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Vishnu Sharma & Dr. Ramkumar Bendapudi

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PREFACE

This report is prepared with the support of Society for Promotion of Wasteland Development (SPWD). The report is part of SPWD's efforts to examine and understand the relevance and significance of biodiversity and its implications in the context of rural livelihood options in Ajmer district and has specific reference to the case of *Prosopis juliflora*.

Prosopis juliflora is fast growing, nitrogen-fixing tree species introduced and propagated aggressively in Ajmer district from early 60s to regenerate degraded forestlands. After its initial seeding, it further consolidated its position in the local ecology due to its natural ability to survive and propagate.

Prosopis juliflora has both positive and negative externalities. It is beneficial in that it meets domestic energy requirements at the household level and it can also produce a variety of valuable goods and services (e.g. construction materials, charcoal, soil conservation and rehabilitation of degraded and saline soils). The problematic characteristic of the species is its invasiveness impacting crop production, livestock production, pasturelands and human health.

With the projected climate change scenarios and vulnerability of rural community to such changes, this perennial resource has the potential to be developed as an adaptation strategy, provided it is properly managed.

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This report is an attempt to understand the perceptions of the rural households about its benefits and problems. Ajmer district in itself has varied soils, vegetation, rainfall patterns and livelihood conditions. Therefore, for the sake of this study, the district is broadly classified into subregions based on the above conditions and the benefits and costs from *Prosopis juliflora* are examined for the respective subregions.

The purpose of this report is mainly to serve as a base to help develop strategies to manage *Prosopis juliflora* in order to enhance its utility, increase livelihood security and reduce its environmental costs.

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CHAPTER 1

Introduction

Biodiversity is the numbers and relative abundances of different genes (genetic diversity), species and ecosystems (communities) in a particular area (IPCC, 2002). Biodiversity in all its components (e.g. genes, species and ecosystems) increases resilience to changing environmental conditions and stresses (FAO, 2007). Genetically-diverse populations and species-rich ecosystems have greater potential to adapt to climate change. Heal (2000) suggests that biodiversity is important from an economic perspective because it provides or enhances ecosystem productivity, insurance, knowledge, and ecosystem services.

Randall (1991), while considering various philosophical approaches to the value of biodiversity, states that ecosystems are complex and fragile, and it is a tenet of ecology that everything has its place in the broader scheme of things. Thus, there is a presumption that species are not only useful directly as suppliers of raw materials and amenities but also indirectly for their contribution to ecosystem support.

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It cannot be denied that rural economy and livelihoods are closely associated with the local ecology. The economic, social and cultural fabric of the rural society very much revolves around the locally available natural resources. Hence, the rural livelihoods options are very much influenced and affected by the condition of local ecology and the natural resource base. In the context of rural livelihood options, access to the available natural resources by the community is also affected by the changes in the local ecology.

Biodiversity management seeks to maintain biodiversity for its associated material, social, cultural, spiritual and ecosystem values (Miller et al.) Biodiversity management is the human effort to plan and implement a set of approaches to (Miller et al.): (i) protect and sustainably use biodiversity and biological resources and ensure adequate sharing of benefits therefrom; (ii) develop the human, financial, infrastructural and institutional capacity to address these objectives and (iii) establish the institutional arrangements necessary to foster the required cooperation and action by private and public interests.

This study has specific reference to *Prosopis juliflora*, an exotic invasive tree species that successfully colonized and now dominates local ecology in Ajmer district. The focus of the study is to understand the perceptions of the community about the specie, its uses and costs due to its presence on their respective private lands together with the ‘management’ of this specie. The purpose of the report is to bring in the concepts of biodiversity management for the case of *Prosopis juliflora* and to serve as a base document to evolve programs for managing it. This would help in strengthening the strategies to adapt to increasing climate variability.

CONTEXT / BACKGROUND

The Stage-I report examined the geography and climate parameters in Ajmer district. It tracked changes in the land utilization patterns, water resources utilization, crop production and livestock production activities based on secondary information sources and field observations.

As was discussed in the Stage-I report, the origin of *Prosopis juliflora* (PJ) in the district has been mainly through the initiatives of the Forest Department (Government of Rajasthan) at different points of time especially starting from the early 60s. At present, *Prosopis juliflora* is found in all the tehsils irrespective of the soil type. The contribution of *Prosopis juliflora* has been both positive as well as negative at individual level and also at the societal level.

This Stage-II report is based on primary information collected from selected villages in Ajmer district. The analysis, of primary information presented in this report, is intended to understand the differences in perceived needs of the rural community as stakeholders, who belong to different subregions of the district that vary in type of soil, rainfall pattern and type of vegetation.

OBJECTIVES OF STAGE-II REPORT

In the proposal submitted for this study, under the sub-title 'objectives' it was clearly stated that the Stage-II report will not only develop a 'framework' which accounts for the various costs and benefits that accrue to different stakeholders, but will also provide suggestions for future strategies and action plans based on analysis of primary information collected from the field. The framework would include the economic,, environmental and social dimensions of costs and benefits. Valuation of these and examining their distribution across the community helps to formulate better strategies for developing a platform for collective action at the local level.

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In addition, such an analysis will also contribute to better understanding and drawing of appropriate action plans that address the various needs of the groups rather than promote a universal solution for all.

Further, the Stage-II report will also cover and throw light on the 'value chain' of key prosopis products especially the 'charcoal making' by different stakeholders.

As such, this Stage-II report attempts to address two very 'specific objectives' of the study project and these are given below:

- To understand the varying perceptions, uses and problems associated with *Prosopis* in the different micro-subregions of the district.
- To Identify the value chain of charcoal generated from *Prosopis juliflora.*

METHODOLOGY

The methodology adopted and followed during the course of the study is discussed in this section and is as follows:

Selection of villages for the study

Ajmer district has a total of 8 Panchayat Samitis. Large tracts of wasteland characterize the Jawaja and Masuda Panchayat Samitis. Some segments or pockets of the Arain Panchayat Samiti and parts of Kekri Panchayat Samiti comprises of land with alkaline soils. The Kekri, Bhinai and Peesangan Panchayat Samitis consist of vast stretches of fertile cultivable lands.

The selection criteria included the type of soils, vegetation types, presence of forestland in the village and river sub-basin approach (see Annexure-1). This helps in accounting for variability within the district. As was discussed in the Stage-I report, the major soils of Ajmer district are sandy loam, rich alluvial soils with high content of clay and shallow rocky and hilly soils. There are also large tracts of saline and alkaline soils in Arain Tehsil followed by Sarwar tehsil. The vegetation types are also characteristic to each type of soil. As such, fit was hypothesized that the district could broadly be divided into four subregions. Accordingly, representative villages were selected for detailed household interviews.

The four subregions are: (a) Subregion 1 (SR-1) – Sandy-loam soils with *Prosopis cineraria* dominated vegetation, (b) Subregion 2 (SR-2) – Light Brown soils with *Acacia leucophloea* dominated vegetation, (c) Subregion 3 (SR-3) – Clay loam heavy soils with *Acacia leucophloea* dominated vegetation and (d) Subregion 4 (SR-4) – Shallow rocky and hilly soils with *Anogeissus Pendula* and *Butea monosperma* dominated vegetation. *Acacia nilotica* is widespread and is present in all the four subregions.

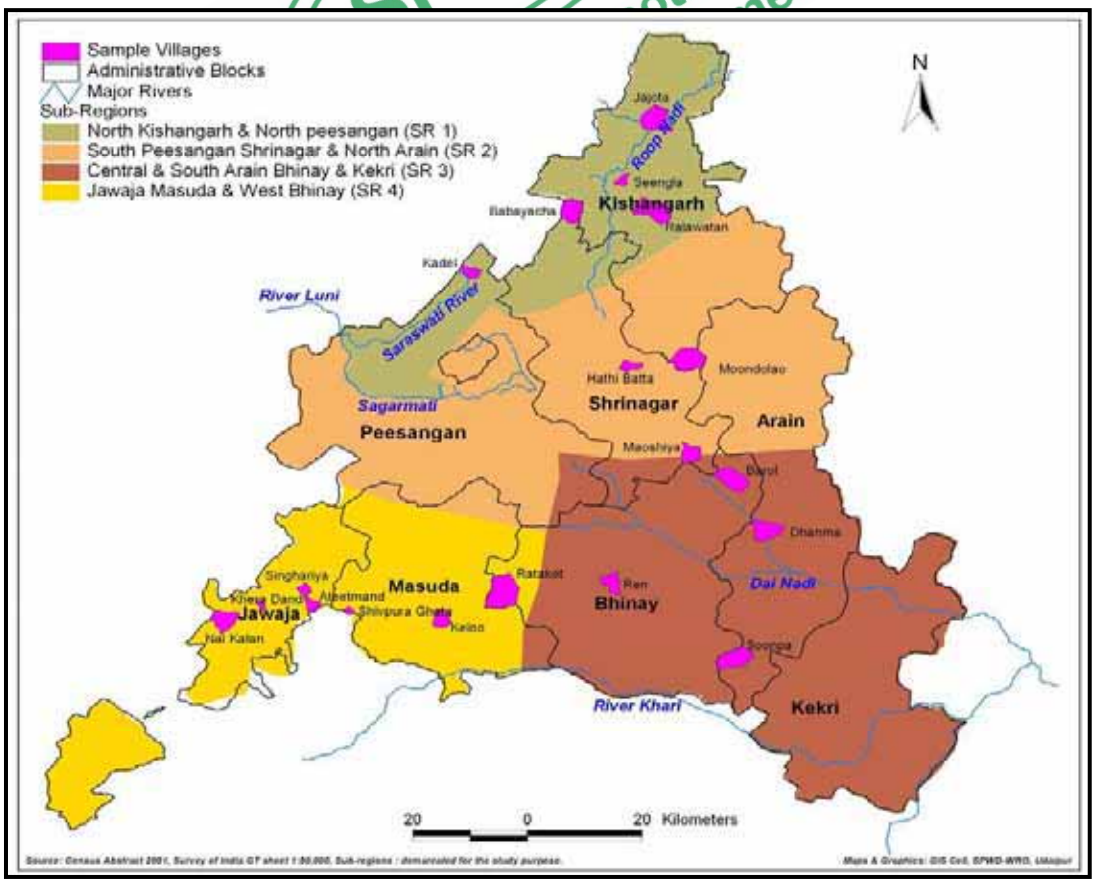

Figure 1: Ajmer district – delineation of subregion with sample villages.

Since, *Prosopis juliflora* was propagated by the Forest department on its respective lands, the presence of forestland, as a criterion, was also considered to select the sample villages. For comparison purposes, villages were also selected where there is no forestland but *Prosopis juliflora* thickets are found.

The criteria used to select the sample villages for the study along with list of finally selected villages are included in Annexure-1.

