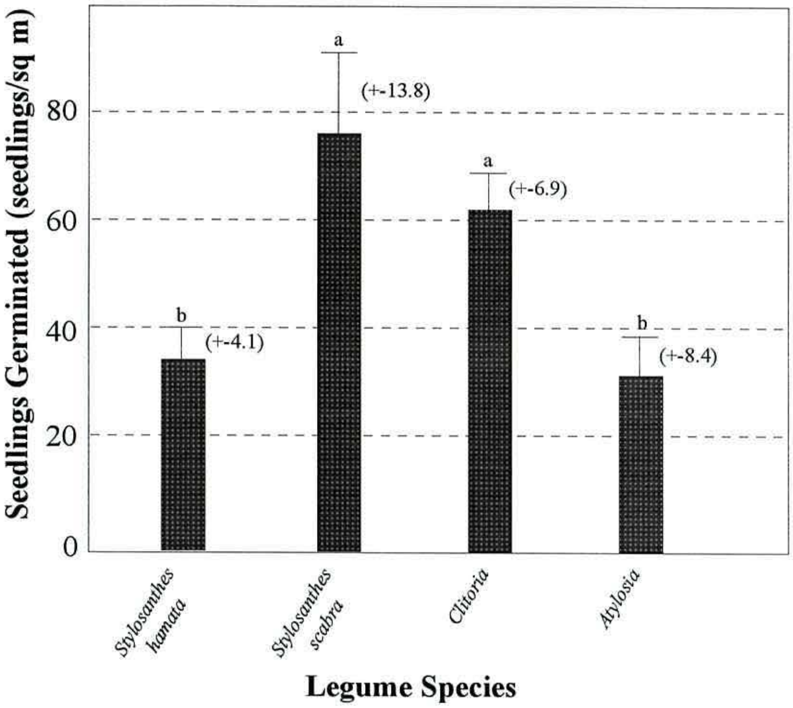


Figure 3.15 Comparison of seed germination between legume species directly sown in the study village plots (1996). *(Note: SE=(+-) and different letters indicate significant differences between species at p<0.05).*

Experimental plots in Ratanmal, Malmahudi and Kikalvary produced the highest number of established grass seedlings. Bar showed moderate establishment while Kadwali Chotti and Amli showed poor grass establishment.

Legume establishment also varied significantly between the six villages (Figure 3.17).

Experimental plots in Ratanmal and Malmahudi produced the highest number of established legume seedlings. Kikalvari, Amli and Kadwali Chotti showed moderate establishment, but establishment rates in Bar village were low.

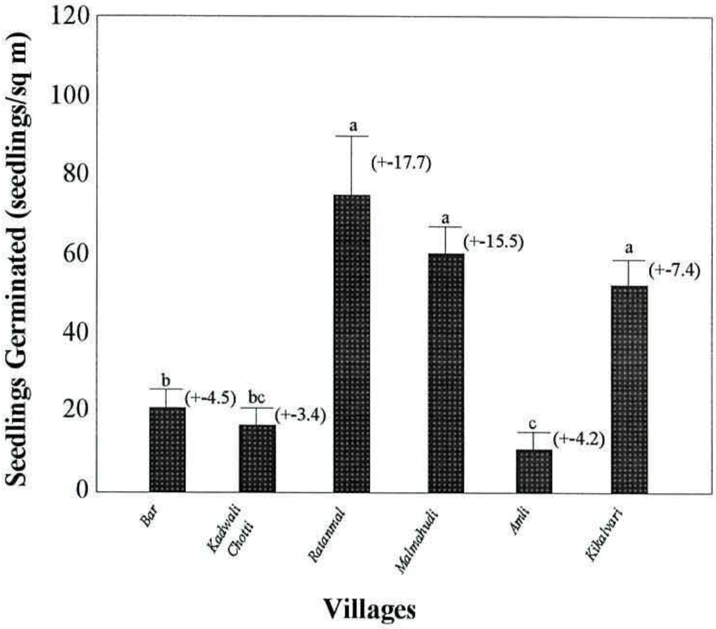
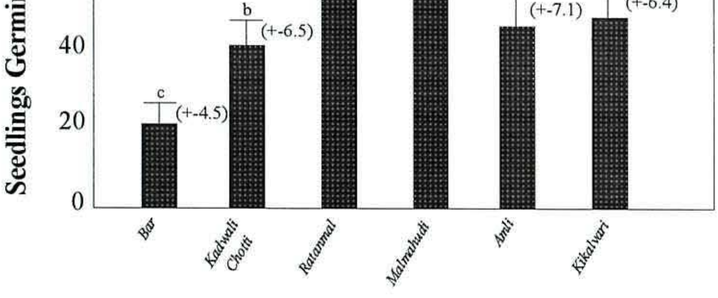


Figure 3.16 Number of grass seedlings germinated after direct sowing in study village plots (1996). *(Note: SE=(+-) and different letters indicate significant differences between villages at $p<0.05$).*



Villages

Figure 3.17 Number of legume seedlings germinated after direct sowing in study village plots (1996). *(Note: SE=(+-) and different letters indicate significant differences between villages at $p<0.05$).*

In the second year, when biomass measurements were from the grass Treatment plots were analysed (Figure 3.18), significant increases were found in biomass production for *Chrysopogon* (1.9 $kg.m^{-2}$) *and Pennisetum* (1.7 $kg.m^{-2}$) compared to the native *Heteropogon* (0.85 $kg.m^{-2}$) (Plate 3.7). No significant differences in biomass were found between *Heteropogon* and *Sehima*. *Dichanthium* did not survive.

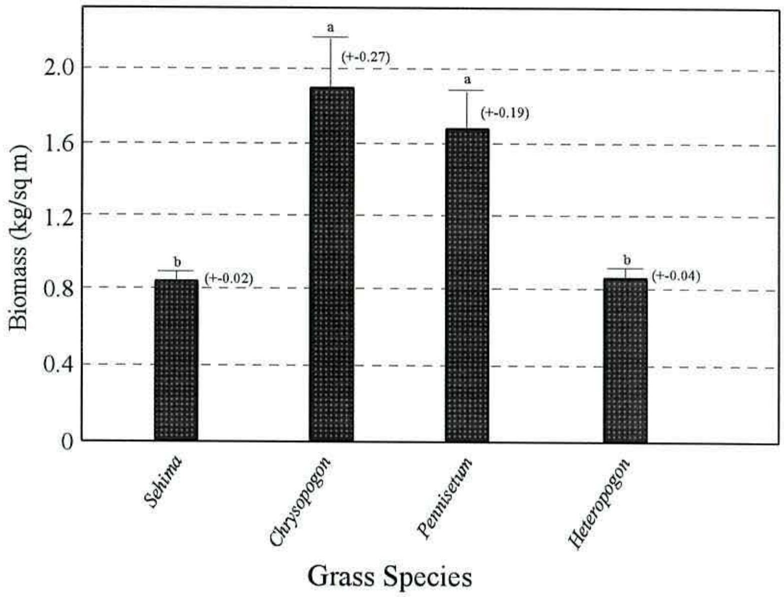


Figure 3.18 Comparison of biomass production between grass species directly sown and established in six of the study village plots (1997). *(Note: SE=(+-) and different letters indicate significant differences between species at $p<0.05$).*

Due to damage from grazing cattle in the legume experimental plots, biomass data for the legumes planted in the previous year were not collected and therefore were not available for analysis.

Plate 3.7 **Introduced *Chrysopogon* (left) and *Pennisetum* (right) compared to local *Heteropogon* (centre) harvested from the CPR area in Malmahudi, Rajasthan (1997).**

3.3.1.3 Conclusions

Chrysopogon and *Pennisetum* grasses directly seeded on to grasslands produced significantly more biomass than the local *Heteropogon* despite the low germination and establishment rates of the grasses tested. With improved establishment techniques, the quantity of grasses produced from direct seeding would substantially increase the amount of cut-and-carry fodder that could be harvested.

3.3.2 Seed Suspensions - Pelleting

Grass species that are native, as opposed to introduced into an environment, are in many situations most appropriate for rehabilitation of degraded grasslands in the semi-arid regions of India (Pandeya, 1988). However, success in re-vegetating with native species tends to be low for several reasons: lack of seed availability, high seed shatter, high seed dormancy and lack of knowledge about seedbed requirements (FAO, 1989). The most common problem encountered in the village study plots was low seed retention on soil due to shifting by winds and rain.

A technique of suspending the seed in an earthen pellet has been suggested to help stabilise seed and facilitate increased establishment of grasses. Several machines have been designed to pellet seed but the one selected as the most appropriate for the subsistence level of farming in the study area was a manually operated tyre-type (Singh and Singh, 1996) (Plate 3.8).

However, after using this technique in the study area, villagers found that grass establishment from pelleted seed was lower than anticipated. This prompted a controlled experiment to compare grass seed germination rates between seed that was contained within earthen pellets and seed that was not pelleted.

3.3.2.1 Experimental procedure

Hypothesis: Germination of grass seed contained within an earthen pellet produced by a tyre-type hand-operated pelleting machine is less than germination of seed that has not been pelleted.

Design: In September, 1997, seed pellets were made from a mixture of soil (3 parts), manure (1 part) and grass seed rotated in a tyre-type of hand powered seed pelleting machine. The pellets produced contained seed from one of two species: *Pennisetum*, and *Chrysopogon*.

In order to test germination without having the pellets fall apart when wet, the seeds and pellets were placed in the troughs of plastic corrugated sheets. Each sheet were covered with paper towel and a layer of cling film to retain moisture during the testing period.

A randomised complete block design was used for the analysis with four Treatments and three replicates in each Treatment. The Treatments were:

Treatment 1 - pure unpelleted seed;

Treatment 2 - pellets with a concentration of 25 g of seed kg^{-1} of soil;

Treatment 3 - pellets with a concentration of 50 g of seed kg^{-1} of soil;

Treatment 4 - pellets with a concentration of 100 g of seed kg^{-1} of soil.

Plate 3.8 Hand-operated grass seed pelleting machine promoted by IGFRI used to make grass pellets for broadcasting in the project area (1997).

Fifty non-pelleted seeds (Treatment 1), and 3 pellets of each pelleted Treatment (2, 3 and 4) were randomly placed within a 10 cm space in the trough area of a plastic corrugated sheet measuring 0.3 m x 0.5 m. Each sheet represented one of four blocks (Figure 3.19).

The treatments were stacked with a separation of 30 cm between the sheets and incubated in an oven at 30°C. Initially, the Treatments were left for 24 h until the pellets and seed reached a temperature of 30°C. The paper towelling was then soaked with distilled water, and the numbers of seeds germinating were counted and recorded every 24 h for 8 days.

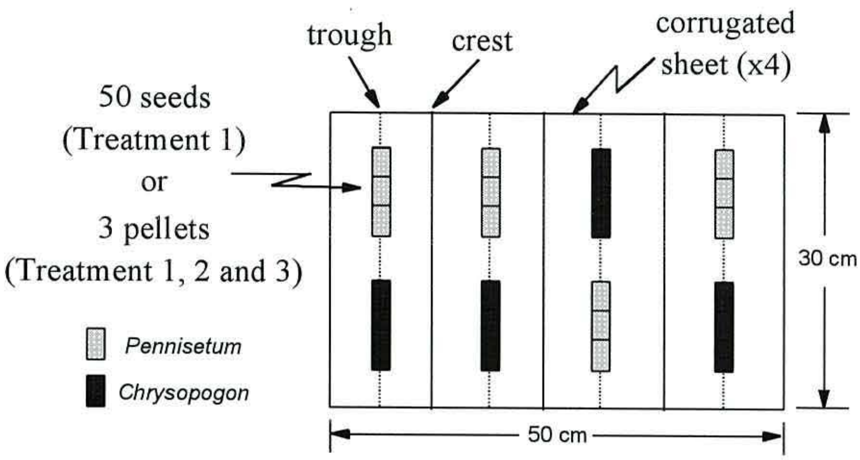


Figure 3.19 Layout of seed and pellet tray used to conduct germination tests under laboratory conditions (1997).

3.3.2.2 Results

The germination rate of the non-pelleted seed (55% and 54%) was significantly higher than that of the pelleted seed (Figure 3.20). Germination also decreased as the concentration of seed within each of the pelleted Treatments was reduced from 100 g to 25 g.

To determine if the differences in germination were due to the number of seeds per weight of soil in each of the pelleted Treatments, further analysis was conducted.

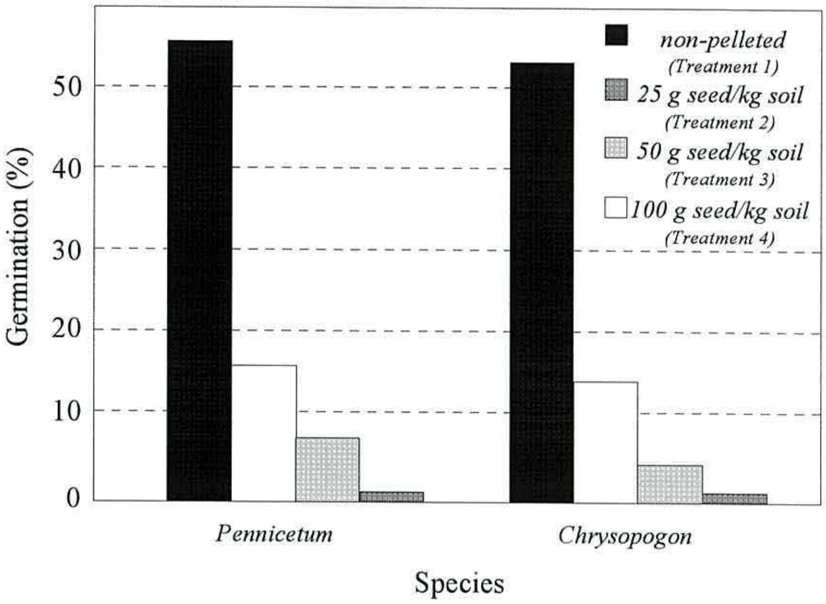


Figure 3.20 Comparison of germination rates between non-pelleted seed, and pelleted seed in different concentrations (1997).

Data showed that pellets containing 25 g of seed per kg of soil were significantly heavier than those containing 100 g per kg soil for *Chrysopogon* (Figure 3.21). There was no difference in pellet weight for the Treatments containing *Pennisetum* seed.

The number of seeds contained in each pellet was significantly more in the lower concentrations (25 g kg^{-1} soil) than in the higher concentrations (100 g kg^{-1} soil for *Pennisetum* and 50 g kg^{-1} soil for *Chrysopogon*) for both species (Figure 3.22).

On a seed per gram of pellet basis, there were no significant differences in the three pelleted Treatments (Figure 3.23).

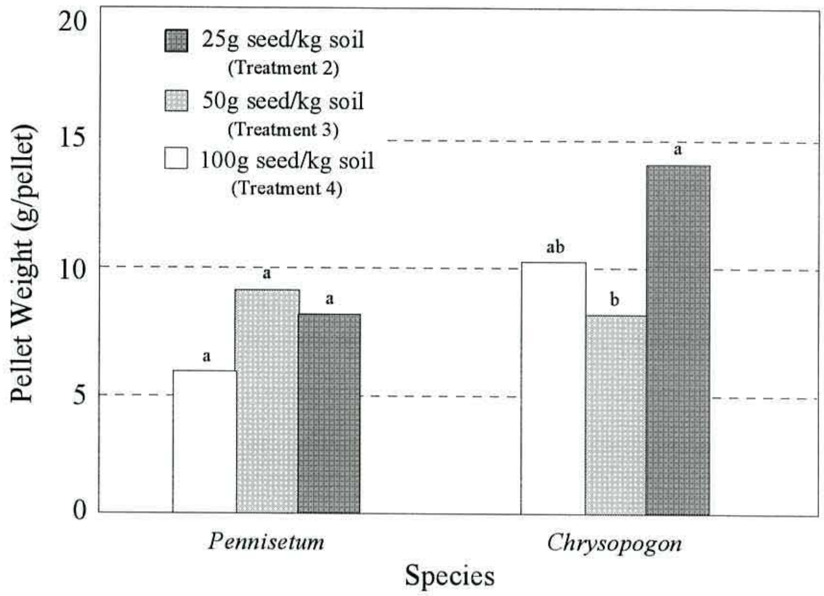


Figure 3.21 Comparison of pellet weight with different concentrations of seed for two grass species (1997). *(Note: SE=(+-) and different letters indicate significant differences within species at p<0.05).*

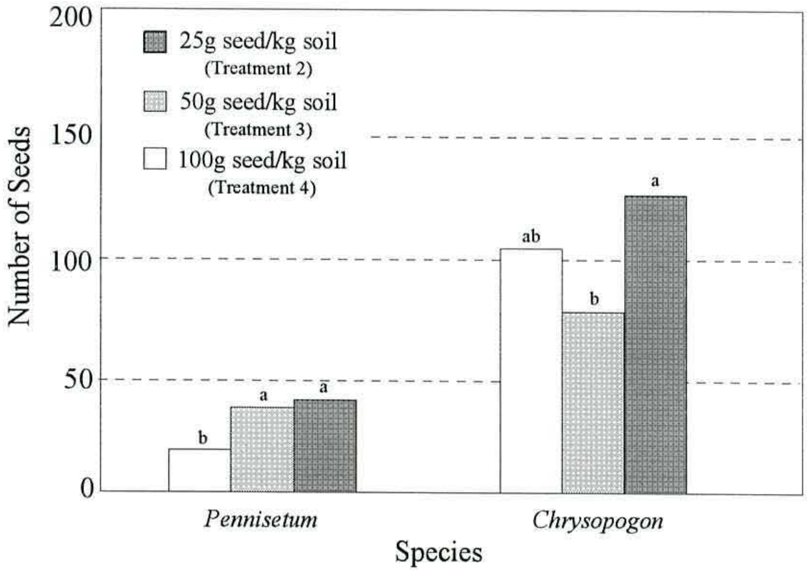


Figure 3.22. Comparing the number of seeds/pellet with different concentrations of seed for two grass species (1997). *(Note: SE=(+-) and different letters indicate significant differences within species at p<0.05).*