Out of the 19 villages selected for conducting household interviews, 13 have presence of forestland within the villages. This aspect can be considered as source of *Prosopis juliflora* in these villages. While 7 villages do not have any forestland but *Prosopis juliflora* is abundant. The river basin approach was applied to the two drainage lines, namely, Roopnadi and Dai / Khari.

Households for detailed interviews were so selected that the sample represents the socio-economic structure of the villages. The village-wise sample size of households covered is shown in Table-1 given below:

Table 1: Village-wise sample households numbers

Subregion	Village	Total households (2001 census)	Sample Households	% of total
SR-1	Relawatan	573	36	6.3
SR-1	Kadel	459	32	7.0
SR-1	Babayacha	526	30	5.7
SR-1	Seengla	140	30	21.4
SR-1	Jajota	360	29	8.1
SR-2	Moondalao	238	30	12.6
SR-2	Dhanma	126	30	23.8
SR-2	Maoshiya	148	24	16.2
SR-2	Hatti patta	223	30	13.5
SR-3	Soonpa	249	29	11.6
SR-3	Ren	101	30	29.7
SR-3	Ratakot	389	30	7.7
SR-3	Barol	178	30	16.9
SR-4	Ateetmand	281	30	10.7
SR-4	Singhadia	181	32	17.7
SR-4	Nai kalan (*neemdi Kheda*)	256	29	11.3
SR-4	Khera-dhand	77	30	39.0
SR-4	Shivpura ghata	112	30	26.8
SR-4	Keloo	220	24	10.9

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Household level and community level perceptions were collected through structured and semi-structured questionnaires based on interviews and focus group meetings in the selected villages.

About 540 households were interviewed with a view to capture the socio-economic strata including land ownership and caste hierarchies in the selected villages. In consultation with the field NGO partners, it was jointly agreed that the norm of at least 50% dalits; 30-35% other backward classes (OBCs) and 15-20% upper castes families

should be covered. These were so selected in order to provide adequate representation of landless, marginal, medium and large farmers from amongst them.

Survey process

To begin with, a reconnaissance survey of the study area was undertaken by the Principal investigators and unstructured interviews were conducted in different subregions for better understanding of the issues associated with *Prosopis juliflora* at the community level, establish the research problem and finally, to facilitate in the process of designing appropriate survey instrument for a more detailed household interviews. Consequently, appropriate and suitable questionnaire was developed for structured individual household interviews. These questionnaires were then pre-tested and, subsequently, modified based on feedback from the field. A separate format was also developed in order to collect village details and record information from focus group meetings and discussions.

With a view to help organize and conduct the survey in selected sample villages, the project engaged and hired field investigators. Since the college and university students were not available, the project staff of field based NGOs were hand picked to carry out the survey. A three days residential orientation-cum-training programme for the field investigators was organized and conducted on the campus of SWERA, at village Kanpura in Ajmer District.

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The Principal investigator supervised the fieldwork. In addition, the Principal investigator also took part in several focus group discussions (FGD) and meetings that were conducted in the selected villages of the study project.

The collected data from the field was then systematically compiled with the help of appropriate data entry formats designed in Microsoft Excel. The raw data was edited i.e. errors and omission were detected and corrected accordingly. The data was then tabulated and analyzed.

Remote Sensing and Geographical Information System (RS & GIS)

Toposheets procured from Survey of India (SoI) were used to digitize the layers for Ajmer district. Further, ARC/INFO GIS system was used for editing, labeling, projection, transformation, edge matching and overlaying processes. Statistical outputs were generated, verified and corrected of before arriving at the final toposheet wise statistics.

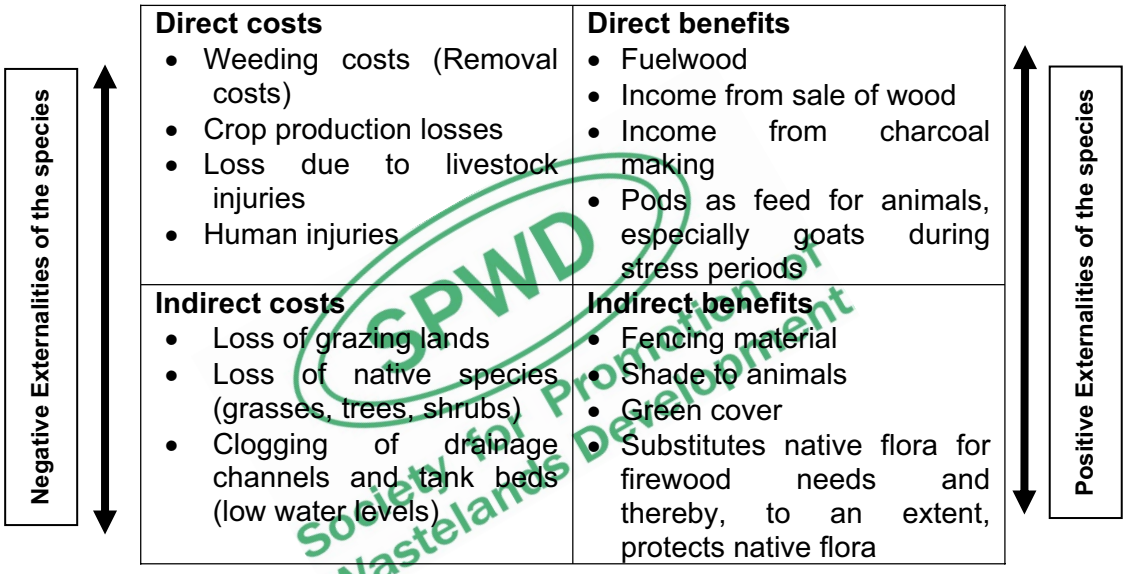
Landsat images were acquired from www.landsat.org. These images were subset and geo-referenced to SoI topographic maps (scale 1:50,000) in the ERDAS imagine (version 9.1) and ArcGIS 9 digital processing systems.

Maps indicating the occurrence of *Prosopis juliflora* in Ajmer district were generated for the time periods 1990 and 2006 to compare / visualize the spread of the specie. For this, Spectral signatures for *Prosopis juliflora* were created. Their histograms and

spectral plots were evaluated for spectral separability. The classified image was smoothed using neighbourhood model analysis through a majority 3x3 filter.

FRAMEWORK FOR ANALYSIS

Ajmer district belongs to the agroecological sub-region (AESR) 4.2, which is *hot semi-arid ecosystem in the Northern Plain (and Central Highlands)*. But within the district, there are differences in the endowment of natural capital. Therefore, as mentioned while discussing the selection criteria, it is important to take into consideration these micro-subregional differences while examining the natural resource such as *Prosopis juliflora*. The following schematic diagram provides an overview / summary of the concept and approach for analyzing role of *Prosopis juliflora* in a location specific context.



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LIMITATIONS OF THE STUDY

It would not be out of place to put on record that while selecting the sample size and also during the entire survey process, the study team experienced two key constraints and these were that of a modest budget and a short time period. However, our emphasis was more on coming up with actionable points with as much scientific rigor as possible within the given time frame.

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CHAPTER-2

Natural resources and Socio-economic characteristics of the subregions

In this chapter, based on the primary information collected from the selected villages and the sample size, the natural resources especially the land and vegetation characteristics and the socio-economic profile of the four subregions of Ajmer District are presented and discussed. In addition, income from different livelihood sources is also discussed. Interestingly, agriculture and livestock are clearly influenced by the soil type and the dominating vegetation in each subregion.

VEGETATION CHARACTERISTICS

The tree species and shrubs listed in Table-2 are based on information provided during the course of household interviews and are related to privately owned lands only. This table does not cover the common lands. The densities of various species have been computed based on the number of trees and shrubs indicated by the respondent on their own land and not through the standard measurement method of ecologists. These figures, therefore, are used as an indication of the dominant species for the purpose of the study. Should the need arise, these can be further validated through more formal approaches at a later stage.

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As may be noticed from this table, the figures support the initial observation that the type of vegetation varies and the same is not uniform within Ajmer district even though *Prosopis juliflora* is dominant across all the regions.

Plate 1: *Prosopis cineraria* on private farm land.

Subregion-1, which covers North and North-Western parts of the district comprising major part of Silora Panchayat Samiti lying to the north of National Highway No. 08 and also the northern and western parts of Peesangan Panchayat Samiti. This subregion is characterized by sandy loam soils. The *Prosopis cineraria* and *Prosopis juliflora* (densities of 6.2 and 6.8 per hectare respectively) are the dominant trees species on private lands in the selected villages, of the study, in this region. *Vitex negundo*, *Zizyphus nummularia* and Alaichi form the important shrub species.

Table 2: Important trees and shrubs on private lands of the sample households

Subregion	Sum of private land of sample households (hectares)	Major tree species on private lands	Major shrubs on private lands
SR-1	335	*Prosopis cineraria* (6.2); *Azadirachta indica* (3.1); *Acacia nilotica* (2.3); *Prosopis juliflora* (6.8)	*Vitex negundo* (35.8); *Zizyphus nummularia* (7.1); Alaichi (2.2)
SR-2	490	*Acacia nilotica* (3.07); *Acacia leucophloea* (2.5); *Prosopis juliflora* (17.3)	*Zizyphus nummularia* (4.9); *Capparis decidua* (2.4); *Lysium barbarum* (0.9)
SR-3	415	*Acacia nilotica* (2.24); *Acacia leucophloea* (2.4); *Prosopis juliflora* (22.4)	*Zizyphus nummularia* (8); *Capparis decidua* (3.1); Alaichi (1.7); Kanti (1.4); *Achyranthes aspera* (1.3)
SR-4	141	*Anogeissus pendula* (13.22); *Acacia nilotica* (3.15); *Azadirachta indica* (1.82); Ber (1.56); *Butea monosperma* (1.47); *Prosopis cineraria* (1.12); *Prosopis juliflora* (N.A)	*Rhus mysurensis* (26.9); *Zizyphus nummularia* (4.8); *Grewia tenax* (4.7); *Capparis decidua* (1.9); *Euphorbia* (4.1); *Acacia senegal* (0.9); *Panicum antidotale* (0.9)

* Figures in brackets indicate the density of the trees species (number per hectare)

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Plate 2: *Acacia leucophloea* on private farm land.

The SR-2 includes the southern part of Silora Panchayat Samiti, the adjoining northern part of Arain, eastern and central parts of Srinagar and the remaining west to east and southern parts of Peesangan Panchayat Samitis. While SR-3 covers the southern parts of Arain, major part of Bhinai Panchayat Samitis and the entire Kekri Panchayat Samiti. These two subregions comprise of relatively fertile soils (light brown soils in SR-2 and clayey soils in SR-3) in the district. In these two subregions, *Acacia nilotica* and *Acacia leucophloea* are important tree species with heavy dominance of *Prosopis juliflora*

(densities of 17.3 and 22.4 per hectare). In the shrubs category, the *Zizyphus nummularia* and *Capparis decidua* are important species.

Subregion-4 comprising of Masuda and Jawaja Panchayat Samitis is the most resource poor region in the district with shallow rocky soils. Interestingly, the *Anogeissus pendula* followed by *Acacia nilotica* are important tree species (densities of 13.2 and 3.1 per hectare). Even though *Prosopis juliflora* is also a dominant species in the region, information about the number of species on private lands was not available (substantiate with satellite imagery). Important shrubs in the region are *Rhus mysurensis*, *Zizyphus nummularia*, *Grewia tenax*, *Euphorbia* and *Capparis decidua* (kindly refer to Table-2).

The grass species too {see Table-3 and 3(a)} were looked into and examined. From the household survey conducted, nearly twenty plus species of grasses, on respective private lands, have been identified. Amongst these, 19% of respondents indicated *Cenchrus biflorus* on their lands in subregion 1 (Table-3). In subregions 2, 3 and 4, nearly 13.7%, 15.8% and 16.7% of the respondents respectively reported *Cenchurs ciliaris / Cenchrus setigerus* on their lands. It can be noticed that *Dicanthium annulatum* and *Cynodon dactylon* are common to all the regions.

Table 3: Important grass species on private lands of the sample households

Subregion	Major grass species present on private lands
SR-1	*Cenchrus biflorus* (19%), *Dactyloctenium aegyptium* (10%), *Cynodon dactylon* (9%), *Digitaria adscendens* (9%), *Bracheria mutica* (7%), *Desmostachya bipinnata* (7%), *Dicanthium annulatum* (6%), Malicha (5%)
SR-2	*Cenchurs ciliaris / Cenchrus setigerus* (13.7%), *Sava codo* (12.1%), Malicha (10.1%), *Dicanthium annulatum* (8.4%), *Cynodon dactylon* (7.7%), Kali Sali (6.6%), *Aristida* (6.4%), Dangdela (5.9%),
SR-3	*Cenchurs ciliaris / Cenchrus setigerus* (15.8%), *Sava codo* (11.3%), *Dicanthium annulatum* (10%), *Aristida* (7.7%), *Cynodon dactylon* (6.2%), *Melilotus indica* (4.6%)
SR-4	*Cenchurs ciliaris / Cenchrus setigerus* (16.7%), *Aristida* (12.4%), Barvadi (10.3%), *Cynodon dactylon* (9%), *Echinochloa colonum* (8.7%), *Dicanthium annulatum* (7.9%)

* Figures in brackets are percentage of respondents indicating presence of grass species n their lands

Table 3 (a): Details of important grasses in the district

Local name	Scientific name	Annual	Perennial	Palatable	Unpalatable
Grasses					
Barvadi	*Panicum antidotale*		Yes	Yes	
Bokana	*Commlina benegallensis*	Yes		Yes	
Bekariya	*Bracheria mutica*	Yes		Yes	
Buhari	*Eremopogon foveolatus*		Yes	Yes	
Bharut	*Cenchrus biflorus*	Yes		Yes (young stage)	
Chandlai	*Amranchus*	Yes		Yes	
Dab	*Desmostachya bipinnata*		Yes	v	

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Doob	*Cynodon dactylon*		Yes	Yes	
Dhaman/ Anjan	*Cenchrus ciliaris*		Yes	Yes	
Dhaman-Kali	*Cenchrus setigerus*		Yes	Yes	
Hama	*Echinochloa colonum*	Yes		Yes	
Jherni	*Digitaria adscendens*	Yes		Yes	
Karad	*Dicanthium annulatum*		Yes	Yes	
Kali-Sali	*Hetropogon contortus*		Yes	Yes	
Lapla	*Aristida*	Yes		Yes (Young stage)	
Malicha					
Mukla/Mukra	*Dactyloctenium aegyptium*	Yes		Yes	
Roisa/Rosa	*Cymbopogon martini*		Yes		Yes
Sava	*Sava codo*				
Sheen/ Hiren	*Sehima nervosum*		Yes	Yes	
Legume					
Metha	*Melilotus indica*	Yes		Yes	

Grasses like *Cenchurs ciliaris / Cenchrus setigerus*, *Cynodon dactylon* and *Dicanthium annulatum* are available through out the year. The general perceptions in all the four subregions strongly indicate growing scarcity of grasses resulting in difficulties while sustaining livestock production.

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SAMPLE PROFILE OF THE SUBREGIONS

Table-4 and 4(a) provide a snap shots of the social profile of the sample households selected for the household interviews. This also indicates the social structure of the villages in the subregions.

Table 4: Social profile of the sample households

Caste category	SR-1	SR-2	SR-3	SR-4	Total
General	17	6	12	0	35
OBC	55	52	54	118	279
SC	55	38	44	21	158
ST	0	17	6	5	28

Table 4(a): Details of survey respondent

Parameters	SR 1 (n=127)	SR 2 (n=114)	SR 3 (n=119)	SR 4 (n=143)
Mean age of household head (respondent) (in years)	47	54	50	44
Mean education of household head (respondent) (years)	0.4	0.6	0.6	0.2
Mean family size (no.)	6.6	7.3	6.4	5.8

LAND OWNERSHIP

Average total land owned is higher in SR-2 and SR-3 at 4.3 ha and 3.5 ha respectively as compared to SR-1 and SR-4 (see Table-5). Average land ownership (1 ha) and also the per capita holdings (0.2 ha) are lowest in SR-4. As can be expected from a semi-arid region, on the whole, area under dry land cultivation is higher than available irrigated land.

Table 5: Average land holding for each sub-region (in Hectares)

Parameters	SR-1 (n=127)	SR-2 (n=114)	SR-3 (n=119)	SR-4 (n=143)
Total land owned	2.6	4.3	3.5	1.0
Per capita land	0.4	0.6	0.6	0.2
Irrigated land	1.2	1.0	0.7	0.5
Dry land	1.4	3.3	2.8	0.5
Family size	6.6	7.3	6.4	5.8

Plate 3: Status of farm land in village Singla (subregion-1).

Land distribution among the sample households is found to be unequal in all the four subregions. The Gini coefficients estimated were high for all the subregions. Land inequalities are found to be highest in SR-1 (0.64) followed by SR-3 (0.61) and lowest in SR-4 (0.49).

AGRICULTURE

In general, the average dry land cultivated area in Kharif season is much larger than that in Rabi season in all the four subregions (Table-6). The average dry land cultivated area is lowest in SR-4, which can be attributed to the presence of shallow and rocky soils in the region.

Table 6: Season wise average cultivated area (in hectares)

Season / Land	SR-1 (n=127)	SR-2 (n=114)	SR-3 (n=119)	SR-4 (n=145)
Kharif				
Irrigated cultivated	0.9	1.0	0.6	0.5
Dry land cultivated	1.3	2.7	2.4	0.5
Permanent fallows	0.1	0.3	0.4	0.1
Seasonal fallow	0.0	0.2	0.1	0.1
Rabi				
Irrigated cultivated	0.1	0.3	0.3	0.3
Dry land cultivated	0.0	0.9	0.5	0.2
Seasonal fallow	0.0	0.4	0.3	0.0

Subregions 2 and 3 are agriculturally strong as compared to the other two subregions with relatively higher average land area under dry land cultivation at about 2.7 ha and 2.4 ha.

Plate 4: View of cultivable dry land.

Agriculture in all the subregions is mainly rainfed (as can be noticed from the Table-7). However, open wells are the main source of irrigation (Table-7) in all the subregions.

Table 7: Average area irrigated by source (in hectares)

Source of irrigation	SR-1		SR-2		SR-3		SR-4	
	Plots (no.)	Mean	Plots (no.)	Mean	Plots (no.)	Mean	Plots (no.)	Mean
Nada			5	0.53	4	0.95		
Open well	9	0.86	128	0.79	132	0.86	201	0.44
Rainfall	324	0.93	338	0.97	301	0.96	211	0.35
Tube well	10	1.45			2	0.67		
Tank			4	0.38	40	1.03	1	0.29

Interestingly, the SR-2 and SR-3 have a wider range of irrigations sources that include nadas and tanks. Tanks as the source of irrigation are more predominant in SR-3. The SR-4 again lags behind in terms of average area under rainfed agriculture (0.35 ha) and also average irrigated area (0.44). Open wells form an important source of irrigation in this region.

Table-8 provides a snap shot of the major crops grown by the selected households in each sub-region. It reveals the variations in the scale of agriculture operations and the important crops in each season in the sub-regions. These differences in the sub-regions can be directly attributed to the soil quality and also the available water resources in the sub-regions.

Table-8: Average area under major crops in each sub-region

SR-1		
Crop	No. of plots	Mean
Kharif		
Pearl Millet	98	1.23
Guar	51	0.77
Sorghum	39	1.24
Green gram	64	0.84
Kidney bean	37	0.60
Sesame	31	0.86
Rabi		
Wheat	7	0.53

SR-2		
Crop	No. of plots	Mean
Kharif		
Pearl Millet	99	0.74
Guar	12	0.91
Sorghum	98	1.40
Maize	36	0.61
Green gram	71	1.05
Sesame	32	0.92
Groundnut	10	0.51
Rabi		
Wheat	33	0.58
Barley	15	0.37

SR-3		
Crop	No. of plots	Mean
Kharif		
Pearl Millet	56	0.62
Groundnut	12	0.54
Sorghum	71	1.45
Maize	74	0.64
Green gram	86	1.16
Sesame	32	0.81
Black gram	26	0.88
Rabi		
Barley	14	0.53
Sarsada	12	1.06
Mustard	23	1.09
Taramira	8	1.18
Wheat	23	1.05

SR-4		
Crop	No. of plots	Mean
Kharif		
Pearl Millet	58	0.35
Cotton	8	0.58
Sorghum	117	0.44
Maize	136	0.42
Green gram	28	0.43
Indian Mustard	11	0.15
Sesame	20	0.21
Black gram	14	0.12
Rabi		
Barley	4	0.33
Wheat	7	0.49

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Among the kharif crops, Pearl Millet, Sorghum and Green gram are important in all the subregions. Maize is found in SR-2, 3 and 4 but it appears to be more predominant in SR-4. Guar is predominant in SR-1. Cultivation of Rabi crops is more prominent in only SR-2 and SR-3, which undoubtedly are better off in terms of availability of water resources. The important rabi crops are wheat and Barley. Crops viz. Mustard and Sarsada are also important in SR-3. During the Rabi cropping season of 2008-09, more number of rabi crops were taken up in SR-3, where some amount of tank irrigation was noticed. As one can observe, the Rabi cultivation is negligible in SR-1 and SR-4.