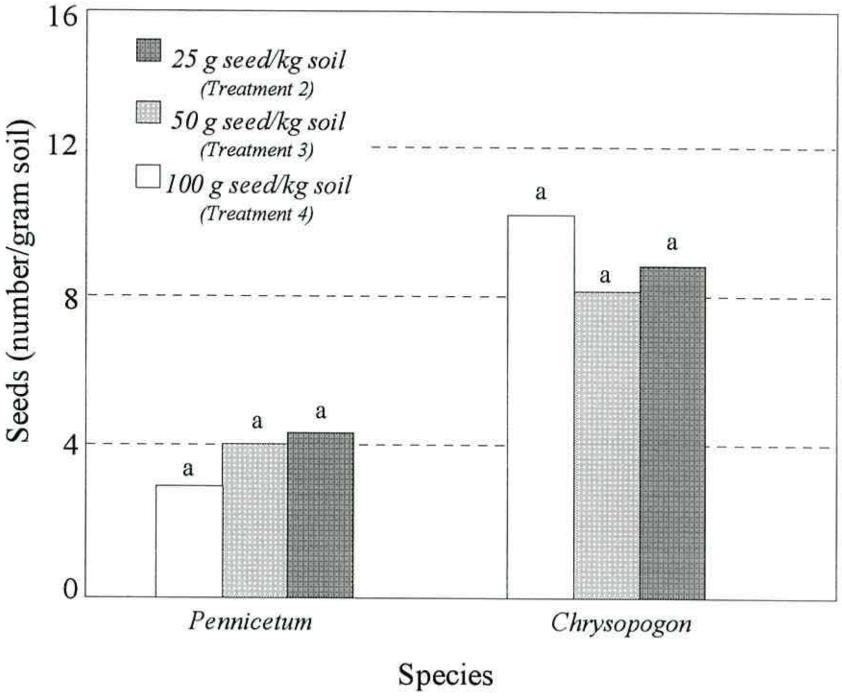


Figure 3.23 Comparing pellet weight and number of seeds/pellet for two grass species (1997). *(Note: SE=(+-) and different letters indicate significant differences within species at $p<0.05$).*

3.3.2.3 Conclusions

The hypothesis was correct. Germination of grass seed contained within an earthen pellet was less than germination of non-pelleted seed (55% for *Pennisetum* and 54% for *Chrysopogon*) of total seed tested.

Germination in the pelleted seed decreased as the concentration of seed within each pellet was reduced (15% at 100 g kg^{-1} soil, 7% at 50 g kg^{-1} soil and 2% at 25 g kg^{-1} soil). Since there was no difference in the number of seeds contained within each pellet compared to the amount of soil making up each pellet, this difference could not be attributed to seed concentration but to some other factor such as size or density of the pellet.

3.3.3 Nursery production of grasses for transplanting

Production of grass seedlings in village nurseries can be time-consuming and expensive. However, it can also ensure high germination and production of good quality seedlings ready for out-planting at the start of the monsoon - particularly important if seed supply is limited. The objective of this study was to test the success of nursery establishment in the study area and determine farmers' criteria for selecting grass species.

3.3.3.1 Evaluation procedure

Hypothesis: Participating villagers could successfully establish grass nurseries and raise from seed in the village, grass seedlings for out-planting.

Design: Grass nurseries[1] were established in nine villages before the monsoon in June and July 1998. Seed from two grass species, *Pennisetum* and *Cenchrus* were distributed to all nurseries. Seed of *Sehima* and *Chrysopogon*, which was in limited supply was planted in only two nurseries in the villages of Katarani Palli and Samlashia (Table 3.5, Plate 3.9).

Table 3.5 Species and sowing rate used for grasses established at nurseries in the study villages (1998).

species	number of nurseries	recommended sowing rate
Pennisetum pedicellatum	10	12 beds @ 100 g per (1m x 6m) bed
Cenchrus setigerus	10	12 beds @ 75 g per (1m x 6m) bed
Sehima nervosum	2	12 beds @ 50 g per (1m x 6m) bed
Chrysopogon fulvus	2	12 beds @ 50 g per (1m x 6m) bed

In August and September 1998, villagers assigned a category of Good, Medium or Poor establishment to their nursery bed two months after establishment. Seedling density in each bed was measured by counting grass seedlings in 0.5 m x 0.5 m quadrats replicated three times for each nursery in each village. Clear limits were set for Good, Medium and Poor establishment by associating density with one of the three categories chosen by the nursery raisers.

[1] Villagers attended a three day training course on grass nursery establishment conducted at IGFRI, Jhansi

Plate 3.9 Village grass nursery before transplanting in Samlashia, Rajasthan (1998).

Observations were used in conjunction with focused group discussions to obtain feedback from nursery raisers and determine issues relating to production and use of nursery grasses in the study area.

3.3.3.2 Results

Successful germination and establishment of grass seedlings in village nurseries ranged from Good (220 - 620 seedlings m^{-2}) to Poor (35 - 50 seedlings m^{-2}) with *Pennisetum* showing consistently better stand establishment than the other three species (Table 3.6, Plate 3.10).

Chrysopogon showed moderate to good establishment (70 - 190 seedlings m^{-2}) and *Cenchrus* and *Sehima* establishment ranged from poor to good (35 - 615 seedlings m^{-2}).

Table 3.6 Establishment rating and density of four grass species raised in village nurseries (1998)

	Pennisetum pedicellatum		*Cenchrus setigerus*		*Sehima nervosum*		*Chrysopogon fulvus*	
village	est	seedlings m^{-2}	est	seedlings m^{-2}	est	seedlings m^{-2}	est	seedlings m^{-2}
1. Kompura	G*	220	P	50				
2. Khundne Rupa	G	250	M	150				
3. Katarani Palli	M	110	P	35	P	40	M	70
4. Samlashia	G	250	G	200	G	210	G	190
5. Bar	G	280	G	620				
6. Kikalveri	G	240	P	40				
7. Titwas	M	95	M	120				
8. Kadwali Choti	G	480	P	45				
9a. Jarola	G	430	G	600				
9b. Jarola	G	200	G	615				

**G = good establishment (above 200 seedlings m^{-2});*
M = moderate establishment (51 - 200 seedlings m^{-2});
P = poor establishment (0 - 50 seedlings m^{-2})

Plate 3.10 ***Pennisetum*** **seedlings pulled from nursery ready for transplanting in Bar, Gujarat (1998).**

Villagers preferred grasses that produced large quantities of biomass, highly palatable to livestock, established easily and regenerated well (Table 3.7).

Table 3.7 Villagers perceptions on selection of species produced in nurseries (1998).

species	+ ve aspects	- ve aspects	rank
Chrysopogon fulvus	• good biomass production; • good palatability; • good establishment.	---	1
Sehima nervosum	• high leaf:stem; • very palatable; • very nutritious; • regeneration good if water sufficient.	• poor germination in many villages.	2
Cenchrus setigerus	• high leaf:stem (comparable to *Digitaria ciliaris* and *Heteropogon contortus*); • nutritious; • regeneration good if water sufficient.	• poor germination in many villages.	3
Pennisetum pedicellatum	• high biomass (good tillering, broad leaves); • good germination; • regenerates well; • not affected by pests or decease; • nutritious.	• unpalatable during the dry season when fodder is required; • animals not used to eating it so leaving some.	4

3.3.3.3 Conclusions

Villagers could successfully establish grass nurseries and raise grass seedlings from seed for out-planting in the village but results vary between individuals.

Germination and establishment of grass seedlings in village nurseries ranged from good (220 - 620 seedlings m^{-2}) to poor (35 - 50 seedlings m^{-2}) with *Pennisetum* showing consistently better establishment than the other three species. The main reason for poor establishment was improper management procedures with insufficient weeding as the most detrimental to good establishment. Nurseries established in conjunction with three or more weeding usually resulted in good establishment where as those with only one weeding resulted in poor establishment. Other management practices that contributed to poor establishment included sheet irrigation that washed seed from the surface to the down-slope of the bed, inadequate irrigation resulting in water stress, and improper fertilisation of the seedbed before sowing.

According to villagers in the study, species selected for nursery production for the purpose of out-planting must conform to specific criteria. For example, high nutritional value is an important characteristic and considered by the community as vital in increasing energy levels of the livestock, increasing milk production of lactating goats, buffalo and cattle, and improving general animal health. Other criteria such as producing high quantities of biomass and easy establishment indicate the importance of production and availability of the grasses when required.

3.4 Germplasm Options with Woody Legumes

Woody legumes introduced into grassland environments can serve a very important function in overall land-use development. The environmental benefits of such legumes are well documented. These include ameliorating the soil (Lalljee et al., 1998) through nitrogen fixation (Lemkine and Lesueur, 1998), drawing unavailable nutrients to the surface with roots deep within the soil profile (Young, 1986) and modifying the micro-climate by reducing evapotransporation by decreasing ambient temperature or wind velocity (Dewalle and Heisler, 1988). However, production of leafy biomass can significantly increase the availability of livestock fodder. "It is a humbling fact for grass pasture experts to realise that probably more animals feed on shrubs and trees, or on associates in which shrubs and trees play an important part, than on true grass-legume pastures" (CABP, 1947).

The additional availability of bole and branch wood from these legumes is a secondary but important benefit especially if there is a scarcity of fuelwood in the surrounding area (National Academy of Sciences, 1983). Species that are capable of regenerating quickly after coppicing can provide a sustainable supply of fuelwood to meet household needs throughout the year.

Leucaena is a woody legume that possesses all of these characteristics and could effectively be introduced into grassland environments in India as a source of livestock fodder and domestic fuelwood.

The local communities have, until now, depended on tree covered areas for timber, but, more importantly, these areas have been a source of fuelwood, animal fodder and a host of other non-timber forest products (NTFP). However, because of the rapid decrease in the number of trees and reduction in the availability of forest products in this area, an acute shortage of domestic fuel and fodder for draught animals has recently developed (KRIBP, 1993).

The *Leucaena* species are among the most productive and well-known multi-purpose tree legumes available in the tropics. Known for versatility in the farming system, these species can provide fodder from grazing and cut and carry systems. In addition, they are major contributors to fuelwood supply and are used to improve soil fertility and help stabilise degraded lands (Shelton, 1998).

However, most past research has focused on the *Leucaena leucocephala* cultivars which originated from a narrow germplasm base (Hughes, 1993) consisting mostly of assessions K8 and K28 - codes developed by the University of Hawaii in the early 1960's. This has resulted in cultivars poorly adapted to acid soils, lacking in cold or drought tolerance, and with low resistance to insect infestations such as the psyllid, *Heteropsylla cubana* (Shelton, 1998). Other characteristics include:

- poor seedling vigour;
- potential weediness due to prolific seed production;
- moderate wood quality for fuelwood or construction;

In 1994, an International Workshop was held to define the current state of research and development in the genus *Leucaena* (ACIAR, 1994). A network was formed (LEUCNET, 1994), to identify research and development priorities and help address the shortcomings from the lack of information and the under utilisation of species within the genus. Information on several of the *Leucaena* species was compiled and made available in book form during this period (Hughes, 1993). In addition, a catalogue summarising and cross referencing the seed holdings of *Leucaena* species by major research groups around the world (Bray *et al.*, 1997) was produced to make it easier to search for and obtain new materials.

To determine the feasibility of introducing exotic species into the project villages, 11 *Leucaena* taxa were selected from the species available based on the potential suitability of growth, and production of biomass for the semi-arid conditions of the project area. Material was raised in village nurseries and planted in controlled plots managed by researchers, and in village areas managed by village community members. The quality and amount of biomass produced in the test plots was monitored, and perceptions on production and utilisation of the species recorded.

3.4.1 Experimental procedure

Hypothesis 1 - Introduced *Leucaena* species selected for growth and biomass production could be successfully integrated into a village land-use system;

Hypothesis 2 - Introduced *Leucaena* species will be adopted by villagers as a source of fodder and fuelwood as part of their livelihood strategy.

Plots of trees consisting of 11 introduced *Leucaena* species were established in 1995. At the beginning of the monsoon in June 1995, scarified seed was planted in poly-bags containing a mixture of soil (3 parts) and well rotted animal manure (1 part) and raised in a village tree nursery. Seedlings were watered twice a day - once in the morning and once in the evening. One month later at the start of the monsoon (July 1995), seedlings were transplanted to the test plot (Plate 3.11).

Design: The layout of the experimental plot consisted of 11 species (Treatments) arranged in a series of line plots (3 m apart) containing ten seedlings per line (0.5 m apart) and replicated four times (Figure 3.24).

Plate 3.11 Six-week old seedlings planted from nursery in line plots in experimental area (Dahod – 1995).

The plots was protected initially by a wire fence but this was eventually replace by a living fence of *Prosopis juliflora* planted from seed around the perimeter when the experimental plots were established.

After one year of growth (June 1996), groups was randomly selected of five contiguous trees at either end of each line plot and coppiced. Biomass was measured for bole wood, branch wood (Plate 3.12) and leafy material (Plate 3.13). Height measurements were taken for the other half of the trees that were not coppiced.

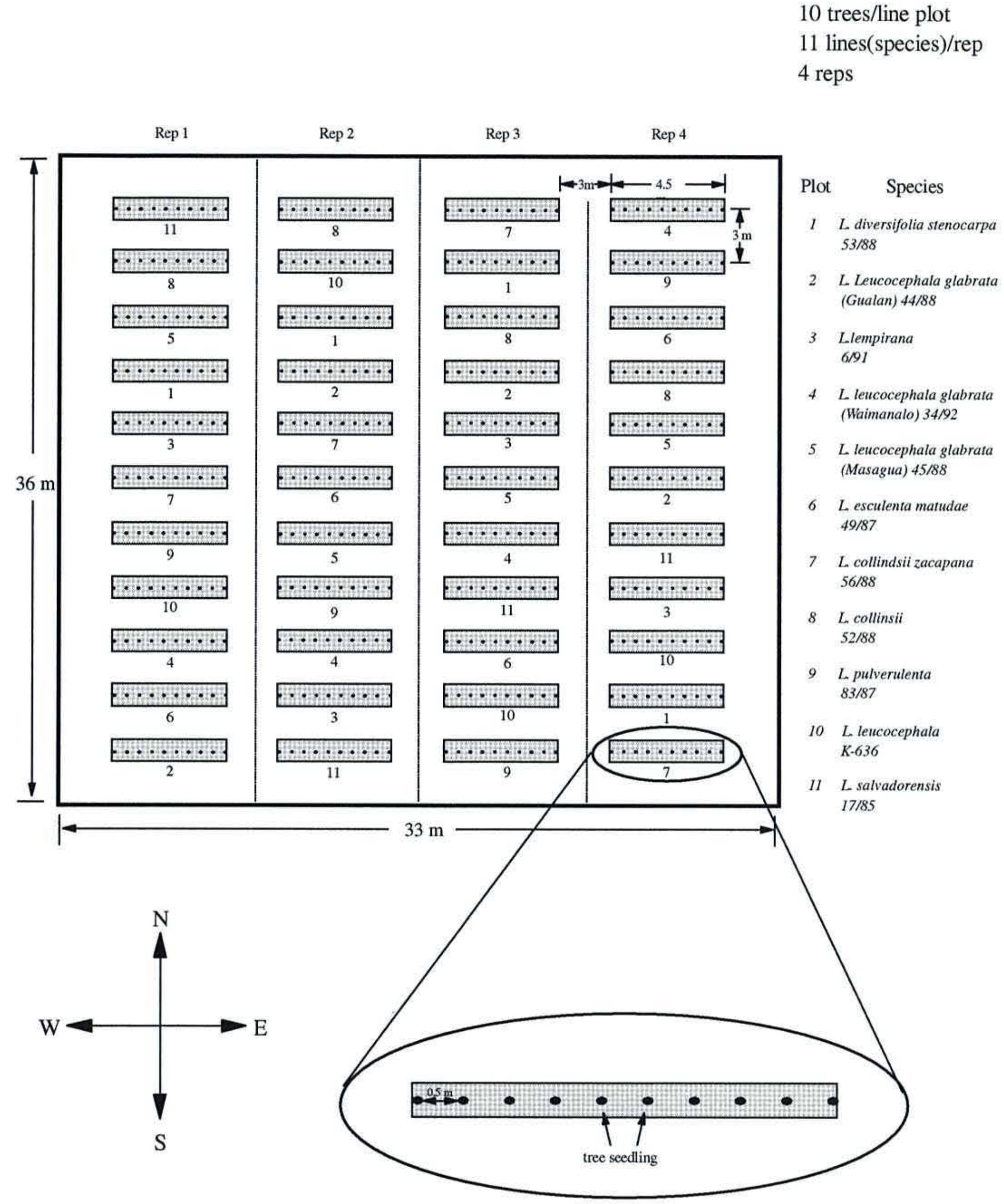


Figure 3.24 **Layout of *Leucaena* line plot experiments in RCBD in Dahod, Gujarat (1995-1998).**

Plate 3.12 Measuring fresh weight of woody biomass after coppicing in control plot (Dahod – 1996).