In terms of crop production, amongst the four subregions, from the tables above, the SR-3 and SR-2 are relatively better off as compared to SR-1 and SR-4.

LIVESTOCK

Livestock forms an important livelihood resource. Small ruminants, especially, goat husbandry are an important livelihood option. The average ownership of goats is high in all the subregions for the sample households as compared to other animals (see Table-9). Goat ownership is the highest in SR-3 (4.17) and this is closely followed by SR-4 (4.09). Nearly 81% and 74% of sample households in SR-4 and SR-3 respectively owned goats. While in SR-1 and SR-2 as many as 70% and 64% of sample households own goats.

Plate 5: Goat husbandry in subregion-1.

The average ownership of large ruminants is found to be highest in SR-2. The average ownership of milch cows and milch buffaloes is highest in SR-2 (at 1.03 and 0.99 respectively). In SR-2, nearly 49% of the sample households own milking cows and 35% households own milking buffaloes. In this subregion, 48% of households also own other cows not in milk and 40% other buffaloes not in milk. SR-2 is followed by SR-3 in terms of percentage of households owning large ruminants. Even though, the average

ownership of milch buffaloes in SR-1 appears to be high (0.76), only 30% of the households own buffaloes.

Table 9: Average livestock ownership (Number / household)

Livestock	SR-1 (n=127)	SR-2 (n=114)	SR-3 (n=119)	SR-4 (n=145)
	Mean	Mean	Mean	Mean
Milch cows	0.63	1.03	0.75	0.53
Milch buffaloes	0.76	0.99	0.50	0.40
Bullocks	0.06	0.31	0.29	0.23
Other cows	0.17	1.54	1.39	0.22
Other buffaloes	0.09	1.27	0.64	0.17
Goats	3.47	3.25	4.17	4.09
Sheep	1.93	3.18	2.10	1.29
Camels	0.02	0.01	0.00	0.04
Poultry	0.00	0.49	0.24	0.38

Plate 6: Livestock and Dairy in subregion-2.

Livestock ownership is closely linked and associated with the available local trees, shrubs and grasses (refer Tables-2 & 3) and the crop production system (Table-8) in the respective subregions. For the large ruminants, the most important green fodder resources mentioned by the majority of households in SR-1 include grasses, mainly, *Cenchrus biflorus*, Malicha and *Cynodon dactylon.* In SR-2, it is *Cenchurs ciliaris / Cenchrus setigerus*, *Sava codo* and Malicha along with many others. In SR-3, *Sava codo*, *Cenchurs ciliaris / Cenchrus setigerus* and *Dicanthium annulatum* are important and in SR-4, *Cenchurs ciliaris / Cenchrus setigerus* and *Echinochloa colonum* are the most important. For dry fodder, Kadab was the common response in all the subregions, which is crop-based (Sorghum, Pearl Millet etc.). In SR-4, Kadab (chaffed fodder) with Chipti (green Sorghum) is also given as dry fodder.

For the small ruminants, important fodder resources are *Acacia nilotica* and *Prosopis cineraria* in SR-1 and in SR-2. Apart from these, neem also forms an important resource. It was also observed that it is a fairly common practice to hire these trees by the animal owners.

ASSETS

These include farm assets such as tractor, electric motors, bullock carts and farm implements. Other assets include housing, vehicles, home appliances, electronic gadgets and other such accessories. The total asset value has been arrived at by summing up of all these values. The average household asset values are given in Table-10.

Table 10: Average household assets (Rs. / Household)

Sub Region	N	Mean	Minimum	Maximum
SR-1	126	141,809	0	535,000
SR-2	115	218,706	0	3,689,800
SR-3	119	93,909	5,000	536,800
SR-4	145	156,085	0	5,027,500

The average household asset value is highest in SR-2 (at Rs. 2,18,706/-) and SR-4 follows it. Even though SR-3 is agriculturally a rich area, however, average asset value is lowest (i.e. at Rs. 93,909/-).

INCOME SOURCES

Table-11 gives the average income from different livelihood sources. These numbers are based directly on figures revealed / specified during the household interviews against each income source and were not computed / estimated from detailed cost of cultivation or production methods. But it is sufficient to indicate the relative importance of different livelihood options that are available in the subregions.

In SR-1 and SR-4, average income from regular employment is relatively high (Rs. 26,855 and Rs. 18,309) as compared to agriculture or any other source of income. The main sources of regular employment in SR-1 are marble industry in Kishangarh town and mining activities in the nearby areas. In SR-4, there are significant number of persons employed in security and defence establishments of the government. Mining too is also an important source of livelihood in this subregion.

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Table 11: Average income from different sources (in Rs./ Household)

Source	SR-1 (n=120)		SR-2 (n=114)		SR-3 (n=119)		SR-4 (n=145)	
	no. of hh	Mean	no. of hh	Mean	no. of hh	Mean	no. of hh	Mean
Agriculture (own land)	95	18,636	110	24,805	114	20,169	120	8,256
Agriculture (leased land)	20	1,571	24	2,071	24	1,210	1	14
Dairy income	52	8,616	50	7,820	55	6,674	44	3,774
Sheep and goats	69	6,263	51	3,444	69	3,849	98	3,239
Sheep penning	16	2,383	5	228	3	261	2	183
Regular employment	75	26,855	89	17,328	69	12,345	45	18,309
Wage employment	88	17,625	102	21,318	111	15,483	136	16,667
Business	51	16,214	30	5,368	27	2,403	72	15,434
Tree_wood	23	1,879	10	987	25	4,155	68	976
Total_hh Income	**120**	**1,00,043**	**114**	**83,369**	**119**	**66,548**	**145**	**66,845**

In SR-2 and SR-3 average income from agriculture is higher than all the other sources of income (at Rs. 24,805/- and Rs. 20,169/- respectively). In all the subregions, regular employment and wage employment are significant sources of income. Average income from dairy is relatively higher in SR-1, SR-2 and SR-3 as compared to SR-4. Average income from goat and sheep is very much higher in SR-1 (Rs. 6,263/-) as compared to all the other subregions. But interestingly, SR-4 has the largest number of households depending on small ruminants for their livelihoods even though average income from small ruminants is lowest (Rs. 3,774/-).

Overall, irrespective of how resource poor or rich a subregion is, agriculture and wage employment are important livelihood sources, especially in terms of number of households depending on these livelihood activities (Table-11).

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CHAPTER-3

Prosopis juliflora in rural household context

INTRODUCTION

The origin and introduction of *Prosopis juliflora* through the institutional pathway was described in detail in **Stage-I Report** of the study supported by SPWD. *Prosopis juliflora* was propagated extensively as a government program but it is the communities at the village level that are directly and indirectly impacted by this specie. Despite all these, however, they still continue to adapt to this specie in their respective ecologies. This section focuses on the perceptions of the community about the specie, the benefits and costs of the specie in their day-to-day life. It is important to understand this aspect since management of *P. juliflora* is now a community issue.

PROSOPIS JULIFLORA COVERAGE IN AJMER DISTRICT

The statistics generated through spatial data base created in GIS reveal that about 37108 hectares was under prosopis class in Ajmer district in1990 (which accounts for 4.54% of the total geographical area of the district). The total area under prosopis as on October 2006 was about 73507 hectares (9% of total geographical area).

In the 1990 imagery (see Figure 2), in general, it is observed that the concentration of Prosopis is higher in western part (e.g. areas in and around cell numbers 41, 52, 53), and is lower in the south-eastern part of the district. In other area, the concentration is higher in patches, for example, cell 91 (towards south of the district) and also in the north-eastern part of the district (e.g. cell numbers 26, 27, 36, 37, 47 and 48). Most often, the higher concentration matches with location of reserve forest and protected areas and /or presence of water bodies and drainage lines. In the southeast part of the district, the concentration is relatively low.

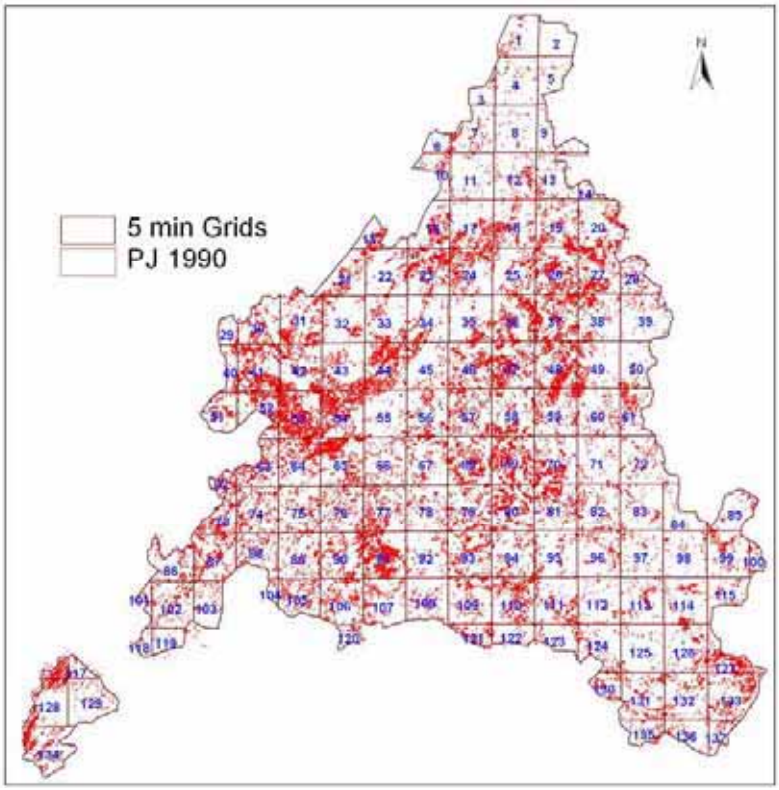

Figure 2: *Prosopis juliflora* in Ajmer district (1990).

In the 2006 imagery (see Figure 3), it becomes apparent that the concentration is higher and evenly distributed across the entire district. There is abundant concentration of *Prosopis juliflora* even in the southeastern part of the district in 2006 (e.g. cell numbers 111, 112,113, 124, 130 etc.), which showed low concentration of Prosopis in the 1990 imagery.

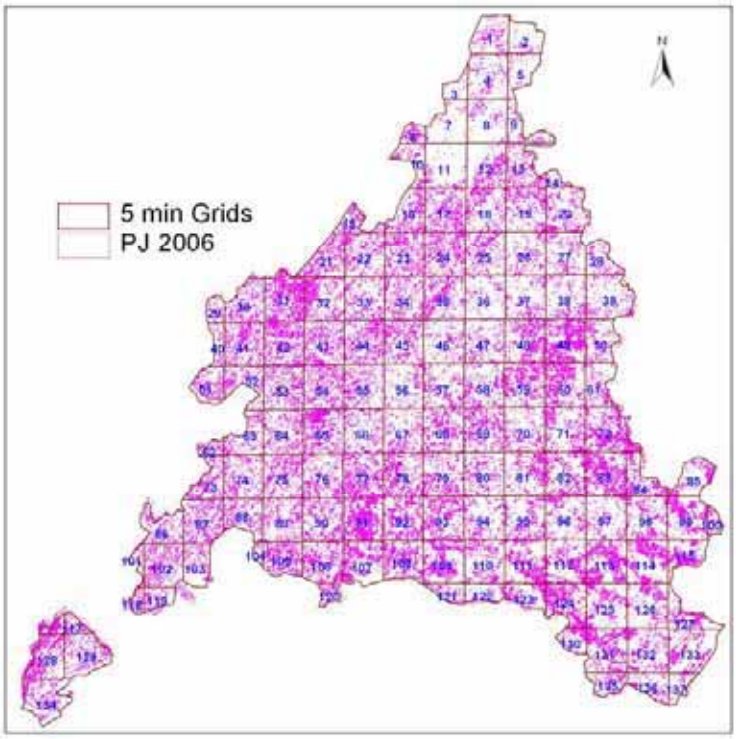

Figure 3: *Prosopis juliflora* in Ajmer district (2006).

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It may be recalled that south and southeastern part (SR 2 and SR 3) of the district has relatively fertile soils and comprises of agriculturally rich areas (refer Chapter 2). This region also receives relatively higher precipitation. Therefore, negative implications from *Prosopis juliflora* (from crop production perspective) can be expected to be more in this region as compared to other parts of the district. Similarly impact of *Prosopis juliflora* on livestock will also vary across the region depending on the type of livestock owned (large ruminants and small ruminants).

ORIGIN AND PERCEIVED USES OF PROSOPIS JULIFLORA

The earliest sighting of *Prosopis juliflora* among the sample households was in 1947 in SR-4. However, in all other subregions, earliest sightings of this specie can be placed around 1958-59. On an average, people started to see Prosopis from the late sixties to early 70s. In the beginning, *Prosopis juliflora* was mainly seen on forest land (29%) and by the roadside (13%) as can be expected since the forest department was directly responsible and had taken up propagation of the plantations during that period (Table-12).

Plate 7: *Prosopis juliflora* in forest land.

There is also significant number of respondents, who indicated others (38%), which implies lots of fallow land and wastelands. We can attribute this to the fact that the younger generation of the res-pondents, which grew up seeing *Prosopis juliflora* in all places in their local ecology. At present, 88% of the respondents indicated seeing *Prosopis juliflora* in the location category "others" (see also Table-12), which suggests and also indicates its adaptability and per-vasiveness in the local ecology.

Plate 8: *Prosopis juliflora* in forest land.

Table 12: Visibility of *Prosopis juliflora*

Location	First time	Now
Road side	66 (13)	3 (0.6)
Forest land	147 (29)	7 (1.4)
Own farmland	16 (3)	3 (0.6)
Pastureland	47 (9)	3 (0.6)
Revenue land	37 (7)	4 (0.8)
Temple grove	2 (0.4)	41 (8.2)
Others	192 (38)	440 (88)
Total	**507 (100)**	**501 (100)**

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* Figures in parenthesis indicate percentage to total respondents

Over the years, there has also been perceptible change in the way communities perceived *Prosopis juliflora* in their local ecology. In the beginning, the opinion about the specie was equally divided regarding its use and harmfulness with 37% of respondents indicating usefulness, 30% indicating harmfulness and 33% indicated both traits (see Table-13). This can also very well indicate some amount of ambiguity or lack of knowledge about the specie. Now, in the present, almost 83% of the respondents pointed out that the specie is both useful and also harmful. This suggests that *Prosopis juliflora* is a useful plant but comes with its negative externalities due to its invasive nature (as discussed in **Stage-I Report**). As long as the negative externalities are not internalized with proper management practices, the harmful side of the specie will continue to dominate.

Table 13: Change in perceptions about *Prosopis juliflora*

Perceptions	First time	Now
Useful	184 (37)	14 (3)
Harmful	152 (30)	74 (15)
Both	165 (33)	416 (83)
Total	**501 (100)**	**504 (100)**

* Figures in parenthesis indicate percentage to total respondents

MAJOR USES OF *PROSOPIS JULIFLORA*

Prosopis has the potential to generate multiple products. A table with detailed list of the different uses (compiled from various sources including CAZRI), was already included and presented in the **Stage-I Report**. However, to be able to convert this potential of its different uses into income sources, it is important to understand awareness levels of the communities about the various products. Otherwise there is every possibility of them lagging behind once marketable products are generated based on the research on *Prosopis juliflora*. Table-14 provides a glimpse of the level of awareness among the sample households.

Table 14: Awareness about various uses of Prosopis juliflora (% of sample households)

Use	Aware (%)	Not aware (%)
Fuelwood	96	4
Fencing	89	11
Shade for animals	86	14
Livestock feed	83	17
Income from charcoal	56	44
Soil conservation to prevent desertification	50	50
Wage employment	50	50
Construction material	49	51
Gum extraction	31	69
Soil improvement	20	80
Willingness to consume (Yes / No)	16	84
Pods for human consumption	15	85

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As can be observed, majority of the households are aware about its uses as fuelwood, fencing, shade for animals and livestock feed concentrate. Even though, charcoal making now is a known and practiced actively in several of the sample villages, nevertheless, when looked in entirety, about 56% of the sample households are not aware about its value as charcoal. About 69% of the households are not aware about gum extraction and also 80% are unaware about any benefits in terms of soil improvement. At present, even though research is in the process of making products (out of the pods of *Prosopis juliflora*) that are suitable and fit for human consumption,

however, 85% of sample households were not aware of situations where pods were consumed. And, almost an equal percentage (84%) of them expressed their unwillingness to consume such products. Now, in future, if products derived from pods of Prosopis are to be developed for human consumption, in that case, there is a definite need for orientation-cum-awareness programs about such products before they are approved or released into the market. It would also help the community to share economic benefits from such products.

Table-15 gives the mean ranks assigned by the households for different uses of *Prosopis juliflora*. The importance given by the households is similar to their awareness about the various uses. Firewood by far is the most important use (mean rank of 1.05) followed by fencing (2.42) and shade for animals (3.54). All the subregions show the same type of ranking (see Annexure-2). For its use, firewood is ranked first by about 97% of the respondents. Fencing comes next and is actually ranked second by 66% of the respondents and this is followed by shade for animals, which is ranked third by 40% of the respondents. Feed concentrate for live-stock is ranked at 4.22. However, it is interesting to note that the feed concentrate was ranked at number 3 by 67% of the respondents in SR-1 while respondents in other regions ranked it between 3rd and 4th position. Largely, this is due to the prevalence of goat husbandry in SR-1 since the pods are used as feed concentrate to some extent.

Plate 9: *Prosopis juliflora* as firewood.

Table 15: Mean ranks assigned by the households for different uses of *Prosopis juliflora*

Use	no. of respondents	Mean Rank
Fuel wood	436	1.05
Fencing	430	2.42
Shade for animals	409	3.54
Feed for livestock	399	4.22
Income from Charcoal	246	4.50
Wage employment	240	4.81
Construction material	269	4.91
Soil conservation to prevent desertification	212	5.59
Gum extraction	185	5.63
Improvement in soil quality	162	6.09

Even though mean ranks are presented in the Table-15 (based on some responses), many respondents could not rank its uses such as charcoal making, improvement in soil quality, soil and moisture conservation and gum extraction. This may be due to lack of awareness about such uses as is also reflected in the Table-14 (pertaining to awareness levels).

LOCATION OF PROSOPIS ON OWN LANDS

Majority of the sample households cited that *Prosopis juliflora* is located on their farmland and field bunds. Table-16 gives an idea about the appearance of Prosopis at different locations. In terms of appearance, on the farmland and current fallows, apparently, it has taken the form of a bush type (50% and 47% respondents respectively).

Table 16: Location and appearance of *Prosopis juliflora* on own land

Location	Appearance (%)		
	Bush	Tree	No responses
Farmland	49.9	45.1	5.0
Fieldbunds	20.2	79.0	0.8
Naadis	32.8	62.7	4.5
Permanent Fallow/Pasture	40.4	58.6	1.0
Current Fallows	47.2	47.2	5.6
Homestead	13.5	84.7	1.6

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Plate 10: *Prosopis juliflora* on field bunds in subregion-2.

Appearance of Prosopis in the form of tree on the field bunds, naadis and permanent fallow is reflected at 79%, 63% and 59% respectively. This indicates and suggests that management of *Prosopis juliflora* is taken up on private lands to some extent.

ROLE OF PROSOPIS AS SOURCE OF ENERGY

Woodfuel accounts for about 20–30 per cent of the total energy consumption in the country. More than 90 per cent of the total quantity of woodfuel used is in the domestic sector, for cooking and heating water (Saxena, 1997). In addition, woodfuels are used for cremation, in hotels and small eating places, in the manufacture of household materials such as bricks, tiles and lime, and in agro-processing, such as jaggery-making and the curing of tobacco.

In a research study by Goel and Behl (2001) on selection and improvement of fast growing tree species suitable for wood fuel production on sodic wastelands (pH 8.6–10.5), field trials of nine legumes (*Acacia auriculiformis, A. nilotica, Albizia lebbeck, A. procera, Dalbergia sissoo, Leucaena leucocephala, Pongamia pinnata, Prosopis juliflora, Pithecellobium dulce*) and three other tree species (*Azadirachta indica, Eucalyptus tereticornis* and *Terminalia arjuna*) were conducted. It was found that *Prosopis juliflora* was the most promising species in terms of its biomass productivity (68.7 tha−1) and fuel value index (148.8) after 8-yr of growth.

Domestic energy needs

In a study carried out by the Indian Institute of Forest Management (IIFM), the mean per capita consumption of fuel wood was estimated at about 1.64 kg or about 1.17 tons per household per annum (Ram Prasad, 1999). The total number of rural households in Ajmer district is 223,745 (based on 2001 census data).

Based on this information, the total annual fuelwood demand from rural households in Ajmer district would be about 261,781 tonnes. Given the widespread coverage of *Prosopis juliflora* in all forms of land in the district, it definitely assumes importance as a fuelwood source to meet this demand.

Plate 11: *Prosopis juliflora* for domestic energy needs.

It has been widely acknowledged by the villagers in all the subregions that if *Prosopis juliflora* was not there, they would have been compelled to eat raw food. Prosopis in a way took the brunt of the demand for fuel wood and helped in reducing pressure on other native flora.

Table-17 provides an overview of the native flora that would have been used for firewood purposes in the absence of *Prosopis juliflora*. These are arranged in the order of preference in each subregion.