Plate 3.13 Measuring fresh weight of leafy biomass after coppicing in control plot (Dahod – 1996).

Following the first cut, the selected trees in each plot were coppiced every few months. A randomised complete block design was used in the plot and ANOVA for the analysis.

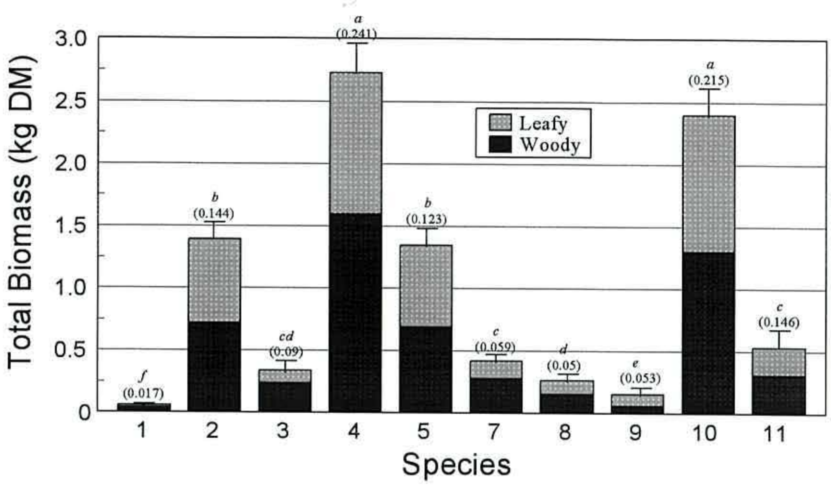
Biomass production was analysed for fodder and fuelwood quality. *In vitro* dry matter digestibility of the leafy material was measured using the faeces liquor method (Omed *et al.*, 1989) and % crude protein was calculated using the kjeldahl method of ammonium-nitrogen digestion for nitrogen content of the leafy material (MAFF, 1985). Calorific values of woody material from each species were measured by pelleting ground samples of wood and burning them in a bomb calorimeter to measure energy output. Wood density was calculated by using the weight of the wood sample after drying (103+- 2^0C), and dividing it by the green volume which is measured by liquid displacement (Olesen, 1971). Height of each uncoppiced tree was measured at the same time as biomass of the coppiced trees was collected. All of the analysis was conducted by the author at the University of Wales, Bangor, farm-laboratory in the UK.

Tree seedlings were also distributed among eight villages in 1995. Since a limited quantity of seed was available at the time, only one species (*L. leucocephala glabrata* (Gualan)) was planted and raised in the village tree nurseries in the study area. Decisions as to where the seedlings were to be replanted were made by the villagers. A random sample of 25 trees in each of the eight villages tested was measured for height 15 months after planting.

3.4.2 Results

Control plots - Of the 11 taxa coppiced regularly in the control plot, *L. leucocephala glabrata* (Waimanalo) 34/92 and *L. leucocephala* K-636 showed the highest production of leafy and woody biomass (dry matter) compared to the other species tested (Figure 3.25).

L. leucocephala glabrata (Gualan) 44/88 and *L. leucocephala glabrata* (Masagua) 45/88 showed similar growth patterns and prolific production of pods each year. *L. lempirana* 6/91, *L. collinsii zacapana* 56/88 and *L. salvadorensis* 17/85 all showed moderate production of woody biomass with *L. collinsii zacapana* 56/88 and *L. salvadorensis* 17/85 producing a leafy portion comparable to that of *L. leucocephala* K-636.



No	Taxa	No	Taxa
1*	*L. diversifolia stenocarpa* 53/88	7	*L. collinsii zacapana* 56/88
2	*L. leucocephala glabrata* (Gualan) 44/88	8	*L. collinsii* 52/88
3	*L. lempirana* 6/91	9	*L. pulverulenta* 83/87
4	*L. leucocephala glabrata (Waimanalo)* 34/92	10	*L. leucocephala* K-636
5	*L. leucocephala glabrata (Masagua)* 45/88	11	*L. salvadorensis* 17/85
6	*L. esculenta matudae* 49/87		

* *species are represented by these numbers in figures throughout Section*

Figure 3.25 Above ground biomass (sun-dried) of 10 *Leucaena* species after four cuttings at 12, 14, 18 and 21 months after planting (Dahod 1995-1997). *(Note: SE=(+-) and different letters indicate significant differences between species at p<0.05).*

The remainder of the species produced very little biomass. *L. esculenta matudae* 49/87 was withdrawn from the experiment because of inability to grow under the conditions of the study area.

A Tukey comparisons test showed that the biomass produced by *L. leucocephala glabrata* (Waimanalo) 34/92 and *L. leucocephala* K-636 was significantly higher after 21 months in all three products (bolewood, branch wood and leafy material) compared to the other species. *L. leucocephala glabrata* (Gualan) 44/88 and *L. leucocephala glabrata* (Masagua) 45/88 came second with significant production in branch wood and leafy material over the remaining species (Figure 3.26).

Seasonal and management effects were highlighted. Trees coppiced 12 months after planting just before the beginning of the monsoon (June 1996), displayed accelerated production of branch wood and leafy material during the monsoon period (Figures 3.27 and 3.28). Production of biomass steadily decreased for the remainder of the year.

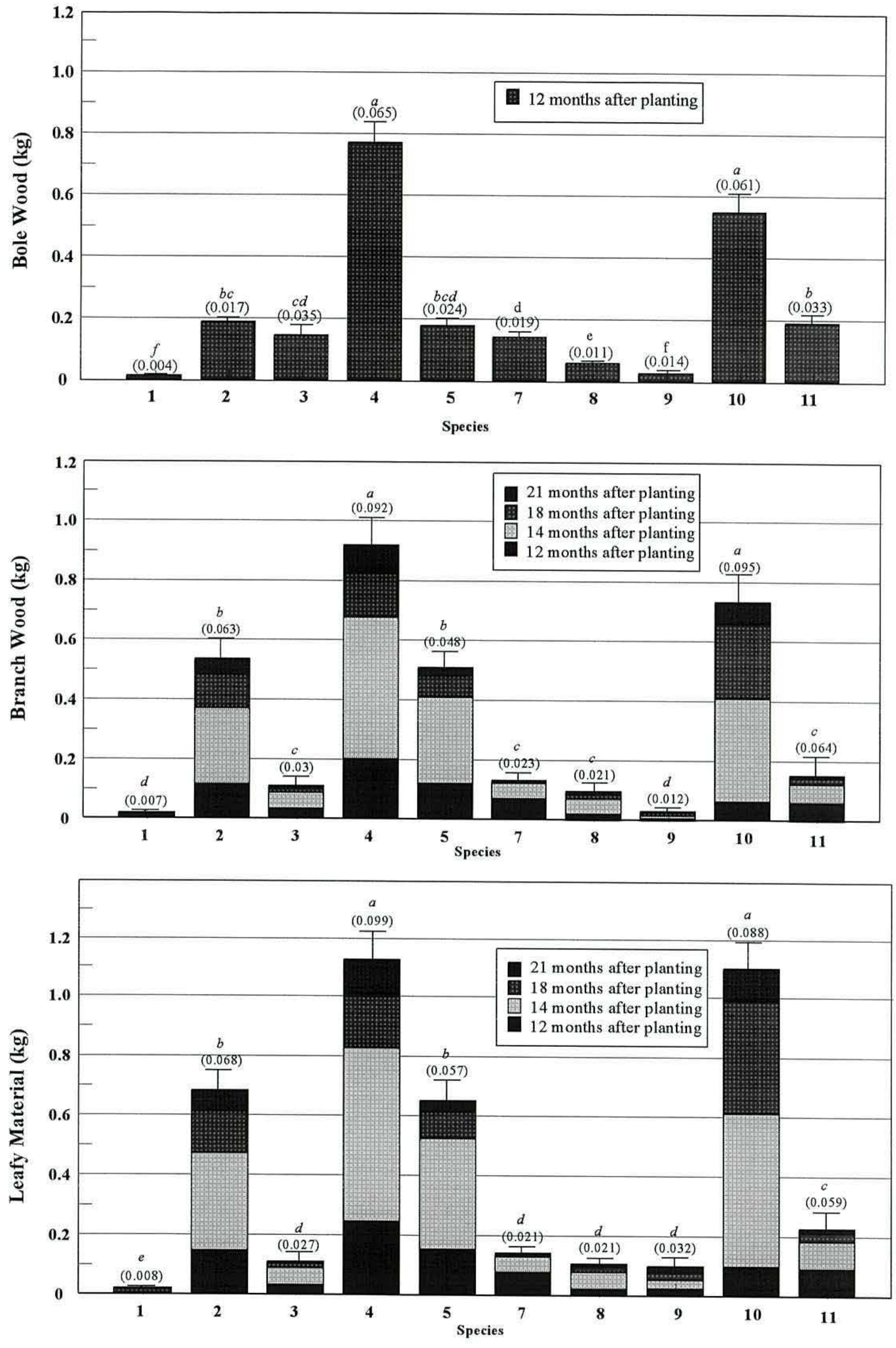


Figure 3.26 Biomass of bole wood, branch wood and leafy material produced by 10 *Leucaena* species coppiced at 12, 14, 18 and 21 months after planting (Dahod – 1995-97). *(Note: SE=(+-) and different letters indicate significant differences between species at p<0.05).*

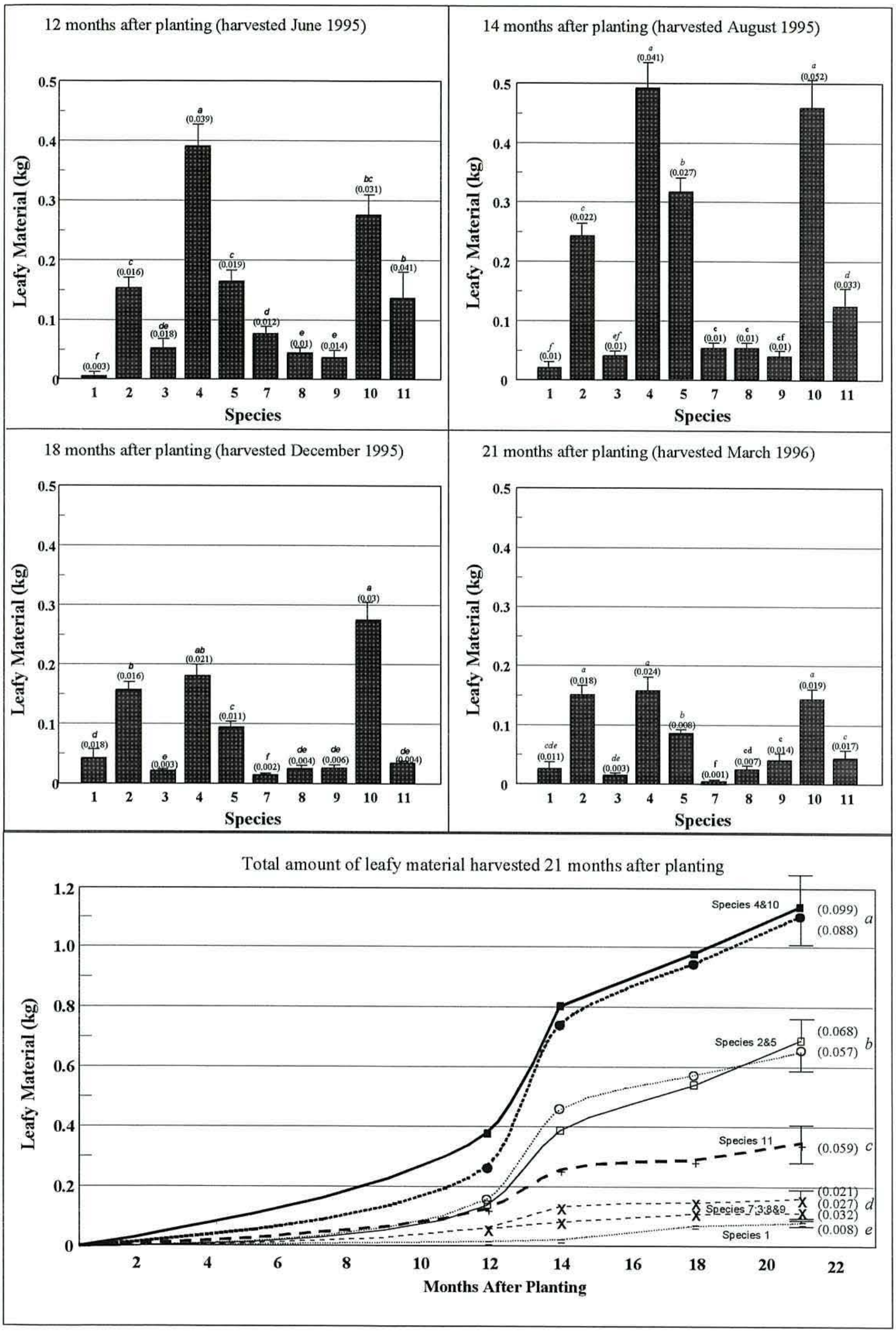


Figure 3.27 Leafy material (kg DM) harvested from 10 *Leucaena* species coppiced at 12, 14, 18 and 21 months after planting (Dahod –1995-97). *(Note: SE=(+-) and different letters indicate significant differences between species at p<0.05).*

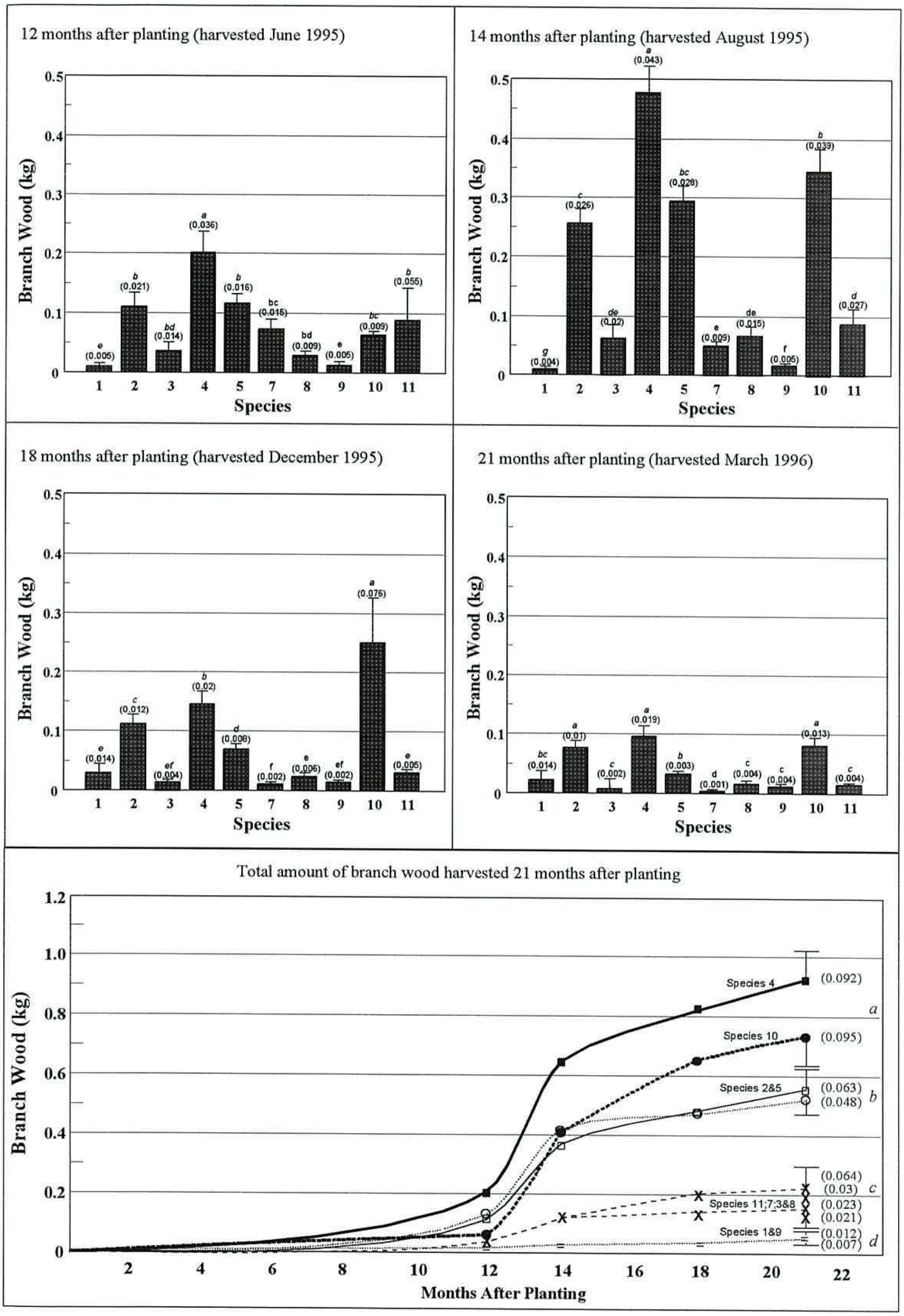


Figure 3.28 Branch wood (kg DM) harvested from 10 *Leucaena* species coppiced at 12, 14, 18 and 21 months after planting (Dahod 1995-97). *(Note: SE=(+-) and different letters indicate significant differences between species at p<0.05).*

Crude protein values ranged from 154 to 207 g kg^{-1} DM and in-vitro dry matter digestibility ranged from 46% to 65% with *L. pulverulenta* showing a low value of 29% (Table 3.8). Energy values of the woody portions of the trees ranged between 17.070 and 17.730 Joules kg^{-1} (density of 606 to 835 kg m^{-3}) which proved to be comparable to the other fuel sources available in the project area.