Table 17: Native flora used as fuel wood in absence of *Prosopis juliflora*

Subregion	Native flora used as fuel wood in absence of *Prosopis juliflora* (in order of preference)
SR-1	*Prosopis cineraria* *Acacia nilotica* *Azadirachta indica*
SR-2	*Acacia nilotica* *Prosopis cineraria* *Azadirachta indica*
SR-3	*Acacia nilotica* *Acacia leucophloea* *Prosopis cineraria*
SR-4	*Acacia nilotica* *Azadirachta indica* / Ber/ *Anogeissus pendula* Ber / *Prosopis cineraria*

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Table-18 compares firewood from *Prosopis juliflora* with other tree species based on responses from the sample households. In general, majority of the respondents (71%) feel and are of the view that quantum of wood that is needed or required as fuel wood has decreased when one compares the quantity available from Prosopis as compared to other wood types. At the same time, however, 67.5% of the respondents observed that the amount of smoke emitted from *Prosopis juliflora* has increased.

Table 18: Performance of *Prosopis juliflora* as fuel wood as compared to other species

Parameters	Responses (%)		
	Increased	Decreased	Same
Amount of wood required	27.6	71.1	1.1
Time cooking (hrs)	55.5	40.5	3.3
Smoke emitted	67.5	29.0	2.9
Time: collecting wood	36.8	52.3	9.6
Distance: collecting wood	15.3	44.6	38.5
Quantity: charcoal and ash	22.4	50.9	12.6
Issues: wood storage	35.5	42.8	18.7

Interestingly, 52.3% of respondents maintain that time taken to collect wood has reduced and 44.6% of them are of the view that distance traveled to collect wood has

also reduced. However, about 38.5% of respondents feel that distance traveled in order to collect fuelwood is more or less the same as before. Issues concerned with storage of wood have decreased (42.8%). This is owing to the fact that the wood from *Prosopis juliflora* is placed both on the field bunds and near the house/homestead as fencing material and allowed to dry before the same is put to use or consumption. In this context, however, in SR-1 issues regarding storage of wood increased (as indicated by about 73% of respondents in the subregion). This needs to be explored further.

Scope for biomass based gassifiers

Biomass based gassifiers assume importance, especially in the context of clean development mechanisms and to reduce pressure on fossil fuels. Biomass gasification is a one of the renewable energy based options that has good potential to meet rural electricity needs. This technology effectively utilizes locally available bio-resources such as forest residue, agricultural residue etc and converts them into a clean gas that could be utilized in dual fuel or gas engines for power generation.

The biomass gasification units can be of varied configurations ranging from small units to large units. At the village level, the concept of decentralized power generation and distribution was demonstrated based on Indian Institute of Science (IISc) biomass gasification technology. A 20 kWe Biomass Gasification System was established at Hosahalli in Karnataka. The power package consisted of a gasification system and a diesel engine.The power was utilized for irrigation. Even though technically sound, the plant operations were stalled due to lack of cooperation / interest from the villagers (Sridhar et al., IISc).

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There are also many cases of private biomass gasification based power generation units. For example, Arashi Hi-Tech Bio-Power (P) Ltd., an Independent Power Producer (IPP), located in Sultanpet village in Tamilnadu, works with the single largest capacity fixed bed gasifier based power package linked to the Grid. For this, 1.2 Kg/Hr biomass is required to generate 1 KWh and cost of power generation comes to approx. Rs. 3 per KWh vis-à-vis Rs. 5.20 per KWh (which is the cost of Grid power), thereby offering Rs. 2.20 / KWh as savings. To generate 1MW power on a continuous basis, 30 tons of biomass is required per day.

Biomass from *Prosopis juliflora* is suitable and also recommended for use in gasifiers. If Prosopis juliflora is to be considered as a biomass resource for such a power generating unit, adequate systems or strategies (woodlots, adequate management practices and institutional mechanisms) are needed to ensure constant supply of the biomass through out the year and active participation of the local community.

Charcoal from *Prosopis Juliflora*

Charcoal from *Prosopis juliflora* has wide range of markets that include laundry units, charcoal briquette manufacturers, lead extractors, metal processing units, agro-processing, incense manufacturers, food vendors and hostels.

In the context of charcoal making, the prosopis woodlots / thickets are on the village commons and also on private lands (homesteads) even though the scale varies in terms of quantity of wood generated. Mostly the traders identify and keep track of the

woodlots on the village commons through scouting and key informants. They make an approximate visual estimate of the quantity of available wood / charcoal that could be derived from the woodlot based on the size / girth of the stems of majority of the trees. Once a woodlot is identified as a viable charcoal-producing unit, they then enquire and enter into negotiations with the *Gram panchayat* and accordingly bid for the woodlot.

Plate 12: *Prosopis juliflora* thickets on common lands.

The trader gets into the business of charcoal-making by hiring contract labor to cut the prosopis, convert the wood to charcoal and then packaging it into gunny bags (40 kg bags are commonly used). These labourers are mostly from the marginalized communities such as Kalbelias, Bavariyas and also the Bhils, (tribals), who generally lead a nomadic life style and also migrate in search of livelihood opportunities. The entire process of charcoal making takes a minimum of about 3–5 months in a given location / village. For this entire duration, the hired labourers live on-site in make shift tents / hutments. The trader pays the laborers an advance to meet their day-to-day living expenses. This amount is later adjusted when the product is delivered. At present, the prevailing rate of payment for the labour invested is about Rs. 4 per Kg of charcoal produced.

The raw material for charcoal making is in the form of stems and also as rootstocks. The rootstocks are preferred (due to their larger mass) even though it requires more effort to dig them out. The stems are graded based on their girth. These are then arranged and piled in a concentric heap with rootstocks and the larger mass towards the inside while the longer and thinner stems are arranged on the out side including the periphery of the same. This heap or pile of wood is then covered by a thin layer of dry soil. Subsequently, the pile is fired and allowed to burn slowly in a controlled manner (i.e. intermittent dousing by sprinkling water). This process of burning usually lasts for about 5 – 7 days. The charcoal is then collected and packed into gunny bags, which are loaded onto the trucks to be transported to the market.

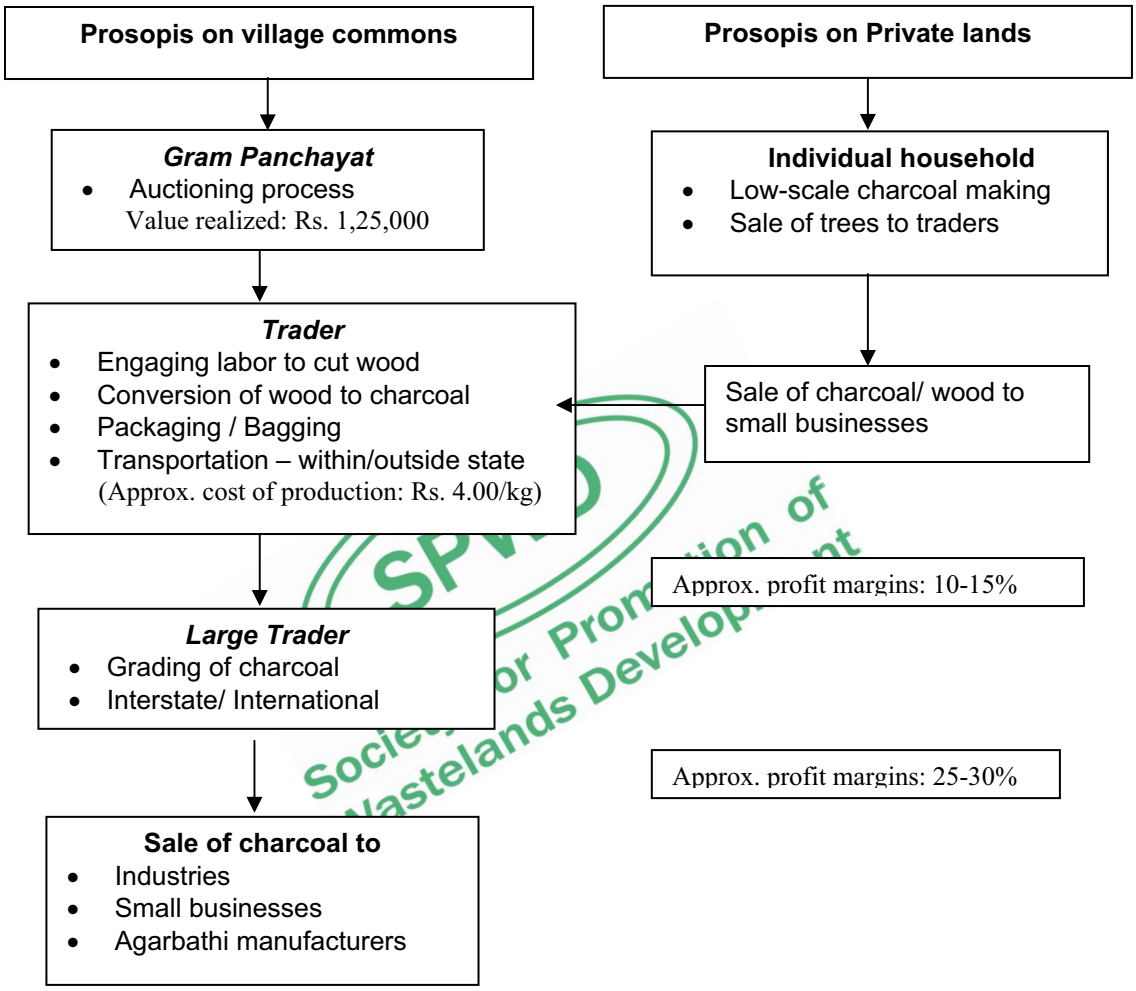
Plate 13: Charcoal making process – (1) Prosopis juliflora harvested; (2) Rootstocks are piled; (3) Thinner stems are arranged on the outside; (4) Slow controlled burning; (5) Charcoal is ready; (6) Charcoal packed into gunny bags.

The local trader transports charcoal from the field location and sells the same to the larger traders in big centres (e.g. Jaipur / Delhi). These large traders/stockists have huge godowns to store the charcoal brought from different places by different traders. The charcoal is graded and the price varies according to the grade and type of usage. The demand for such charcoal comes from various sources such as chemical industries, foundries etc. and small scale businesses (ironing of clothes, incense stick manufacturing) including food catering services for the elite in urban centers.

In general, the stockists / large traders control the price and movement of coal and also have an important lever in the form of the money they advance to the traders. According to Saxena (1997), charcoal is normally sold at prices ranging from Rs 95 to Rs 125 per quintal and it is estimated that the original tribal labourers get around just 10 per cent of the final value in the whole production activity. The same pattern is observed even in the case of Jajota (please refer following schematic diagram).