Table 3.8 ***Leucaena* species tested for quality of fodder and fuelwood (Dahod – 1997).**

no.	species	crude protein (%)	digestibility (%)	calorific values (Joules kg^{-1})	wood density (kg m^{-3})
1	*L. diversifolia stenocarpa* 53/88	16.0	46	16.221	772
2	*L. leucocephala glabrata* (Gualan) 44/88	15.9	61	16.947	723
3	*L. lempirana* 6/91	18.1	58	16.397	667
4	*L. leucocephala glabrata* (Waimanalo) 34/92	15.6	56	16.204	577
5	*L. leucocephala glabrata (Masagua)* 45/88	17.6	59	16.812	718
6	*L. esculenta matudae* 49/87	--	--	--	--
7	*L. collinsii zacapana* 56/88	20.7	65	16.556	621
8	*L. collinsii* 52/88	19.4	64	15.110	556
9	*L. pulverulenta* 83/87	15.4	29	16.258	761
10	*L. leucocephala* K-636	15.5	57	17.730	835
11	*L. salvadorensis* 17/85	18.9	57	17.074	606

Tree height was measured six times over a 27 month period. *L. leucocephala* (waimanalo) (species 4) and *L. leucocephala* (K636) (species 10) proved to be significantly taller that the other species (Figure 3.29; Plates 3.14 and 3.15).

Village Plots - Since the decision as to where the seedlings were to be transplanted was entirely up to the villagers, trees were planted in several different areas in and around the study villages. The highest proportion of trees was planted in patch plantations on protected private lands (35%) and in protected home gardens (34%). Trees planted in fields constituted 18% and trees on bunds 8% and along nallahs 6%.

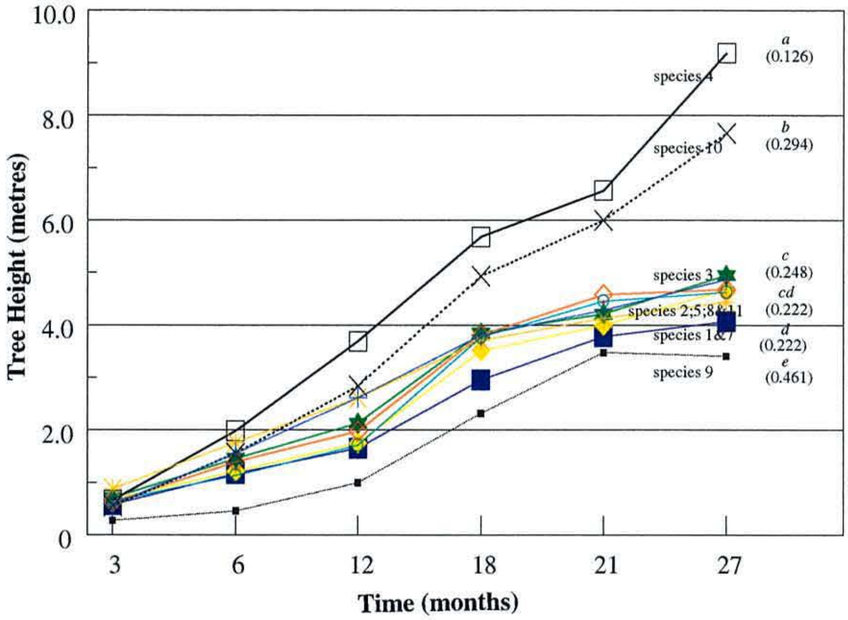


Figure 3.29 **Height of ten *Leucaena* species over 27 months after planting (Dahod 1998).** *(Note: SE=(+-) and different letters indicate significant differences between species at p<0.05).*

Plate 3.14 **Control plot of ten *Leucaena* species surrounded by a living *Prosopis juliflora* fence 27 months after seeding (Dahod – 1998).**

Plate 3.15 ***Leucaena leucocephala glabrata*** **(Waimanalo) after 27 months growth in a control plot under rain-fed conditions (Dahod – 1998).**

Since villagers were reluctant to cut the trees before they reached pole-size, height measurements were used to compare growth of trees planted in the village with those planted in the control plots. Tree height in the villages after 15 months ranged from 1.6 m in Jaliapada to 3.1 m in Kompura (Plate 3.16; Figure 3.30).

Plate 3.16 ***Leucaena leucocephala glabrata*** **after 21 months growth in village plots under rain-fed conditions (Kadwali Chotti – 1997).**

Compared to tree height in the control plot, there was no significant difference in tree height in four of the six villages for *L. leucocephala glabrata* (Gualan).

Farmers' Perceptions - FGDs revealed that farmers were very impressed with both the palatability of the leafy matter (and pods in some cases) and the rate of biomass regeneration, particularly after livestock had entered and browsed some of the patch plantations within the villages. In determining the quality of *Leucaena* wood as a fuel source for food preparation, several opinions were expressed by the household members especially the women who are responsible for the gathering of fuelwood and cooking meals. Results of the interviews showed that most of the households believed that the wood burned longer than most other species presently used for cooking resulting in the need for less fuelwood to cook the same amount of food. Other typical responses indicated that the wood was perceived as: producing a good taste to the food; producing less smoke and ash; and burning similarly to, or better than, teak wood.

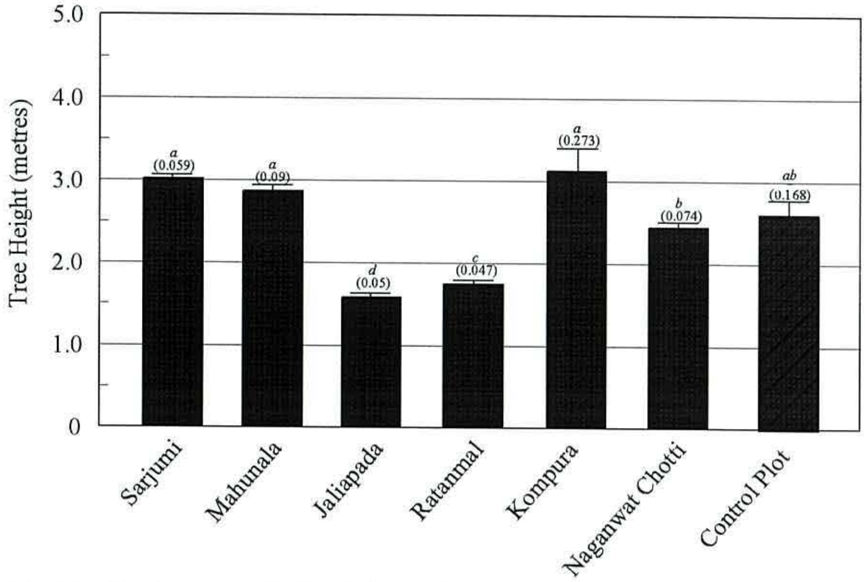


Figure 3.30 **Height of *L. leucocephala glabrata* in six villages 15 months after planting compared to control trees at 12 and 18 months after planting (Kadwali Chotti – 1997).** *(Note: SE=(+-) and different letters indicate significant differences between the control plots where N=20 and the villages were N=25 at p<0.05).*

3.4.3 Conclusions

Results showed a high potential for biomass production in some of the *Leucaena* taxa that were studied. In particular *L. leucocephala glabrata* (Waimanalo) 34/92 and *L. leucocephala* K-636, for both fuel and fodder; and *L. leucocephala glabrata* (Gualan) 44/88 and *L. leucocephala glabrata* (Masagua) 45/88, particularly for pod production to be used for animal fodder.

Crude protein values (154 to 207 g kg^{-1} DM) and in-vitro dry matter digestibility of most of the *Leucaena* species tested were considered high in comparison to available fodder sources. Energy values of the woody portions of the trees ranging between 17.070 and 17.730Joules kg^{-1} (density of 606 to 835 kg m^{-3}) also proved to be relatively high compared to the other fuel sources available in the project area.

Trees (*L. leucocephala glabrata* (Gualan)) planted in project villages and measured after 15 months produced similar growth (2.6 m) and biomass (1.4 kg $tree^{-1}$) production to those trees planted in the control plots. Planting sites in protected areas such as private patch plantations and home gardens were preferred by villagers whereas open areas such as bunds and nallah banks were planted to a much lesser extent.

CHAPTER 4
DISCUSSION

Kadwali Chotti and Potaliya are typical of remote villages in the study area in both socio-economic and bio-physical terms. Mostly Tribal Bhils, people of this area are closely related within and between village communities (2.1.2). With a corresponding average population of 7-10 persons per household (2.1) Kadwali Chotti and Potaliya are ruled under the overall political structure based on the Panchayat system of governance (2.1).

Erratic rainfall, undulating topography (2.2) and eroded and infertile soils (2.2.3) are some constraints shared by all villages in the area. Even land-use (2.2.3) and the availability and use of resources (2.2.4.1) particularly with regard to importance and utilization of livestock fodder in and around the village (2.2.4.2; 2.2.4.3), can be associated not only with Kadwali Chotti and Potaliya, but with the study area as a whole.

Livestock in Kadwali Chotti and Potaliya, mostly cattle (*Bos indicus*) and buffalo, are used mainly for draught purposes, with production of manure and marketable calves as valuable by-products (2.2.4.1). The reduction in grassland productivity has resulted in a shortage of good quality fodder (2.1.3), especially at the end of the dry season before the monsoon begins (2.2.4.1). This can produce under-nourished and weak draught animals just when they are needed to help prepare the fields for planting in the *kharif* season. The low plain of nutrition can also reduce fertility rates so fewer healthy calves are born reducing still further the assets of the household and their well-being status within the community (2.1.4).

4.1 Relative merits of information gathering techniques

Obtaining general information on the social interactions between households and management of resources did help to understand the livelihoods strategy of farm households in the study area. However, if specific information is required, for example, to understand fodder availability during the year, the questions asked should be kept specific to the topic to ensure that the time invested by the participating villagers is optimised.

In attempting to collect specific information, e.g. land-use practices, there was some confusion at the beginning of the project as to the purpose of the diagnostic exercise. Some staff facilitated sessions with specific intervention objectives in mind and were therefore able to formulate questions that would help to address those specific objectives (such as identification of key criteria used by farmers during transect walks (2.2.1)). On the other hand, others facilitated sessions focusing on empowerment issues which were more abstract and political, and often detracted from obtaining sufficient information to pursue activities that would help to design and implement activities (e.g. social mapping (2.1.1)).

If one area within the livelihoods strategy, such as livestock fodder, is first identified and research activities are focused to provide evidence for wider-scale interventions, then efforts must be made to ensure that studies are designed and only relevant information is collected that is necessary to supplement those interventions. The degree of participation of both farmers and researchers must reflect the type of information required for those specific interventions.

To help encourage and direct participatory research, the focus of specific research activities were emphasised when discussions were held with village participants. For example, questions directly related to designating areas for establishment of fodder grasses focused on issues related to land-tenure and access, and not questions such as importance of police to the community or number of family members. Another example is an activity such as criteria selection for fodder species. This should involve questions directly related to productivity, management and use and not questions or exercises relating to identifying family relationships in the village (as did occur on some occasions).

Most of the villagers involved in the study participated in ether a consultative or collaborative way. However, all of the research could be classified as adaptive targeting areas of intervention that that farmers in collaboration or consultation with staff have identified as researchable. And because of the nature of the study and its purpose to address the issues related to inadequate availability of livestock fodder, most of the research activities focused on adapting technologies to present land-use strategies.

As part of the process used to help identify areas if intervention, tools and techniques used to help assess the social (2.1) and biophysical status (2.2) of the study area, and to characterise access to and use of fodder among village groups (2.2.4.1) ranged in their effectiveness. Some of the techniques, such as transect walks (2.2.1) and revenue maps (2.1.1), were found to be very useful for providing information contributing to initiatives related to improving grassland fodder in the study.

Transect walks were a highly participatory exercise providing the opportunity for both investigators and villagers to explore the village area accurately and in detail. The exercise proved useful in several ways. It helped to identify the components within the village area that are important to individuals and determine the criteria used by them to describe each component (2.2.1). This was particularly important for the staff in helping them to understand the physical environment and facilitate discussions on problems experienced, including biophysical constraints, and possible solutions.

Villagers were quite familiar with the revenue maps easily obtained from the local land office and could easily locate individual plots and identify the persons associated with management of those plots. Using a GIS database along with digitised maps proved useful by providing a template on which to display village information collected and entered into the database (2.1.1). Although the level of participation from the villagers was less than the social mapping exercise, this proved more effective for planning, recording and discussing interventions.

On the other hand, tools such as social mapping used to encourage participation of the villagers and help draw out those individuals who are not normally part of the decision making process was of limited use (2.1.1). Although most of the village households were represented during the first day at the social mapping exercise, only certain members of the community took the lead and actively participated in the exercise. Due to the qualitative nature of the information on the map, and the fact that the map was constructed on the ground and not a permanent record, future planning of interventions using the spatial dimensions produced on the ground had severe limitations.

Matrix ranking proved interesting as an exercise for documenting all of the trees and grasses found in the village area, but it also was of limited value in providing additional insights into related problems and constraints (2.2.2). Even though villagers were able to participate in listing and discussing local species, most of the important trees and grasses, and their uses, were already identified during the transect walk.

However, a ranking and scoring exercise similar to that used for identifying trees and grasses did prove useful in detailing the distribution of land-use and soil-types. FGDs in 10 of the study villages and more detailed household surveys conducted in Kadwali Chotti and Potaliya confirmed that each land-use category (forest, pasture, cultivated and uncultivated land) as selected by the farmers covered similar proportions of land in other villages the study area (2.2.3). It became very clear that the majority of land through out the project area was used for cultivation, but was followed closely by the amount of land allocated as forest land. Relatively small areas were designated as pasture or uncultivated land. This information in effect could influence the decision on where interventions involving changes in land-use strategies could be applied and the potential impact they would have on outputs.

Time lines constructed during FGDs seemed to be more useful for facilitating discussions of past events and helping to build relationships between project staff and the village community then they were for collecting accurate information on the village history (2.1.3). Based on the recollections and perceptions of a few villagers, the general trend showed a decrease in availability of village resources and use (particularly for fodder and fuelwood) as population density increased. However, further analysis and graphical interpretation of the data presented by the group showed that even though livestock numbers decreased within each household over time, the total number of livestock increased and then levelled-off for the last 20 years. This would indicate that some limitation to stocking density had been reached two decades ago and that with an ever increasing human population, the number of cattle per household will continue to decrease.

FGDs used to elicit information on fodder use from the communities at Kadwali Chotti and Potaliya proved useful in developing a more detailed profile of the study area and determine fodder resources presently used in the study villages (2.2.4.1). Detailed surveys conducted in Kadwali Chotti and Potaliya provided information on use of crop residues, particularly maize stover, wheat straw and rice straw, that are important sources of livestock fodder, especially during the later part of the *rabi* season. Grasses from grazing and cut-and-carry were shown to be the most important fodder source year round. However, much of the information collected during the surveys could have been more easily obtained during FGDs with each of the well-being groups. Similarly, FGDs with villagers using revenue maps proved to be very useful in recording land-use patterns. Villagers were familiar with the maps and with utilisation of land in and around the village through out the year.

4.2 Results of the Participatory Diagnosis

Conscious of the value time has to participating villagers, it is necessary to balance the extent and nature of the information needed (quantitative or qualitative) with the level of participation from different groups within the study villages and strive to collect and discuss information on issues that are absolutely necessary. The varying degrees of participation necessary to simply compare the average number of people residing in a household in Potaliya and Kadwali Chotti with those of the rest of the project area is a good example (2.1). According to secondary sources, where very little participation is necessary, the average village population density in 1995 in the 3 districts of Gujarat, Rajasthan and Madhya Pradesh was 7 to 10 persons/household. The census conducted in Potaliya and Kadwali Chotti, which involved all of the village members and therefore a higher degree of participation, agreed with this statistic as each village had on average 7 persons per household. Both activities, one with a low level of participation and one with a high level of participation were used to validate government statistics and helped to determine relevancy to the rest of the study area.

Casual conversation with villagers outside of planned exercises, such as that with the older village member who outlined the family line of the village of Potaliya, proved invaluable (2.1.2). Although participation was restricted to only one man with several others sitting around listening, identification of the village family structure very clearly and quickly showed that the village community in Potaliya and Kadwali Chotti were closely related. This relationship could be useful in identifying members of working groups involved with implementation of project activities.