The charcoal making is also done at individual household level on their homesteads in similar manner but on a small scale. The charcoal generated is either directly sold to the nearby small businesses or to the trader. Some times, the farmers simply sell the prosopis trees on their farm bunds / homesteads to the trader for certain amount, which varies with number and age of the trees.

Charcoal making: Present process of trade and key players (case of Jajota)



IMPACTS OF PROSOPIS JULIFLORA

Prosopis juliflora has its uses but when left unmanaged, it has wide range of negative implications for individual households, community at large and as well as on the local ecology. It impacts crop production activities in terms of increased cost of weeding and reduced yields. It hampers livestock movement, results in injuries and reduces availability of fodder. These impacts may vary within the district depending on the subregional characteristics.

It also causes injuries to humans because of its thorns on pathways and allergens in some cases. Finally, at macro level, it clogs drainage channels impeding free flow of water into tanks and occupies the tank bed itself. It has the capacity to smother other flora and dominate the local ecology.

Impact on crop production

As mentioned in earlier section, *Prosopis juliflora* is put on the bunds as fencing material to protect the farmland. But it is also seen as a weed when it occurs on the farmland itself, which it seldom does. Table-19, provides an overview of the efforts needed to weed out the plant from agriculture land. Average cost of labor is about Rs. 530/-, which comes to about Rs.1085/- per hectare. The cost of weeding again varies with the subregion (Table-20). SR-2 incurred relatively higher cost on weeding, about Rs.652/- per household as compared to the average (Rs.530/-) for all the subregions. This can be expected since this subregion has relatively Sesame soils and also agriculture is the dominating livelihood activity. SR-4 incurred the lowest cost on weeding (Rs.286/- per household), which can be related to the low agricultural production activities and also small farm holdings in the subregion.

Table 19: Average labor and cost incurred to weed out *Prosopis juliflora* from farmland

Parameters	N	Mean	Std. Deviation	Minimum	Maximum
Labor (mandays)	281	8	8	1	60
Average cost incurred (Rs./ household)	281	530	491	65	3,900
Average labor cost per hectare	281	1,085	1,003	26	3,575

Table 20: Subregion-wise average labor and cost incurred to weed out *Prosopis juliflora* from farmland

Parameters	SR-1 (n=22)	SR-2 (n=103)	SR-3 (n=94)	SR-4 (n=64)
	Mean	Mean	Mean	Mean
Labor (mandays)	8.3	10.1	8.5	4.4
Average cost incurred (Rs./ household)	541	657	550	286
Average labor cost per hectare	1,127	1,167	926	1,176

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Plate 14: (a) Prosopis as weed on arable land; (b) Weeding out Prosopis juliflora.

Another problem expressed by majority of respondents is that crop under its canopy has poor stand and there is hardly any grain setting. But this could also be due to a combination of many factors such as its extensive lateral root system that depletes subsoil moisture in the crop root zone and also due to the allelopathic effect in its leaves that affects crop growth under its canopy. It needs more research to establish

the exact cause. During the course of this study, interaction with the households and experts associated with the specie and primary information from the subregions revealed that crop production losses due to its canopy varied from 5-15% of the total potential production depending on the type of crop grown. For our study purpose, we took the lower side of the losses and assumed that production losses were 5% of the total potential production. Table-21 gives the average value of the production losses computed for each subregion.

Plate 15: Crop residue not visible under the canopy.

Table 21: Average value of production losses (Rs./ household) resulting from the canopy of *Prosopis juliflora*

Subregion	N	Mean	Std. Deviation	Minimum	Maximum
SR-1	84	884.5	896.0	0.0	5,712.9
SR-2	104	455.2	461.2	23.5	2,680.2
SR-3	105	976.4	1,710.1	0.0	11,197.5
SR-4	129	231.4	369.0	19.7	3,145.9
Entire region	422	601.9	1,035.6	0.0	11,197.5

The average production loss estimated for the entire sample area is about Rs.602/- per household. The mean loss was highest in SR-3 at about Rs.976/- per household and lowest in SR-4 (Rs. 231/- per household).

Impact on livestock production

As already discussed in Chapter-2 of this report, livestock production is an important source of livelihood and the type of animals owned in a region is based on availability

of local fodder and crop production system. Large ruminants are mainly concentrated in SR-2 and SR-3. Even though goat husbandry is an important income source in all the sub-regions, SR-1 and SR-4 are relatively more dependent on this as a source of livelihood.

Negative externalities of Prosopis on livestock production include reduced availability of grasses, reduced grazing lands and injuries to animals. These costs vary with the type of animal ownership. Regions with more numbers of large ruminants can be expected to bear greater burden.

Plate 16: *Prosopis juliflora* thickets on common land.

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The average costs incurred per household due to injuries to animals in each subregion are given in Table-22. About 297 households out of the total 504 sample households incurred some cost due to injuries to livestock. The costs include cost of transportation, treatment of injured animals, production losses (this includes dead animals also) and labor cost (own as well as hired) involved in tending to injured animals.

Table 22: Average costs incurred per household due to injury to animals

Subregion	N	Mean	Std. Deviation	Minimum	Maximum
SR-1	56	2,012	2,149	100	13,500
SR-2	69	3,727	5,560	430	38,870
SR-3	78	3,597	5,596	130	32,975
SR-4	94	1,575	1,487	250	7,975
Entire region	297	2,688	4,213	100	38,870

As was expected, average costs due to livestock injury are highest in SR-2 and SR-3 (Rs. 3,727/- and Rs. 3,597/- respectively) as compared to SR-1 and SR-4. One reason for the higher costs is due to injuries and loss of animals, especially in the context of the large ruminants, reported in these subregions (resulting in maximum losses of up to Rs. 38,870/- and Rs.32,975/-, where animals were reported dead). In SR-2 and SR-3, out of the total households reporting some injuries to animals, 55% and 51% of them indicated injuries to large ruminants as compared to 20% and 16% in SR-1 and SR-4. Whereas, in the subregions, SR-1 and SR-2,, the percentage respondents indicating injuries to goats is more. As many as 93% and 86% of the respondents in SR-1 and

SR-2 reported injuries to goats as compared to 59% and 65% of the respondents in SR-2 and SR-3.

With respect to type of injury reported, suffice to say, that the incidence of damage to the udders of the animals is high and this results in loss of production especially the milk. Others include injury to ears, foot and hoofs that are pricked or pierced by the thorns/spikes of Prosopis. For costs animal category-wise incurred due to injury, kindly refer to Tables 23 and 24.

Table 23: Average costs incurred due to injury to animals

Cost incurred due to injuries to livestock	N	Mean	Std. Deviation	Minimum	Maximum
Cost large ruminants (Rs./ household)	297	1,418	4,059	0	37,195
Cost large ruminants (Rs./ animal)	297	841	2,788	0	37,195
Cost goats (Rs./ household)	297	1,107	1,305	0	9,250
Cost Goats (Rs./ animal)	297	502	509	0	2,800
Cost sheep (Rs. / household)	297	164	571	0	3,650
Cost sheep (Rs./ animal)	297	49	197	0	1,800
Total cost incurred on injury to animals (Rs./household)	297	2,688	4,213	100	38,870

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Table 24: Average costs incurred due to injury to animals (Subregion wise)

Cost incurred due to injuries to livestock	SR-1 (n=56)	SR-2 (n=69)	SR-3 (n=78)	SR-4 (n=94)
Cost large ruminants (Rs./ household)	457	2,503	2,440	346
Cost large ruminants (Rs./ animal)	426	1,560	1,171	288
Cost goats (Rs./ household)	1,524	980	931	1,096
Cost Goats (Rs./ animal)	731	403	274	629

Table-25 gives the average ranks given by the sample household members regarding their perceptions on impact of P*rosopis juliflora* on their livestock. Interestingly, reduced availability of grazing lands and grasses are ranked almost equally as the first problem. This is followed by injury to animals, which is ranked second (2.69).

Table 25: Mean ranking of reasons for changes in livestock activities due to *P. juliflora*

Reasons	SR-1	SR-2	SR-3	SR-4	Total
Reduced of availability grazing lands	2.37	1.38	1.41	1.48	1.57
Reduced availability of grasses	1.77	1.68	1.81	1.71	1.74
Injury to animals	2.29	2.88	2.81	2.63	2.69
Increased efforts for grass procurement	3.17	2.91	3.26	3.67	3.29

Impact on Human health

Prosopis juliflora, in many ways, has negative implications for humans as well. These include injuries due to thorns, allergies and side or ill effects due to the smoke emitted from firewood. Most of these injuries can be avoided with precautionary measures such as protective gears and better and improved chulas. Nevertheless, these injuries result not only in loss of working days but also in meeting the costs of treatment subsequently.

Table-26 summarizes the various losses. For example, number of lost persondays due to injuries (13.5 days) and costs incurred on treatment (mean cost Rs. 834.50) are the leading negative impacts. These also received highest responses among all the other types of negative effects. As one can notice, all other remaining effects did not generate adequate responses from most of the villages.

Table 26: Mean losses for various aspects related to human well-being

Losses	N	Mean	Std. Deviation	Minimum	Maximum
Lost persondays due to injuries	447	13.55	22.2	0	180
Cost incurred on Treatment of injuries (Rs.)	358	834.5	1,730.29	0	15,000
Lost persondays due to ill effects of smoke	216	3.81	9.05	0	60
Cost incurred to treat ill effects of smoke (Rs.)	227	237.18	774.3	0	8,000
Lost persondays due to allergy	195	0.55	2.5	0	20
Cost incurred to treat allergy (Rs.)	167	82.34	372.4	0	3,500

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Plate 17: *Prosopis juliflora* thorns unsafe for human and animal movement.

Environmental impacts

As mentioned in the earlier sections, *Prosopis juliflora* has both positive and negative impacts. The positive impacts are in the form of green cover and prevention of desertification. The government personnel mostly maintain this view.

Plate 18: *Prosopis juliflora* as green cover.

The negative environmental impacts, which are felt at the community level, are due to aggressive nature of the plant (fast dispersal, allelopathic trait and adaptability). Most of the drainage channels are clogged with *Prosopis juliflora* resulting in obstruction to water flows, and thereby reducing the inflows into tanks. Simultaneously, the tank beds too are heavily infested with *Prosopis juliflora* resulting in low water levels and in higher maintenance of tanks.

Plate 19: Drainage lines and water bodies affected by *Prosopis juliflora*.

Prosopis also smothers plant species under its canopy. Most of the respondents indicated, “nothing grows under its canopy”. It was also indicated that there is reduced availability of grasses once *Prosopis juliflora* has established itself.

Plate 20: No other flora visible near *Prosopis juliflora*.

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Further, Prosopis also poses as environmental hazard. For example, it is a hindrance in pathways both within as well as outside the villages. In majority of places, even the district roads are lined with dense Prosopis foliage, which acts as an impediment to movement of traffic.