The well-being ranking exercise involved a high degree of participation and was very useful in showing that the availability of assets to the household was the main factor that distinguished between a household that was resource-rich, resource-moderate or resource-poor (2.1.4). Households categorised as resource-rich households generally had more food available during the year as a result of having access to more land, owning more livestock, and receiving higher amounts of money, for instance, during *Nothra* ceremonies. On the other hand, resource-poor households did not have access to sufficient quantities of food to last the entire year due partly to insufficient land resources. In addition, lack of cash to purchase food and pay credit debts results in long periods of migration (eight months) when many of the active family members leave home to earn cash to buy food and re-pay debts.

Participation of a representative cross section the village in the well-being exercise helped to emphasised that the resource-poor with little or no livestock still consider fodder as important. Fodder collected by the resource-poor group is sold for cash to the moderate and resource-rich. If sufficient quantities are available, then this would reduce the amount of time required for out-migration during the year and allow the household members to spend more time with household farm activities.

A limitation of the well-being exercise is that within the social and environmental conditions and limitations of the study area, the ranking can easily be shifted. For instance, a household may need to borrow money in case of a serious illness, or for a wedding. In these situations, the dependency or access to income and assets could easily shift toward credit and expenditure. As a result, a household identified as being in one category (e.g. resource-rich) can easily fall into another category (e.g. resource-moderate) during the study period or even within a season. For this reason, a 'snapshot' well-being analysis of the community taken at the beginning of the study may change several times for some households though out the duration of the study.

There is a clear difference in the amount of land privately owned and managed by single households in Kadwali Chotti and Potaliya (2.2.4). However, whatever land is owned and managed privately, or owned by the local ruling council (Panchayat land) or by the district (revenue land) and managed for cultivation by groups of households, the proportion of land allocated for cultivation in a village remains similar between villages.

There is also an indication that there is some difference in the area of land available to each of the well-being groups, with the resource-rich having access to more land-based resources which contribute to the household livelihoods system. However, there is little difference in the timing and techniques used for cut-and-carry and livestock grazing activities between well-being ranks within each village. This would indicate that interventions of fodder development based on land-use systems would potentially impact the resource-rich households more than resource-poor households of the study area.

Activities involving cut-and-carry of fodder grasses and livestock grazing between well-being ranked groups in each village were similar (2.2.4). Results from Kadwali Chotti and Potaliya show that patterns of grazing and fodder utilisation involved restricted grazing from July to September, partial grazing from October to February/March and open grazing from March/April to June with cut and carry activities from August to March/April. However, there were differences between the well-being groups where resource-rich households had access to more fodder than did resources poor villagers.

Semi-structured interviews relating to the household cycle involved the participation of a representative sample of villagers and were helpful in confirming the importance of migration for providing cash for those households having limited access to agricultural surplus (2.1.5). Income, expenditure, credit and assets form the main components of the household activities and livelihoods strategy in the study villages. The extent and direction of flows between these components indicates the ability of the household to cope with stresses. It became quite clear that the resource-rich households, ones that were more capable of recovering from stresses, were characterised by a greater emphasis on access to income and assets than on the need for credit to cover household and farm expenditure. The resource-poor households on the other hand, were less capable of recovering from stress situations due to a greater dependency on credit.

4.3 Constraints Identified

It is clear that the households in the study villages, pursue a combination of the three broad choices of the livelihood strategies, intensification/extensification, diversification and migration, as identified by Scoones (1998). For example, intensification could have a major impact on household livelihoods since grain cultivation, particularly for rice and maize, is the main activity within the farming systems (2.2.4.1). Introduction and participatory selection of crop varieties previously unavailable to the farmers has proven to be very successful not only in increasing yields, but also in providing the household with crops containing the desired characteristics important to their livelihoods strategy (Joshi and Witcombe, 1996). Extensification of the cropping area could also have a major impact but without irrigation facilities, expansion of arable lands will be limited to the climatic cycle and seasonal rainfall under rainfed farming systems.

Diversifying income through harvesting and sale of non-timber forest products, such as seeds, medicines, fruit and gum, from forest lands presently helps supplement income and provides products, including grass and fuelwood, that are essential to the household livelihood strategy (2.2.4.3).

Migration plays a major role in the livelihoods of the study area (2.1.6). Linked to the well-being of the household, particularly food security and livestock ownership, villagers from the poorer households tend to migrate to jobs outside the village for longer periods (eight months) than the better-off households (less than two months) during the dry season. Most of the money earned goes to pay creditors, with the remainder used to buy food.

Although there are many needs associated with the households in the study area, restricted access to good quality fodder affects all of the components of the household village cycle - income, expenditure, credit and assets - for all three of the well-being groups identified in the study villages. Planning trials and discussion of test interventions using focus groups required a constant dialogue between the participating villagers and the study staff through out the study period.

With a plethora of grassland management strategies available (Heady and Child, 1994), including an impressive list of species and establishment techniques developed on research stations (IGFRI, 1995), prioritisation of when and where interventions should take place is essential to ensure success and efficient utilisation of resources.

Interventions related to grass fodder production and utilisation in the study area should take account of the classifications determined by seasonal availability and harvesting methods. The FGDs conducted in 10 villages indicated that the highest priority should be cut-and-carry, after the monsoon and during the *rabi* and dry seasons (2.2.4). During this period, little fodder is available for livestock until next monsoon and the grasses that are available are not of good quality. Despite the relatively poor nutritional quality of *Heteropogon* and *Themeda*, these grasses are still considered to be the most important fodder grasses simply because of relative availability during the dry season. Efforts focused on improving availability, quality and/or storage of post-monsoon grasses were considered to potentially have the most impact with the least effort on village fodder production in the study area.

Medium priority was allocated to developing grazing lands throughout the year. Grazing of bunds surrounding cultivated land, and on pasture lands is adequate when supplemented with cut-and-carry grasses during the monsoon. However, quantity and quality of fodder grasses quickly diminishes after the monsoon. Hence, interventions to improve management of pasture grasses, including introduction of superior species, would have a potentially positive impact on fodder availability. This would require significant social changes in the present strategy of open grazing.

The lowest priority was given to cut-and-carry grasses during the monsoon. For example, *Echinochloa* is the preferred species for livestock fodder during the monsoon. Because of the abundance of *Echinochloa, Digitaria, Dichanthium, Cynodon* and *Tephrosia* during this period, interventions during the monsoon would likely have very little impact on the fodder availability under the present livestock production system.

Since forest lands, and other common property resource areas, constitute a significant proportion of village land where post-monsoon cut-and-carry is traditionally practised (2.2.3), the potential impact for improving fodder resources on these areas can be easily realised, particularly during the *rabi* season.

4.4 Implementation and Results of Interventions

The diagnosis phase of the research process (Chapter 2) showed that farmer's involvement in the information gathering exercises was essential in helping research staff understand the complexity and diversity of the socio-economic and agro-ecological conditions of this marginal environment. Although some tools were more appropriate than others for the diagnosis, all required some degree of time and effort from participating villagers.

4.4.1 Management Options

One of the more interesting findings from the diagnostic phase was in the area of land management. Unlike the significantly small area of land in the study owned by individual households (2.2.4.1), the majority was either managed by groups of individuals, or not managed at all and left for open grazing by livestock. This created a window of opportunity for improving management practices of large areas and lead to the formation of groups of villagers responsible for management of specific areas - the main focus being common lands used for open grazing.

Protection of these areas from grazing livestock had a profound effect on increasing the availability of animal fodder particularly for those of the community who had very little or no private land. However, the potential for social conflict resulting from any collective action is usually high (Singh, 1994), and the project area was no exception. In developing a methodology for establishing the common property resource (CPR) areas of Kadwali Chotti and Potaliya, several key issues were identified as contributing to their success.

- In comparison to the total land area in and around the village, the CPR areas were small (less than 1 % of the total village area). The small size along with clearly defined boundaries (emphasised by the cattle trench along the perimeter) provided the villagers with a visual demarcation of the area involved, and a definite perception of the area to where the rules for the CPR apply;
- The number of households in both villages involved in establishment and maintenance of the area, and who would be involved in utilisation of the resources from this area was relatively small making management schedules easier to organise;
- The area selected was located at the perimeter of the homesteads and was in full view of many of the village members. This increased the number of people that were able to monitor the CPR area daily and increased the chances of spotting anyone not complying to the rules established by the CPR committee;
- The village committee imposed a series of fines for those individuals who were caught breaking the rules pertaining to the CPR area. These fines were set at a level appropriate enough to deter possible violators;
- Regular group meetings facilitated by the research staff to discuss the issue of insufficient fodder resources helped encourage regular maintenance and supervision of the area and establish a longer-term view needed to develop these resources;
- In addition, regular meetings were conducted in which the CPR committee discussed problems or issues regarding the CPR area. With a forum in which to discuss issues and ask questions, small problems were easily solved before they

could become a threat to the success of the CPR area;

- With the whole village involved in planning and establishment of the area, mutual consent and obligation was strong. Only in one instance did a villager who lives at the edge of the village, farthest from the CPR location in Kadwali Chotti, have any complaints regarding the selection of the area after the fact. Since he was absent from the village when the discussions were held, he was unaware of the decisions that were made. Following an explanation by the committee members, he joined the rest of the village in agreeing with the concept of the CPR area as planned;
- The direct costs to the villagers associated with protection of the CPR area were relatively low compared to the potential benefits. Since the villagers were paid for digging a cattle trench around the CPR area, it can be argued that the chances of success are lower as this could be viewed as only an income generating activity. Due to the socio-economic circumstances which force the villagers to migrate and earn money outside of the village during this period, it was felt that payment for the task was warranted;
- The policy of depositing half of the wages earned from the establishment phase into a bank account to pay for a *Chokida* (therefore receiving only half of what they would have received outside the village for similar work), was a positive indication. Some of the indirect costs associated with changing the village routine to graze livestock in a different part of the village while excluding any other persons and their animals from the CPR area also emphasises the commitment and the costs they are willing to incur.

In both Kadwali Chotti and Potaliya, identification, establishment and maintenance of protected areas resulted in significantly higher quantities of two of the most important cut-and-carry species, *Heteropogon* and *Themeda* (3.2.1). It also resulted in a significant increase in the proportion of ground covered by *Dichanthium* and *Sehima* species, both considered as very important to villagers because of high nutritional value. At the same time, the area covered by unpalatable annuals and weedy species deceased significantly over the three-year period.

Reactions from the villagers during FGDs conducted in the first year of protection indicated that they were pleased with the re-growth of grass biomass. When results from the second year were compared with those of the first year during FGDs, villagers were surprised at the extent of regeneration of *Dichanthium* and *Sehima* - considered more nutritious than other local species. This was again re-emphasised with results from the third year leaving the participants with an appreciation of the potential benefits to protecting village grassland areas.

To further improve fodder nutrient availability, the traditional practice of harvesting local grasses for cut-and-carry after they have matured at the beginning of the *rabi* season (October/November) was challenged (3.2.2). Unlike the conflicting opinions expressed on the outcome of regenerating grasses in protected areas, group participants all acknowledged that grasses were more nutritious at the vegetative stage and less so at maturity, but it was unclear as to why it earlier harvesting was not a regular practice. It was also unanimously agreed by the villagers that a second cut in the same season was not feasible.

Results from this study supported the villagers' assumptions. *Heteropogon* and *Themeda* showed very little re-growth when cut before the flowering stage at the end of the *kharif* (August/September). These results follow reports by Dass (1974) who observed that net primary production decreased with increase in frequency of clipping of grassland communities. It also concurred with Singh and Billore (1975) who found that the more frequently *Heteropogon* is cut, the greater the reduction in plant vigour and the lower the capacity to produce biomass. Plants clipped more frequently may have a higher nutrient content but this is at the expense of biomass production indicating that for these local species growing under rainfed conditions, only one cut per season is practical.

With the nutrient value of grasses highest during the vegetative stages, harvesting before seed set (August/September) resulted in a significant increase in total protein available in both *Heteropogon* and *Themeda*, as well as for the associated grasses within each grass community.

However, the benefits from the increase in fodder quality were overshadowed by the inability to adequately dry the grass bundles before storage. A period of four to five days without rain is required to properly dry a bundle of harvested grass. During this period just after the monsoon, the chances of a five-day dry period are low.

It was uncertain what implications harvesting grass at the vegetative stage before seed drop had on the soil seed bank and the regeneration capacity of the grass sward (3.2.3). However, perceptions from the farmers indicated that regeneration would not be affected for several years. But the study found that this varied depending on location along the slope of undulating land. Grass regeneration on the upper slopes of hills of the protected areas is much less than that on the lower regions in most study villages. The explanation appears to be the difference in the quantity of viable soil seed contained on the top 1 cm of soil between the two regions. Recommendations from the villagers included supplemental seed sowing in the upper regions of the grasslands to increase total production, and optimise availability of fodder grasses in the protected areas.

With regular monitoring and discussion of project activities, it was clear to the village participants that by organising themselves to protect and manage areas used for open-grazing, fodder availability and quality increased substantially. Detailed calculations based on field data clearly showed that the protected study areas could contribute to regeneration of almost four tonne per ha (dry weight) of grass fodder at the vegetative stage. This is a potential increase in dietary energy available for livestock during the dry season of almost 76 GJ/ha with total protein amounting to over 176 kg/ha. One hectare of regenerated local grasses from the area would amply support the energy requirements of three 250 kg steers (30.93 MJ of ME/day at maintenance level per steer) but the protein requirements would not be sufficient (Annex 5a). This would have to be supplemented with a protein source such as legumes.

4.4.2 Germplasm Option with Grasses

Supplemental seed sowing of grasses and legumes gave mixed results in establishment and growth, and resulted in a range of opinions ranging from good to poor performance among the participants (3.3.1). One of the problems was with the quality of the seed available at the time of the study. This contributed to poor germination and establishment in some of the initial village plots. Germination tests revealed that seed quality (<50%) was poorer than normally attributed to distributed seed.

Apart from seed quality, variability in soil quality and soil management contributed to poor growth. The study showed that if properly done, simple management techniques such as weeding and scarifying of the soil surface of areas suitable for growing selected grass species, can increase biomass production of superior quality fodder (e.g. *Chrysopogon* and *Pennisetum*) two-fold over that of the local species (e.g. *Heteropogon*) (3.3.1). However, villagers were not very interested in spending the time necessary for seed establishment in the field.

To help encourage seed supplementation, discussions were held into ways of reducing the time required for establishment and maintenance of grasses resulting in testing the techniques of seed pelleting. FAO (1989), reported that the dislodging of seed by wind and rain is one of the main contributing factors to low poor seedling establishment. This was also experienced by the participants who found that directly sown seed that had not been properly anchored into the soil was washed to one side of several plots by monsoon rains while some seed was blown by winds out of the plot area.

To help prevent dislodging of seed, several techniques have been developed including mixing the seed with manure slurry before planting, and pelleting the seed before sowing (Singh and Singh, 1996). Theoretically these techniques would provide both an anchor for the seed thus aiding in germination, as well as nutrients for the one-week period after seed reserves have been depleted (McWilliam *et al.*, 1970) resulting in improved establishment. However, practical experience in this study have shown that pelleting seed of acceptable quality can result in a significant reduction in seed germination compared to the unpelleted seed (3.3.2). This further discouraged villagers from investing time in supplementing grass seed.

The reason for the reduction in germination may have been due to the density of the pellet surrounding the seed. Much of the soil used for pellet production was of high clay content (>50%) – something that is not warned against in pelleting recommendations (Singh and Singh, 1996). When dry, the pellet forms a very hard coat around the seeds making it difficult for water to penetrate and for seeds to germinate. As seed concentration increases, seed germination increases. With higher concentration within the pellet, more seeds are close to the pellet surface layer where water penetrates.

Seed suspensions are an alternative to improving establishment and growth of grasses. When mixing seed into a soil/manure pellet, the mixture should be firm enough to hold the pellet together but should also be friable enough for the seeds throughout the pellet to germinate and emerge with minimal restriction. Friability depends on the proportion of clay and manure in the soil pellet mixture. The pellets used by the villagers tended to be very hard when dry indicating a higher than acceptable clay content for germination.

The other alternative to direct sowing discussed with the participants was to first establish grasses in a nursery. The seedlings would then be transplanted in patches in the field, and allowed to self-seed the surrounding area quickly suppressing inferior local vegetation to produce large swards of high quality animal fodder. This seemed particularly relevant for those species of which seed availability was limited (e.g. *Sehima*) and/or intrinsically difficult to germination (e.g. *Dichanthium*) ensuring a high probability of germination and seedling development.

Establishing grass nurseries required much more time and effort than was required for direct sowing of seed. The practical difficulties encountered in the study included late establishment resulting from a delay in distribution of materials. Nurseries were established well into the monsoon period when they should have been established 6 - 8 weeks prior to the start of the monsoon in order for seedlings to be transplanted at the beginning of the monsoon.

Besides availability of water at the end of the summer season, one of the major constraints in grass nursery establishment was that the benefits obtained from production of transplanted seedlings were less than other opportunities at the time

(3.3.3). Nursery establishment and out-planting activities have significant implications to the farming system. Like many activities conducted in the villages during the summer months, nursery maintenance requires to people stay in the village. As a consequence, those involved in nursery production could not migrate during this period. Although no financial data was collected, participants indicated that this negatively affected household income and their livelihoods, particularly for the resource poor in the village.

4.4.3 Germplasm Option with Woody Legumes

Throughout the study, villagers monitored growth of the fodder trees planted at the beginning of the study (3.4). Although all were in agreement that to further enhance productivity of land and intensify production of fodder and fuelwood, woody legumes planted on grasslands was a feasible option, few were willing to fully accept tree species they were not familiar with. Through observation and utilisation of tree biomass, this barrier was slowly being eroded and villagers began to accept *leucaena* as a useful product within their farming system.

Detailed results from a selection of *leucaena* taxa indicated that introduction of appropriate *Leucaena* species would help increase production and availability of fodder and fuelwood in the project area. Both *L. leucocephala glabrata* (Waimanalo) 34/92 and *L. leucocephala* K-636 produced sufficient quantities of biomass to counter fodder deficits during the year.

Fodder production averaged 6.3 tonnes ha^{-1} $year^{-1}$ for *L. leucocephala glabrata* (Waimanalo) 34/92 and *L. leucocephala* K-636. Very little production data is available on Waimanalo. The reported biomass from this study is more than that reported from other studies. For example, for K636, 3.0 – 4.0 tonnes ha^{-1} $year^{-1}$ (Brook, 1993) and other varieties such as 3.0 tonnes ha^{-1} $year^{-1}$ for K8 varieties, 3.6 tonnes ha^{-1} $year^{-1}$ for K341 (Guevarra *et al.*, 1978) and 1.3 - 5.2 tonnes ha^{-1} $year^{-1}$ for K28 (Mureithi *et al*, 1994a). Biomass was comparable to Hawaiian types producing 7.2 tonnes ha^{-1} $year^{-1}$ (Budelman, 1988) with coppicing intervals of three months.

Based on energy and protein requirements (264 g day^{-1}- Kearl, 1982), a 250 kg steer at maintenance level, for example, would require leafy material from less than six trees each day - almost 2000 trees each year if *Leucaena* leaf was fed at 100% of the diet (Annex 5b). However, as forage grasses and crop residues are abundant during the *kharif* and *rabi* seasons, it is advised to supplement only a proportion of the diet (25%) with *Leucaena*. As a result, harvesting leaves from a total of 500 trees would be required to provide one steer with enough high quality supplemental feed to maintain weight over the year. At a spacing of 1 m x 1 m, a spacing normally used by the villagers for eucalyptus plantations, this would require protection and maintenance of a plot measuring 20 m x 25 m (500 m^2). One hectare would supplement 20 steers at maintenance level.

Fuelwood from *Leucaena* species was considered acceptable to the extent that households believed that the wood burned longer than other species - particularly teak - presently used for cooking. This is probably due to the higher density of *L. leucocephala glabrata* (Waimanalo) 34/92 (835 kg m^{-3}) compared to *Tectona grandis* (620 kg m^{-3}- Tewari, 1992) which is one of the main native species regenerating from rootstocks in protected areas.

Based on the production of woody biomass from *L. leucocephala glabrata* (Waimanalo) 34/92 and *L. leucocephala* K-636, less than 430 trees would be required in Kadwali Chotti and Potaliya villages to provide one household with the equivalent amount of fuelwood (270 kg) presently harvested for cooking during the year. At a spacing of 1 m x 1 m, one hectare of plantation would supply enough fuelwood to substitute the wood presently being cut from other sources for over 20 households. This means that protection and maintenance of *L. leucocephala glabrata* (Waimanalo) 34/92 and *L. leucocephala* K-636 on 3.3 ha of land in Potaliya, and less than 1.0 ha in Kadwali Chotti, would be sufficient to substitute for the quantities of fuelwood presently harvested.

This represents a small proportion of the land base (<1%) in the project villages. Plantations could be small and easily established on both private or jointly managed land within the village, or on suitable areas of forest land as part of the land-use management plan.

As dung provides a substantial proportion of the energy fuel used in each village, (216 - 540 kg per household per year at 20% DM), establishment of larger areas would provide a substitute fuel source for the dung and increase the quantities available as a fertiliser for field crops. At calorific values of dung (15 J kg^{-1}) similar to that of wood from the *Leucaena* species tested (16+ J kg^{-1}), 342 to 857 tree per household would be required to produce enough fuelwood to substitute the use of dung. The additional area of land required to substitute for the dung presently used in Potaliya would be 2.6 - 8.6 ha, and 0.8 - 2.0 ha in Kadwali Chotti.

The total land area required to provide every household in the study villages of Potaliya (77) and Kadwali Chotti (23) with sufficient fuel for cooking throughout the year (including replacement for the fuelwood presently used from the forest area) would be 6-12 ha and 2-3 ha respectively. In addition, production of leafy material from these areas would provide an annual fodder supplement for 120 to 240 steers in Potaliya and 40 to 60 steers in Kadwali Chotti on a maintenance diet.

Substantial production of biomass could be gained by planting and regularly harvesting these trees. By introducing seed from two of the other species tested, *L. leucocephala glabrata* (Waimanalo) 34/92 and *L. leucocephala* K-636, both woody and leafy biomass production would increase significantly. With the acceptance by villagers that *Leucaena* possesses the characteristics for a fodder and fuelwood species, it is feasible that it could be adopted into the land-use system to provide a sustainable source to help improve fodder and fuelwood availability and quality for the local communities.

CHAPTER 5
CONCLUSIONS

Participatory methods are important to rural development activities but often require extensive involvement of facilitators working with farming communities. A focus on empowerment and improving livelihoods tends to restrict the target groups, limit the number of farmers and communities reached and detract from key issues related to the activities under discussion. Even though it is important to understand the household and the decision making process used, it is equally important to focus on specific objectives related to key activities within the study, particularly with results that have relevance to wider areas than just those in which interventions are tested (Chapter 4).

As many of the diagnostic tools and techniques require investment of time by the participating villagers, assessment tools should be selected for their relevance to the information required. One of the most useful techniques in this study was the transect walks. Information on the important criteria used to characterise natural resources and the environment was collected, and problems with possible solutions discussed within a short time (4.1). Other tools such as GIS mapping provided a means for understanding and planning management strategies within the spatial and temporal diversity of an area, timelines which quickly identified linkages between livestock numbers and population growth, and above all, focus group discussions which maintained feedback were essential for proposing and implementing interventions in this study.

Migration and its relation to the socio-economic status of the household, clearly showed that the more disadvantaged in the community had to spend longer periods working for a wage outside of the village. However, regardless of the status, livestock fodder was considered important to all. Particular emphasis was on the requirement for fodder during and after the *rabi* season when most study interventions were initiated.

Simply be changing current management practices, regeneration of biomass and eventually better quality native grasses, can increase the availability of fodder when most needed in the *rabi* (4.4.1). By encouraging group formation within the village community and facilitating discussions on specific issues such as protection of grassland areas, the dramatic results of increasing fodder availability in a short time will encourage the practice.

Introduction of germplasm can play a significant role. If good quality seeds of appropriate species are identified and established using proper planting techniques, then growth and biomass production can provide an improved fodder (and fuel) source. Woody legumes such as *Leucaena leucocephala* (waimanalo) and K-636 proved to potentially produce enough fodder and fuelwood to supply the requirements on the participants in the study villages. What is required now is a change in the attitudes of villagers toward this newly introduced species. The understandable reluctance to include these woody legumes in their farming system will give way if the experience over the coming few years remains positive.

It was clear that the increase in population is resulting in changes in land management in the study villages. Particularly relevant is the move to manage previously open-grazed areas (CPRs) as sources of cut-and-carry fodder. Since pasture land designated for grazing (8%) is a small proportion of the village, there is an increasing percentage of households that are adopting stall-feeding management practices including cut-and-carry.

This has implications on several fronts and requires investigations into the impact of this shift, both bio-physically and socio-economically. These investigations should not only look at issues such as selection of appropriate species to match the changing management systems, but also aspects such as the implication on soil health from nutrient flow away from the CPR area, the effect of stall feeding on the livelihoods of the resource poor, and the implications of transition from draft animals to potentially more profitable production oriented livestock such as milk cows.

5.1 Efficacy of Approach and Methods

In identifying areas for intervention during the diagnosis stage, time could be utilised much more effectively if the focus was primarily on using only specific diagnostic tools relevant to the task. Techniques used to collect information on general social interactions and physical environment are certainly necessary to help outsiders understand the village environment. But, as was the case in this study, much of the information collected in the test villages could have applied to a much wider geographical area, and the results of test interventions applicable to villages within, and even outside, the study area. Time of both researchers and participating villagers would be utilised much more efficiently.

When designing test interventions, complicated designs using multiple comparisons, such as an RCBD, which takes into account strict statistical rules related to replications and randomisation are too complicated for the farmers and some staff. A simple comparison of one intervention with another was deemed as the most appropriate because it reflected a more realistic and field based application of the intervention.

A focus group discussion is ideal for planning, implementing and evaluating interventions. With specific objectives to discuss, a facilitator with good facilitation skills can effectively lead participants through the planning process, and develop criteria to monitor and evaluate agreed interventions. Without good facilitation skills, there is uncertainty within the group and objectives of the discussion will most likely not be achieved. To help ask the right questions, facilitators should be fully trained in specific areas such as problem analysis. Target areas of intervention and research topics should have clear objectives to help facilitators target responses and to reduce the time required for group interaction

5.2 Approach for Development

A livelihoods approach is useful in identifying and selecting areas where interventions may be most appropriate. However, it is unrealistic to expect a single individual or group of individuals to be capable of addressing all problems, or even the top priority problems, identified within the livelihoods strategy. Although it may be necessary to enter a community with a 'blank sheet' if nothing at all is known about the community, it is essential to focus on interventions that are realistic to implement and not necessarily the issues that are regarded as top priority. For example, although water quality was one of the major constraints in the study area, the objectives of the study focused on fodder availability. This was simply because the author chose one constraint (inadequate fodder) that was identified in which he had an interest and the expertise to address.

During implementation of the study, there was clear confusion between using PRA techniques for gathering information to address specific objectives, and using them to empower individuals within the communities. PR should be seen as an activity and not regarded only as an empowerment strategy. PR is simply a means to address a problem or constraint that will gradually lead to improving the quality of life and empowerment of individuals and communities.

Finally, there seems to be a history of conflict between research and development – partly due to the technical bias associated with research and the social bias with development. Much of the research presented in this study is adaptive research. As such, the participatory techniques used in information gathering, analysis and evaluation can easily be considered as extension activities. Whether research or extension, the participation of all stake-holders, including target farmer groups, study staff and research institutes, is essential for judging the appropriateness of technologies and adoption of successful interventions.

5.3 Approach for Government Institutions

There is a generally poor level of communication between extension staff working in government institutes and rural communities, especially the poorer households. As a result, much of the technologies developed on government research stations have not been widely adopted. For example, IGFRI has an extensive list of grass forage species that have been selected for potential growth in the semi-arid regions of India and tested within a research station environment. However, few have been adopted by farmers simply because the criteria for selection is identified by the researchers and not the farmers themselves.

The farming system is complex and the livestock and forage management systems vary between villages and between well-being groups within each village. The challenge lies in identifying the criteria different farmer groups use for selecting interventions, such as forage species, and continuing the process of adaptive research with the participation of the farmers in monitoring, evaluating and eventually adopting the intervention.

Many government institutes have neither the policy nor, with the exception of a few innovators, the institutional cultural will to pursue this strategy in the short term. Most staff either are poorly trained in participatory skills, or they lack the ability to interpret and adapt the necessary skills to rural development.

A long-term strategy may be to continue developing the researcher's skills in participatory planning and facilitation in order to come up with researchable topics by identifying problems/constraints and opportunities for interventions. However, training must go beyond the diagnostic stage of simple appraisal and focus on the design, monitoring and evaluation of interventions with the participation of farmers.

A more practical, short-term approach would be to link with field-based organisations, such as NGOs, who have had much more experience with facilitation at the village level and are much better suited to identify and present researchable topics to technical staff based in research institutes. This would allow researchers to test interventions under a range of agro-ecological and socio-economic conditions using the networks established by the NGO's.

5.4 Approach for Non-Governmental Organisations

Linkages should be developed with outside institutions who can explore environmental and physical problems identified within the villages and provide technical support where and when required. These may include government institutes, or commercial companies such as seed producers who may have ready access to germplasm that fulfils the requirements of the farmers and could be tested using the companies own expertise.

Developing NGO staff skills in facilitating problem analysis and using diagnostic tools to help design research interventions is of primary importance in developing a PR strategy. More efficient use of the farmers' time would maintain interest and help focus information gathering on the most relevant necessary to address key objectives.

However, staff should also be familiar with some of the basic technical aspects associated with the interventions that are tested. For this reason, adequate numbers of staff involved in interventions must first have sufficient technical training in grassland management with a key area of the training being practical concepts such as methodologies of monitoring and evaluating participatory research interventions.

5.5 Final Thoughts

The finding reported in this study are unique. That is to say, this was the first time outsiders had entered into the two main study villages of Kadwali Chotti and Potalyia to conduct this type of activity. Although the process used was a standard participatory research approach involving diagnosis, design and implementation, much of the information that was generated was new to both the villagers and the investigators. Many of the interventions produced results that will help the community increase availability and improve the quality of livestock fodder in and around the study area.

Since initiation and completion of the study, government research and extension agencies, as well as NGO's, have gradually provided support to the villages. This support ranged from income generating activities associated with soil and water conservation schemes, to mobile health clinics providing vaccinations for children.

With an increasing population and increasingly limited resources, the future of these communities is uncertain. Migration trends may dominate the livelihoods strategy even more than at present, and what was once a rural community may shift into a predominantly peri-urban or urban existence. What is clear, however, is that the diagnostic process to determine appropriate technologies for adaptive research or extension activities can serve a useful purpose as long as the efficiency of the human and budgetary resources is maintained. This is a process adaptable to any situation, leaving the final decision of what to adopt with the community.

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GLOSSARY

Akateez custom: Is considered the proper time for commencing agriculture operation. Before sowing a cultivator sets a stone up at the top of the field and anoints it with red lead breaking a coconut over it. This stone represents lord Ganesh.

Bigha:	1 Bigha	= 0.1626 ha
	6.15 Bigha	= 1 ha (in Rajasthan)

Dasa custom: The *dasa meta* is worshiped by musical women on the festival of *Dasa Mata-ka-varat*, on the tenth day of the dark half of Chait (April), for the welfare of the family. It is, however, the god *Kasumar*, symbolised by a silver horse, who commands the general recognition. A special priest (hereditary) is appointed to invoke the deity. Each year on Chaitra purnima (full moon day in April) the he comes with a silver horse in a palanquin. The place dedicated to god *Kasumer* is worshipped. People pay homage to the god when their desires are fulfilled as a result of his supposed benediction. It is on this account that the worship offered is called *Jatar* (pilgrimage). Local musical instruments are played during this ritual.

Dewasa festival: The festival is celebrated either in the last days of Sawan (July) or in the early days of Bhado (August) when the maize crop is about one foot high. The priest, *Tadvi*, collects subscription from all the families/households in the form either of money or commodity and brings liquor, goat, milk, rice, a coconut, vermilion and incense and an earthen lamp. The village folk gather at the place of *Badadeo* (the deity of the village god). Then the priest burns fire and cooks sweet pudding of rice. He worships the deity and sacrifices the goat. Drops of liquor are sprinkled on the deity and the offerings are distributed to the participants. The festival is celebrated in order to please the village god so that he may protect the village from calamities.

Diwali festival: Also known as Diyari, is celebrated in the month of Kartic (October-November). On the 14th day of the month, the tribals cook *ghat* (maize-mash) and pulse. On the 15th day they prepare sweet dishes of maize flour and decorate their house at night by lighting earthen lamps. On the day following Diyari, bullocks are worshiped and offered good fodder and salt. The body of the bullock is painted with different hues and the horn with special green or red colour. This day is known as *Badi-Diyar* and is followed by *Chhoti Diyari* on a day chosen by the people. The festival is the day of worship of the bullocks.

Focus group discussion: A special type of group interview in which the researcher controls the purpose, size, composition and procedures of the group. Discussion involve in-depth analysis of a particular topic and usually conducted with groups of 15-20 farmers/villagers. The discussion of the particular topic is in relation to the concept, the past experience in operationalising the concept, the relevance of the concept to the rural settings, the pertaining problems and their solutions.

Holi festival: Is celebrated at the end of Phagun (March). Fire walking is the most important event during Holi. During this period, people make promises to the gods at this time to help alleviate difficulties. Fire is made of wood and after offering it a cock and a coconut, they walk on the coals. A special performance takes place in Holi. A man is blackened with charcoal and dressed in a blanket and is called *Budelya* and another man is dressed as a woman being called Raiyi. These two dance and one of the two sings obscene songs. This is a time for copious consumption of alcohol.

***kharif* season:** Cropping season during the monsoon in the months of July to September.

Navratri festival: Among the Bhils of the district of Malwa in north-western India, Jowar grain is planted in seven small baskets during *Naoratras* (nine days fast which precedes the festival of *Desarya*). These are then arranged: two to the north in the names of *chamunda mata* and *Kachumar*, two to the east in the names of *Dharm raj* and *Sharda*, one to the south in the name of *Rani kajla*, and two in the names of *Manora* and *Devi mata*. They are sprinkled with water until they germinate. Music and dancing is performed round them. On the Desarya day the baskets are floated in the nearest stream amidst singing and music.

Notra Festival: The day after the marriage is fixed, some rice dyed with tumeric is given to Bhil community members. The men leave rice on the threshold of all invited to the wedding. The recipients entertain the messenger according to their means. This is the ceremony of *Notra* or invitation.

Participatory rural appraisal: An intensive, systematic but semi-structured learning experience carried out in a community by a multi-disciplinary team which includes community members.

***rabi* season:** Cropping season after the monsoon in the months of September to March.

Rakhi festival: This festival falling on the full moon day in the month of Sawan (August) has a special significance for the Bhils as its proper observance is intended to protect their tools. If the tools survive, no one can injure the tribe. On this day they tie sacred cotton thread (*Rakhi*), to the implements.

Semi-structured interviews: Interviews based on a written list of questions or topics that need to be covered but do not specify the wording of order of the questions.

Wealth Ranking: An exercise where the relative well-being (social, economic) of every villager is assessed by the villagers themselves. It is an intra-village exercise where socio-economic categories of (resource) rich, (resource) moderate, and (resource) poor is assigned according to the perceptions of the villagers for each other. The indicators of wealth ranking are usually based on assets, but also include aspects of inputs/expenditures and access to credit.

ANNEXES

Annex 1. Analysis of Soil Samples from Two Locations in the Study Area.

1	**Area**	**Kadwali Choti Rajasthan**	**Pandya Farm Gujarat**
2	Date collected	13/08/96	14/08/96
3	Date analysed	28/08/96	28/08/96
4	Soil colour (Munsell)	brown	brown
5	Soil texture	clay loam	fine sandy loam
6	pH (1:5 water)	7.0	7.6
7	Organic Carbon	1.2	1.2
8	Nitrate Nitrogen mg/kg	5.8	4.4
9	Sulfur mg/kg	4	9
10	Phosphorous (BSES) mg/kg	92	5200
11	Phosphorous (Colwell) mg/kg	12	75
12	Potasium (Amm. Ac.) meq/100g	0.38	0.25
13	Calcium (Amm.Ac.) meq/100g	24.36	8.06
14	Maganesium (Amm. Ac.) meq/100g	13.03	2.92
15	Sodium (Amm Ac.) meq/100g	0.15	0.27
16	Chloride mg/kg	10	30
17	Electrical Conductivity dS/m	0.04	0.09
18	Copper (DTPA) mg/kg	3.4	6.0
19	Zinc (DTPA) mg/kg	1.1	2.9
20	Manganese (DTPA) mg/kg	8	11
21	Iron (DTPA) mg/kg	17	30
22	Boron (Hot $CaCl_2$) mg/kg	0.42	0.76
	Calculations		
	Cation Exch. Cap. meq/100g	37.93	11.51
	Calcium/Magnesium Ratio	1.87	2.76
	Sodium% of cations (ESP)	0.4	2.36
	Elec. Conductivity (se) ΔS/m	0.3	1.0

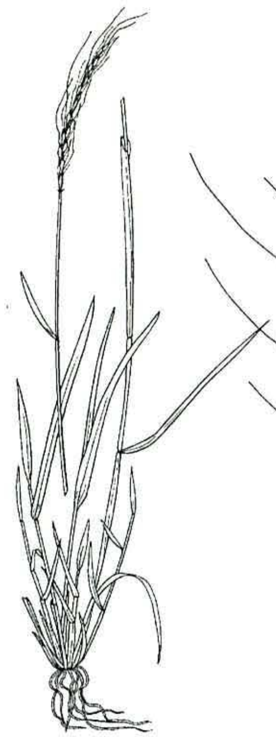
* Analysis conducted by Soils Testing Laboratory, Queensland, Australia

Annex 2 Tree and Shrub Species Found in the Study Area

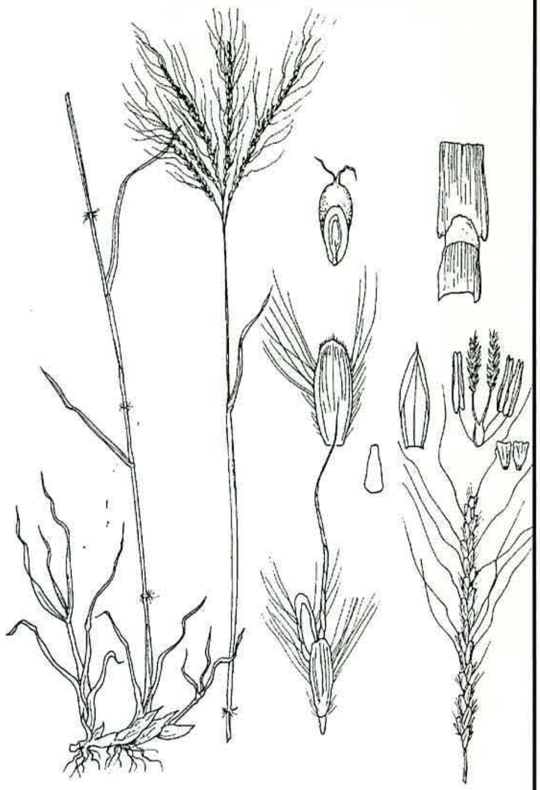
BOTANICAL NAME	LOCAL NAME
Acacia auriculiformis	bangali babul
Acacia catechu	khair
Acacia nilotica	babul, baval
Acacia tortilis	israili baval
Achyranthes aspera	aligera, anghedo
Adangitum hemorpil	ankal
Adina cordifolia	adru, haldu
Ailanthus excelsa	arduso
Ailanthus procera	hahda, her, white sirus
Alangium salviifolium	ankol
Albizzia lebbek	black siras
Anogeissus latifolia	dhowada, dhavdo
Anogeissus pendula	dhok
Azadirachta indica	limda, limhera, neem
Bauhinia racemosa	asotri, hitri
Bambusa arundinacea	vans, vahen, bamboo
Boswellia serrata	selar, saledi
Buchanania lanzan	charoli
Bassia latifolia	mahua
Butea monosperma	khakhra, palas
Capparis aphylla	kerdo
Casuarina equisetifolia	saru
Cassia auriculata	aval
Cassia fistula	garmalo, annval, karmela
Commiphora wrightii	gugal
Cordia dichotoma	gunda, dogri
Cordia gharf	gundi
Dalbergia latifolia	shisham
Dalbergia sissoo	sissoo, shisham
Delonix alata	sandesaro, hadra
Dendrocalamus strictus	vans, manvel
Diospyros melanoxylon	tendu, timru, timerwa
Eucalyptus tereticornis	nilgiri

Euphorbia hirta	dudhi, thor (herb)
Ficus religiosa	pipal (bo tree)
Gardemia turgida	gugli, akala, hingoli
Gmelina arboria	sewan, shevan
Grewia tiliaefolia	dhaman, dramaniya, gangrechi
Helietera isora	antedi, merdashingi, marorphalli
Holarrhena antidysenterica	indrajav, karva
Indigofera cardifolia	bhakho, menandi
Ipomea spp.	nasar ganda, mariadvel, khokharvel
Jatrapha curcus	ratanjyod
Kigelia pinnata	nani padar
Lagerstroemia parvifolia	bondaro
Lannea coromandelica	gunjla, gurjan, modad, moina
Lantana camera	danidalia, basarum, bandaragal
Leucaena leucocephala	subabul
Madhuca indica	mahuda
Manikara hexandra	rayan
Mitragyna parviflora	kamra, kalam
Morus alba	shetu (mulberry)
Occinium centum	bhangra, bhoot
Peltophorum pterocarpum	bia
Pithecolobium dulce	goras amli
Pongamia pinnata	karanja
Prosopis cineraria	khijdo, samado, sangri
Prosopis juliflora	ganda baval
Ricinus communis	arand (caster bean)
Samania saman	barsati (rain tree)
Sehima sulcatum	sanyar
Siola grewidoes	zhorpits
Spermacaco hispida	kuba
Tectona grandis	sag, teak
Terminalia balerica	bahera
Terminalia tomentosa	hadad, sadad
Typhrosis spp.	papri
Wrightia tinctoria	khirhi, khirni, dudhi, kudo

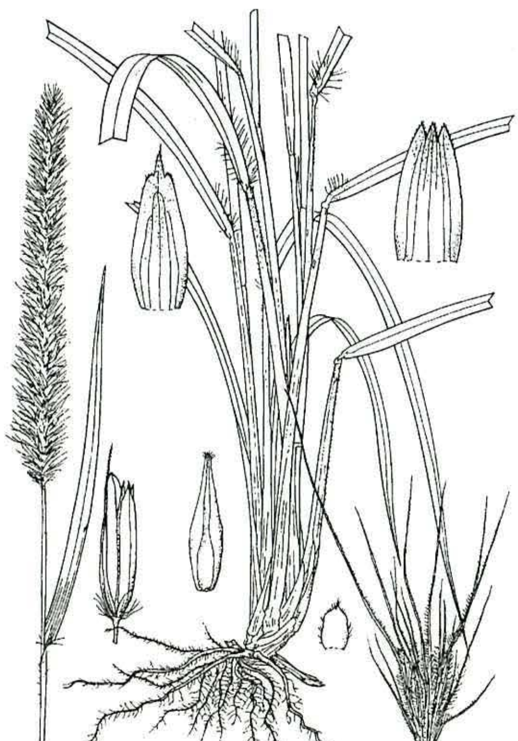
Annex 3. Illustrations of Grass Species Found and Tested in the Study Area



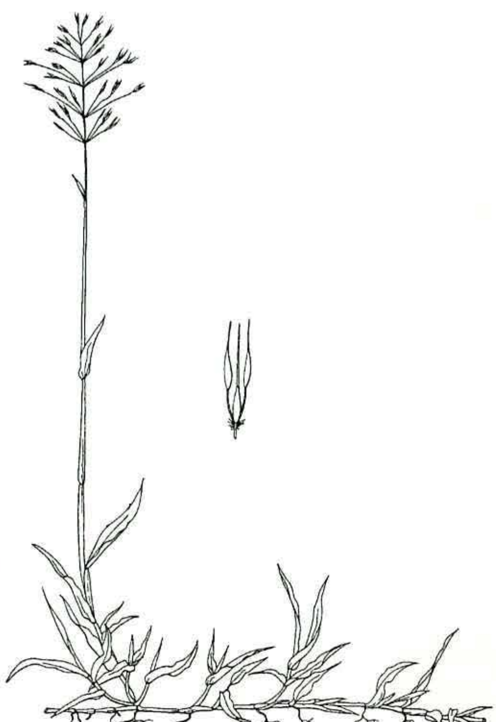
Sehima nervosum



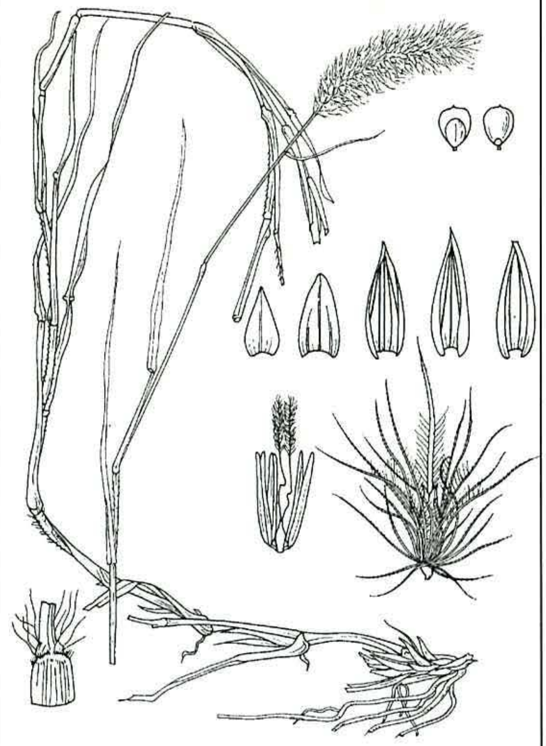
Dichanthium annulatum



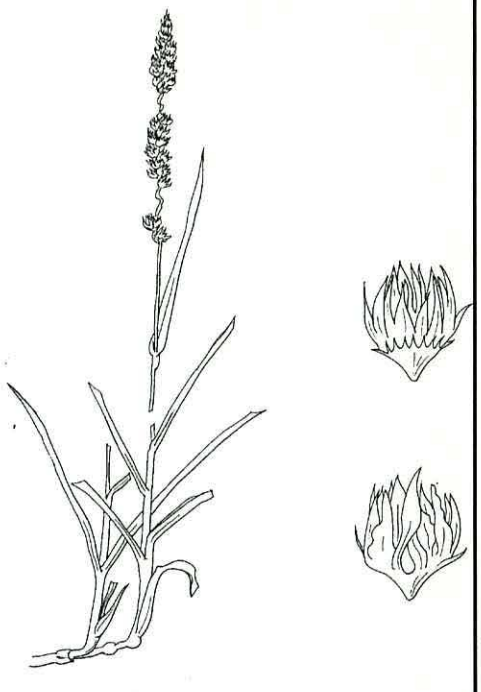
Pennisetum pedicellatum



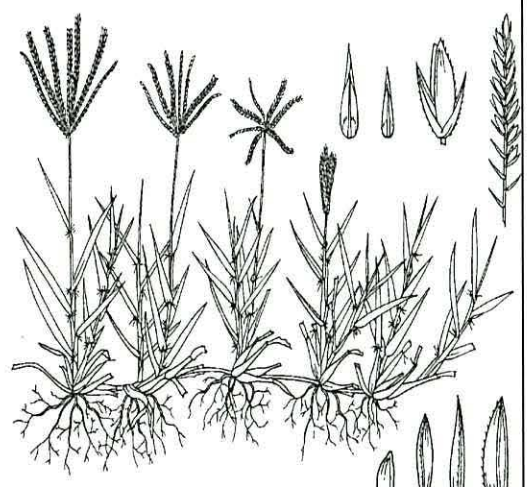
Chrysopogon fulvus



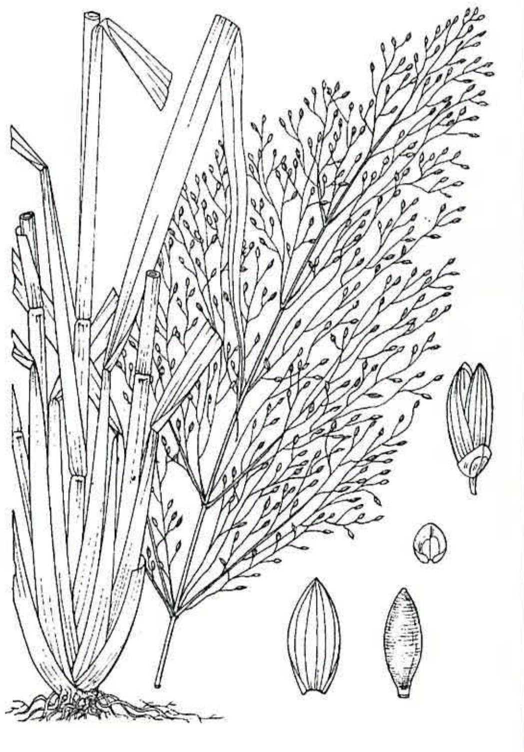
Cenchrus ciliaris



Cenchrus setigerus



Cynodon dactylon



Panicum maximum

Annex 4. Examples for the Restricted Number of *Leucaena* Varieties Tested

variety	row inter (m)	spacing intra (m)	cutting height (m)	cutting interval (days)	biomass yield (kg/m/yr)	leaf ratio %	reference
	1.9		0.05-0.1	90-120	1.04-1.5[i]	60	Oakes & Skov, 1962
Peru	0.3		0.3	60-90	1.01[b]	65	Partridge & Ranacou, 1973
Salvador	0.3		0.3	60-90	0.9[b]	65	Partridge & Ranacou, 1973
K8	0.5	0.15-0.45		75-120	0.44-1.07[b]	59-79	Guevarra *et al.*, 1978
K341	0.5	0.15-0.45		75-120	0.59-1.21[b]	49-79	Guevarra *et al.*, 1978
	<1		0.1-0.3	40-120	5.4 t/ha	ratio	Pathak *et al.*, 1980
Peru, 'K'	0.4	0.05	0.15	60	0.89-1.02[a]		Mendoza & Jarvier, 1980
Peru, Salv	single			30-120	0.94-1.56[d]		Osman, 1981a
Peru			0.75	30		52-65	Osman, 1981b
Peru	2		0.15-0.5	90	1.25-1.69[d]		Osman, 1981c
K28	4	0.25	1.5	60-75	2-2.8[c]		Kang *et al.*, 1981
'K' series	1	0.15		40-45	1.5-2.13[f]		Rewani *et al.*, 1982a
K8	1-1.5	0.1-0.3	1	40-45	1.27-1.68[g]		Rewani *et al.*, 1982b
Hawaiian	1	0.2	0.15-1.5	40-70	0.4-1.21[a]		Krishna & Gowda, 1982
Peru	3		0.5-3	60-120	2.86-7.21[a]		Mendoza *et al.*, 1983
K8	0.8-0.9	0.1	0.25-0.75	75-90	0.58-1.26[h]		Rewani, 1983
K8	2	1	0.6-1.5	50-70	0.81-1.55[a]		Krishnamurthy & Gowda, 1983
several	3	2		120-240	2.4-2.8 m³/ha	36-42	Lima, 1986
several	2	2	0.75	75	9[k]		Arora *et al.*, 1986
Salvador	3-5	0.6-1	whole	1.2 yr	d² + ht		Nimbkar *et al.*, 1986
	2-6	0.5-3			0.57-2.42[b]		Gethaun & Jama, 1986
Hawaiian	1	1	0.5	90	1.54[h]	100	Budelman, 1988
K28	4		1.5-0.75	60	2.34-2.84[a]		Jonsson *et al.*, 1988
K28	2	0.25	0.25-1.5	30-180	0.32-2.66[c]	graph	Duguma *et al.*, 1988
	3	0.45-3	whole	4.5 yr	3[k]	45	Chandrasekharaiah & Prabhakar, 1988
K28	2-8	0.5-3	0.5	45	1.52-3.75[e]	42-73	Macklin *et al.*, 1988
Peru	3	0.25	grazed	360	0.24-0.27[b]	100	Cooksley *et al.*, 1988
K8	0.75-3.75	0.25	0.75	90	1.9-3.26[c]	75	Mittal & Singh, 1989
several			dbh	6 yr	0.04-0.06 m³/tree		Jama *et al.*, 1989
Cunning	3	1	1	120-270	5.03[i]	40	Akkasaeng, 1989
K8, K72	2.73	2.73	whole	7 yr	0.74-0.81[a]	0.81	Moraes & Brouard, 1989
	3-6	0.5	0.3-0.9	75-120	0.72-0.87[j]		Jama & Nair, 1989
K8	0.5	0.3	0.3	40-60	0.58-0.92[a]		Jeyaraman *et al.*, 1989
K8	1.35-5.95	0.2	0.75	90	1.06-4.47[c]	55	Rao *et al.*, 1990
	4	0.25	0.5-1.5	75-90	2.7-3.6[a]		Atta-Krah, 1990
K8	1	1	whole	5.5 yr	1.56[a]	50	Lugo *et al.*, 1990
Cunning	2		0.1-6	0-50	0.27-4.15[b]		Field & OeMatan, 1990
K28	2	0.1-0.8	0.5	2.7 yr	0.55-2.37		Jama & Gethaun, 1991
K28	4	0.5	0.25	75-90	3.2-3.4[a]		Siaw *et al.*, 1991

variety	row inter (m)	spacing intra (m)	cutting height (m)	cutting interval (days)	biomass yield (kg/m/yr)	leaf ratio %	reference
	4-5	1	0.25-1	30-90	0.02-0.13[l]		Karim *et al.*, 1991
K8, PR	1	1	whole	5.5 yr	1.2-1.55[r]	46	Wang *et al.*, 1991
1094	1.5-3	1.5	whole	1-2 yr	1-3.03[a]	6-43	Gathaara *et al.*, 1991
Cunning		0.25	0.75	180	0.64-1.3[m]	25-35	Bray & Woodroffe, 1991
	0.5-1.5	0.5-1.5	1	45-60	0.1-0.5[a]	100	Ella *et al.*, 1991a
	4	4	1	90	0.2-0.5[k]	100	Ella *et al.*, 1991b
			0.5	90	0.12-0.17[l]		Bassala *et al.*, 1991
	1.5	1.5	0.5	120	0.22-1.35[a]	100	Felker *et al.*, 1991
KX1	3	0.5	0.5	30-50	0.4-2.2[a]		Rosecrance *et al.*, 1992
	4		0.25	30	1.24-2.8[a]		Palada *et al.*, 1992
Cunning	1	0.1	0.6-1	365	1.27-1.74[a]		de Lucena Costa & de Cruz Oliveira, 1992
Salvador	2	2	1		0.5[a]	40-50	Sanchez & Moreno, 1992
					9.2/tree		Toky *et al.*, 1992
	1	1			13[k]	10	Chaturvedi *et al.*, 1992
K8	6	6			0.5-0.73[a]	30	Gill *et al.*, 1992
	1	0.25			1.2[b]		Mishra *et al.*, 1992
K28	single tree		whole	60	0.14-0.53[l]		Kadiata & Molongoy, 1992
Peru	4.5	0.5	0.5-0.6	75	2[a]		Rathert & Werasopon, 1992
	1	1	form factor	5 yr	0.54-1.1m^3		Bhatnagar *et al.*,1993
several	1	0.25	0.5-0.75	90	1.3-2.4[p]	50-75	Lai *et al.*, 1993
	4	4	whole	2 yr	2.2[a]	30	Hooda *et al.*, 1993
	1.5	1.5	0.75	60-90	0.28-0.4[a]	100	Krecik *et al.*, 1993
K636	6	0.5	1	120-210	0.5-0.8[q]	100	Brook, 1993
Peru	4	0.5		30	4.8[a]		Rathert & Werasopon, 1993
	1	1	0.5	360	0.25-0.58[a]	25	Duguma *et al.*, 1994
several	1	0.25	0.5	180	0.2-1.35[a]	100	Wheeler *et al.*, 1994
K28	5	0.25	0.5	30-60	0.13-0.52[a]	100	Mureithi *et al.*, 1994b
	2	2	dia 0.3m		0.15-8.8[k]	removed	Stewart & Dunsdon, 1994
	2	2	whole	2.3 yr	2.32[a]	14	Kamara & Maghembe, 1994
	4	0.4	0.6	90-360	4.7-13.6[a]	10-35	Cobbina, 1994
several	1	0.5	0.5	60-90	2.22[a]	57	Mureithi *et al.*, 1994b
	4	0.2	0.5	45	0.4-5.72[a]		Shannon *et al.*, 1994
several	3		0.25-1	90-180	0.4-0.9[m]	100	Yuahnehi & Ivory, 1994

Leucaena leucocephala biomass yields calculated from:

[a] tonnes/ha/yr
[b] kg/ha
[c] tonnes/ha
[d] kg/plot
[e] tonnes/ha/season
[f] quintal/ha/yr
[g] quintal/ha
[h] quintal/ha/cutting
[i] tonnes/acre
[j] kg/yr/m
[k] kg/tree
[l] g/tree
[m] g/m row
[n] g/m^2
[p] kg/m^2
[q] kg/m hedge
[r] Mg/ha

Annex 5a. Calculation of Energy and Protein Requirements and Availability

Grasses for 250 kg Steer at Maintenance.

Pasture grasses	4 tonne/ha
Crude Protein	4.4%
1 kg grass	= 19MJ GE/kg
@ DMD	= 50% then divided by 50%
DE	= 9.5MJ/kg
ME	= 80% of DE
then grass contains	9.5 MJ/kg * 0.8 = 7.6 MJ of ME/kg
so 1 m2	= 7.6 MJ ME/kg * 0.4 kg/m^2 = 3.04 MJ of ME/m^2
since	a 250 kg steer requires 7.4 Mcal of ME/day at maintenance (30.93 MJ of ME/day)
then	feed for one day will require 30.93 MJ of ME/3.04MJ of ME/m^2 = 10.17 m^2
so for 1 year	1 animal would require an area of 10.17 m^2 * 365 days = 3,712 m^2/year
therefore 1 ha	would support 2.7 animals

Would this support protein requirement?

Protein/m^2	= 0.4 kg/m^2 * 4.4% = 0.176 kg CP
Since	a 250 kg steer requires 0.337 kg CP/day
then	an additional 0.161 kg CP/day is required
	This is almost half the minimum requirement of 0.337 kg CP/day

Some options: increase the area of grass required for the animal to 19.32 m^2/day (7,052m^2/year) for each animal (0.161 kg CP per day /0.4 kg * 0.044 = 9.15 m^2/day). This would reduce the number of animals supported to 1.5 animals/ha.

or supplement the remaining protein requirement with high quality legumes (0.161 kg CP per day/0.15 CP/m^2 = 1.07 m^2/day) requiring an additional 392m^2/year. A native grassland to legume ratio of 10:1 would support 25.5 animals/year.

Annex 5b. Calculation of Energy and Protein Requirement and Availability

Tree Legumes for 250 kg Steer.

Leafy material	0.63 kg/tree/year
Crude Protein	15.6%
DMD	56%
19MJ GE/kg	Divided by 56%
DE = 10.6MJ/kg	85%
ME = 9 MJ/kg	2.15 Mcal/kg DM
	0.63kg of forage DM produces 5.7 MJ of ME
	= 1.36 Mcal ME
	250 kg steer @ maintenance needs 7.4 Mcal ME
	= 7.4/1.36
	= 5.44 trees
Protein?	5.44 x 0.63 x 0.156 = 535 CP
	This is above the minimum 337 so it is OK.

Annex 6 Strategy to Improve Livestock Fodder

A development strategy aiming to improve the quality and increase availability of livestock fodder should do so by: rehabilitating degraded grasslands into late succession plant communities through protection of heavily grazed lands; and introducing improved grass and legume species into the land-use systems presently employed. Implementation of the strategy must take into consideration land-use, land tenure and current land management. It must also consider the people involved in the interventions and their training to develop the capacity for implementation of activities.

Consideration as to how the land is presently managed by the community is essential before planning and implementing activities because grassland improvement activities inevitably involve significant changes to these land-use patterns. Further divisions can be made within each category according to land tenure and how the land is currently managed.

To help encourage grassland development, grass establishment activities should be discussed with full participation of village members. Areas designated for establishment should be selected and activities such as seed purchase and nursery establishment started well before the time of out-planting to allow sufficient time for properly implementing grass establishment activities.

Method of establishment depends upon four factors:

- size of the area allocated for establishment (the larger the area, the more difficult it will be to manage);
- location of area (common property areas currently used for open grazing are more complicated to manage than private lands);
- upper and lower catchment areas (self seeding is less effective on the upper slopes);
- amount and quality of seed available (limited quantities will restrict method, size and location of establishment.

However, location depends on land-use practices presently used:

Open forest land

Forest land is owned by the state government. For this reason, involvement in Joint Forest Management schemes are the only option for neighbouring village communities to develop and legally benefit from resources obtained.

To improve availability and quality of grasses and legumes in these areas, the demarcated forest land must be surveyed and micro-habitats identified for the suitability of specific species. Other considerations include:

- The area should initially benefit from natural regeneration that takes place during the first year of protection. Regeneration will facilitate identification of micro-habitats which are species-specific. This will significantly increase the success of establishment and production of introduced species;
- Planting techniques should involve shallow scarification on the surface of each micro-habitat designated for planting. This is then followed by either pouring a slurry mixed with grass seed in shallow furrows, broadcasting seed or seed pellets, or transplanting seedlings from a nursery where appropriate at the beginning of the monsoon. Legumes do not require a slurry mixture and can be directly sown on to the scarified soil surface;
- Established grasses should then be allowed to set seed before harvesting in the following year.

Cultivated land

As part of the crop rotation, planting legumes to improve soil conditions and crop production, and provide a source of high quality fodder to supplement lower quality grass species, should be encouraged;

Promotion of silvopasture systems incorporating a grass/legume mix and fruit trees or pole/fodder trees would provide a significant increase in fodder availability as well as a source of income from production of fruit and/or pole wood:

- The area selected must be protected throughout the year and tree density must be wide enough to accommodate tree and grass sward growth;
- After cultivation of the selected area, both trees and grass/legume mix can be planted at the start of the monsoon;
- Early in the dry season soon after the rains have stopped, drip irrigation systems should be installed for fruit trees to aid tree growth and survival. Pasture grasses will also benefit from any excess irrigation water intended for the tree saplings;
- Micro-irrigation systems can be dismantled in the third year after planting and moved to a new site.

Pasture land

- Designated Land owned by the Panchayat is usually considered a common property resource and used for open grazing particularly during periods of restricted grazing in the *kharif*. Pasture improvement on these areas must include restricted access and protection from grazing livestock for the first few years. To facilitate development of CPR areas, a participatory approach is required using FGDs in village groups to develop management strategies (e.g. selection of species, protection, fines and payments, scheduling of activities) for the CPR area. This is similar to the JFM scheme with the main difference being that the Panchayat and not the forestry department is the controlling body, and villagers should be empowered enough to more easily reach agreements.
- The pasture areas could be used for controlled grazing or for *cut and carry*, but a portion of the revenues obtained by the village communities from grass/legumes or even tree products could be collected by the Panchayat and invested to further develop the CPR area;

- For designated revenue land, similar procedures as described for Panchayat land could be implemented on revenue land to create a CPR area for improving grass/legume availability. However, this could be more complicated to manage as the land is owned by the state and the local Patwari may have more difficulty obtaining permission to establishing a CPR area on behalf of the village community;
- Much of the undesignated pasture land is degraded open forest and the only legal option to improving the availability and quality of the grasses/legumes obtained from these areas is through the Government JFM scheme using procedures described previously;
- The essential first step is to protect the area, after which suitable grass or legume species are introduced onto micro-habitats based on soil type and vegetation patterns. This will help increase the rate of succession and establish improved primary succession species;
- On undesignated Panchayat and revenue lands, similar procedures should be followed for establishing a CPR area on designated pastures. However, as in the designated pastures, agreement and organisation of implementing activities may be more difficult than on forest lands.

Uncultivated Land

- Much of the cultivable land considered to be in the uncultivated category is land that is left fallow as part of the regular crop rotation. The present practice is to allow natural vegetation, mostly weeds, to grow on the previously cropped fields. Scarification of the soil followed by direct sowing with legume seed would help to improve soil conditions and provide a nutritious source of fodder;
- At times when farmers are forced to fallow their land and reduce the area cropped in a season, perhaps due to lack of livestock to pull the ploughs, good quality grass seed should be broadcast by hand onto the scarified area. Green fodder could then be harvested and fed to livestock during the monsoon, or ensiled and stored until the dry season;

- Uncultivated structures on cultivated land including areas of field bunds, nallah plugs and nallah banks can make up a significant proportion of the village land area and therefore potentially provide grasses and legumes for controlled grazing and cut-and-carry. Establishment, particularly on bunds, requires grass seed to first be mixed in a slurry before application. Legumes can be directly sown into a shallow trench (less than 1 cm deep) and lightly covered;
- On uncultivatable areas, usually consist of steep slopes and very rocky areas, enrichment planting with seed from hardy grasses (encapsulated in earthen pellets) and legumes (directly sown) will help control erosion of steep banks, as well as provide fodder for grazing livestock.

b) Other recommendations

- Restricting access to areas designated for grass/legume improvement is of the highest priority since uncontrolled grazing by livestock is the main limitation for grass/legume establishment. However, compensation should be considered for losses incurred by restriction of livestock grazing during the early establishment phase to encourage planting and management activities. This compensation could be by the provision of fodder grasses from outside the village during the first year of establishment of a CPR area;
- Forest land areas, next to cultivated lands, is one of the largest land-use categories in the study area and can potentially have one of the biggest financial and environmental impacts on village livelihoods. Protection of these areas schemes such as JFM should be facilitated to encourage;
- *Panchayat* and revenue pasture lands presently used for open grazing should be developed into protected CPR areas using modalities similar to those outlined in the government JFM schemes, to promote better management and production of higher quantities of better quality vegetation such as livestock fodder;
- Under the rainfed conditions of the study area, only one harvest per season should continue under regular management conditions in the project area. However, techniques for adequately drying or ensiling harvested grass before flowering when nutritional quality is highest storage should be investigated;

- When protecting grassland areas for natural vegetative regeneration, be aware that production will be vary significantly within the area (i.e. less on the lower slopes compared to the higher slopes). Enrichment seeding will help to supplement the soil seed bank, reduce the time for sward establishment and increase production;
- When introducing species into an area, careful consideration must be given to the appropriateness of the species selected as well as the micro-habitats within the planting sites. For instance, *Pennisetum* produces large quantities of biomass but has low palatability during the period (late *rabi*) when fodder is required to feed livestock;
- Seed quality must be monitored regularly to prevent distribution of seed with low viability into villages. Unsuccessful germination of poor quality seed can easily result in adversely affecting the attitudes of villagers and undermining the entire process of promoting potentially beneficial interventions;
- Once selection has been made, the quantities of seed required must be determine at least one year before implementation of planting activities to ensure sufficient time for seed multiplication to meet those requirements;
- Grass seed should not be sown loosely onto the planting area. Seeds should first be suspended (i.e. mixed with a soil/manure slurry solution and then poured in lines onto the planting area, or made into proper soil/manure pellets before sowing) to anchor the seed and increase the chances for establishment. Remember that when mixing seed into a soil/manure pellet, ensure that the mixture is firm enough to hold the pellet together. However, make sure that the pellet is friable enough for the seeds throughout the pellet to germinate and emerge with minimal restriction - friability based on the proportion of clay and manure in the soil pellet mixture. When using a slurry solution to suspend grass seed before sowing, ensure that the mixture is thick enough to hold the seed in suspension;
- Awareness of the benefits associated with improved grasslands must be emphasised for both the village community using participatory approaches and the staff through training and provision of teaching materials;

- To ensure scientific rigger and provide an opportunity to explore environmental and physical problems identified within the villages, technical support should be regularly provided by outside institutions (i.e. such as the Indian Grassland and Fodder Research Institute (IGFRI), Jhansi, the Arid Forest Research Institute (AFRI), Jodpur and the State Forestry Departments);
- Regular monitoring of interventions would maintain a dialogue between the institutions and the villages facilitating constructive feedback on activities;
- There is a generally poor level of communication between extension staff and households, due either to a shortage of people trained in participatory skills, or people lacking in the ability to interpret and adapt these skills to rural development. Training in facilitation should be provided;
- Adequate numbers of staff involved in interventions must first have sufficient technical training in grassland management to properly implement and monitor activities;
- Practical and appropriate training along with basic training material using pictures and diagrams should be developed to be used by the villages involved with interventions.