Plate 21: Hindrance to pathways.

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CHAPTER-4

Management of *Prosopis juliflora* on private and common lands

Management of *Prosopis juliflora* includes both technical and social dimensions. Technical component involves aspects such as spacing between two plants, cutting and removal / eradicating and managing the root systems. These activities including tending operations are clearly based on site requirements, location of the plant and also the purpose for which the plant is cut.

Social dimensions imply rules and regulations and systems that are in place to check indiscriminate cutting and unplanned spread and growth of the plant especially on village common lands and on private lands. It also includes any institutional mechanisms, at the village level, that are in place to auction prosopis on common lands and distribution of the derived benefits among the community.

While exploring level(s) of 'awareness about management practices', interestingly, almost 92% of the respondents, irrespective of the subregion, denied having any knowledge and/or are even aware of any specific training programs on managing *Prosopis juliflora*.

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TECHNICAL DIMENSION

Based on Primary data generated with the help of structured and non-structured interviews, we draw inferences as follows:

Existing management practices (applicable to the tree)

Majority of the respondents indicated that the main method of Prosopis propagation has been by seeds, saplings and coppice / root-suckers. On the farmland, seed was the main mode of propagation (as indicated by 44% of respondents). This implies that propagation was on its own (natural) and not purposive. Planting through saplings was the major method of propagation on the field bunds (38% of respondents) and homestead (39% of respondents), which implies purposive propagation i.e. for fencing material at these locations by the households. For details see Table-27.

Table 27: Prevalent methods of propagation at different locations on own land

Methods		Location			
		Farmland	Field bunds	Permanent fallows/ pastures	Homestead
No response	Count	97	133	73	112
	% within Location	47.5%	34.2%	64.6%	35.7%
saplings	Count	9	148	9	123
	% within Location	4.4%	38.0%	8.0%	39.2%
Seed	Count	90	64	28	66
	% within Location	44.1%	16.5%	24.8%	21.0%

Suckers	Count	8	44	3	13
	% within Location	3.9%	11.3%	2.7%	4.1%
Total	**Count**	**204**	**389**	**113**	**314**
	% within Location	**100.0%**	**100.0%**	**100.0%**	**100.0%**

There are no standard practices followed to manage the growing plants or mature trees. The only major operation is cutting of plants for charcoal making. The average age at which a plant is cut was about 4.7 years with girth of 8.9 cm. The average rotation period is about 3.8 years. For details see Table-28.

Table 28: Mean values of tree parameters at the time of cutting

Parameters	N	Mean	Std. Deviation	Minimum	Maximum
Age of tree (years)	721	4.7	4.7	1	35
Girth when cut (cm)	641	8.9	10.9	1	75
Rotation period (years)	734	3.8	5.9	1	63

Eradication operations (see Table-29) are also undertaken where the tree is removed along with its root system. This practice is mainly taken up on farmlands. Nearly 89% of the respondents indicated that eradication has been undertaken on their farmlands.

Table 29: Eradication of *Prosopis juliflora* (with roots) at different locations

Location		Eradication (with roots)		Total
		No eradication	Eradication	
Farmland	Count	20	162	182
	%	11	89	100
Field bunds	Count	213	50	263
	%	81	19	100
Permanent fallows/ pastures	Count	57	27	84
	%	68	32	100
Homestead	Count	199	25	224
	%	89	11	100
Total	Count	489	264	753
	%	65	35	100

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SOCIAL DIMENSION

In this context, primary data (information) generated from the field revealed the following:

1. Awareness level

Table-30 indicates awareness or familiarity of the sample households about any kind of social regulations in the villages. Respondents appear to be familiar with social regulations that have largely been introduced through 'projects' planned and implemented by field based NGOs. It is highest from SR 1 (81.5%) while in SR-4 and SR-2 also respondents indicated awareness to some extent (63% and 60.5% respectively).

Table 30: Awareness about social regulations in each subregion

Subregions	Aware (%)	Not aware (%)	no. of respondents
SR-1	81.5	18.5	124
SR-2	60.5	39.5	114
SR-3	34.5	65.5	119
SR-4	63.0	37.0	115

2. Benefits accrued from auctioning of *Prosopis juliflora* on common lands

Table-31 gives subregion-wise responses regarding benefits accrued to the households by auctioning of *Prosopis juliflora* on village commons. In SR-4 and SR-2, nearly 41% and 39% of the respondents indicated some form of indirect benefits from auctioning. This, to an extent, implies gains from improvement in village infrastructure (repair of school building, temple, community well). In SR-3, almost all of them denied any such benefits / auctioning system.

Table 31: Benefits from auctioning of Prosopis on common lands in each subregion

Subregions	Benefits from auctioning	None	Total respondents
SR-1	32 (25)	93 (73)	125
SR-2	44 (39)	70 (61)	114
SR-3	3 (2.5)	116 (97.5)	119
SR-4	47 (41)	68 (59)	115

* Figures in parenthesis indicate percentages to total

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3. Willingness to accept rules and regulations for managing *Prosopis juliflora*

Table-32 gives an overview of the willingness of the households in each subregion to participate and/or accept any kind of rules and regulations in order to access or manage *Prosopis juliflora*. Only in SR-4, there is clear indication among the respondents to participate and/or willingness to accept any form of regulations (about 73% of the respondents) that might be put in place at the village level. This to a large extent can be attributed to the popular 'Jawaja Project' now known as Magra Mewar Vikas Sanstha (MMVS). In all the other subregions, the respondents were almost equally divided, even though majority of them in SR-2 and SR-3 (54%) are favourably inclined towards accepting rules and regulations.

Table 32: Willingness to accept social rules and regulations

Subregion	Willing (%)	Not willing (%)	no. of respondents
SR-1	44.5	55.5	110
SR-2	54.0	46.0	114
SR-3	54.0	46.0	119
SR-4	73.0	27.0	115

4. Choice of institutional system for managing *P. juliflora* on common lands

The village panchayat is the most preferred institutional system in all the subregions for managing *Prosopis juliflora* (Table-33). Only in SR-4, about 39% of the respondents preferred to have a separate body instituted in order to manage this specie, while in SR 2 nearly 25% of the respondents opted for a watershed committee.

Table 33: Institutional system preferred

Type of institution	SR-1 (n=125)	SR-2 (n=114)	SR-3 (n=119)	SR-4 (115)
Panchayat	56%	60%	81%	71%
Watershed committee	4%	25%	8%	0%
SHG	1%	7%	4%	2%
Constitute a separate body	39%	9%	6%	0%

Even though the '*Gram panchayat'* is preferred as a broad category by the majority of respondents, however, much more thought about the institutional mechanisms (functional and financial aspects) are needed and modalities for coordinating the various activities and monitoring for management of the specie need yet to be evolved.

5. Problem of encroachments

Prosopis juliflora is fast becoming a means of encroachment on the village common lands by the economically rich and powerful and socially influential village residents. Nearly 78% of total respondents associate *Prosopis juliflora* with encroachment of commons and/or nearby located government revenue lands. The encroachments are high for all the subregions (see Table-34). However, SR-1 is in the lead with 92% of respondents indicating encroachments. Most often, encroachment occurs by gradual shifting of field bunds into the adjacent common land where *Prosopis juliflora* concentration is high and the land is not under any use. By constant maintenance of the piece of land, the encroacher claims ownership. In some villages, the landowners with mutual consent divide among themselves the patches of land with concentration of *Prosopis juliflora* and, subsequently, overtime claim the land as their own.

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Table 34: Encroachment problems due to *Prosopis juliflora*

Subregion		Encroachments due to Prosopis		Total
		No encroachment	Encroachment	
SR-1	Count	10	115	125
	% within SR	8.0%	92.0%	100.0%
SR-2	Count	37	77	114
	% within SR	32.5%	67.5%	100.0%
SR-3	Count	23	96	119
	% within SR	19.3%	80.7%	100.0%
SR-4	Count	32	83	115
	% within SR	27.8%	72.2%	100.0%
Total	Count	102	371	473
	% within SR	21.6%	78.4%	100.0%

6. Willingness to contribute for managing the species

The respondents were asked to state their willingness to contribute in the form of labor and/or cash. Reponses received are higher for labor contributions as compared to cash contributions (see Table-35). The average contribution in the form of labor and cash are 7.6 days and Rs. 143/- per annum respectively

Table 35: Willingness to contribute for managing *Prosopis juliflora*

Contribution	N	Mean	Std. Deviation	Minimum	Maximum
Form of labor (mandays)	319	7.6	7.9	0	60
Cash (Rs./ annum)	205	143.4	202.8	0	1,400

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CHAPTER-5

Conclusions

BACKGROUND

The objective of this report was to examine the varying perceptions, costs and benefits associated with *Prosopis juliflora*. Even though Ajmer district, which is the study area, is classified as Agro Ecological Region (AER) 4.2, within the district there are variations in the local ecology (important trees, shrubs and grasses), soil types and the major livelihood strategies of the communities. From Chapter 2, it can be inferred that SR-2 and SR-3 are relatively fertile with agriculture dependent populations. SR-1 and SR-4 are relatively poor in terms of soil quality, land ownership and major livelihood sources are mainly off-farm. Dependence on small ruminants is relatively higher in these subregions. One general conclusion is that there is close association between crop-livestock and local ecology.

The role of *Prosopis juliflora* among the sample households is examined under these different conditions in Chapter 3. There are similarities and also dissimilarities in the perceptions of the community about *Prosopis juliflora*, its uses and associated costs, and the benefits varied among the subregions.

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BENEFITS FROM PROSOPIS JULIFLORA

In all the subregions, *Prosopis juliflora* is considered as an important fuel wood resource. It was ranked first in terms of its uses. Even though *Prosopis juliflora* by its very nature smothers growth of other native species, however, there is also a view point that it indirectly helped in reducing pressure on other trees and shrubs that would have been cut for fuel wood purposes if it had not been there. Therefore, there is some ambiguity in its impact on local ecology that needs more research.

> ***Note:*** *Controlled and well-managed trees are important rather than the present practice of random cuttings that result in heavy coppicing giving the plant a bushy appearance.*

Even though there are many positive responses for *Prosopis juliflora* as fuel wood in terms of reduced efforts and time to collect firewood, nevertheless, one common observation by majority of households (67.5%) is about the increased smoke emissions.

> ***Note:*** *There is scope to promote improved chulas in the villages that will help to overcome the problems resulting from high smoke emissions when prosopis is used as firewood.*

OTHER BENEFITS

Apart from fuelwood, the respondents also ranked fencing and shade for animals as other important uses of *Prosopis juliflora*. Charcoal making from the plant is taken up in some of the sample villages but the income at the household level is not much and is sufficient to purchase food items during stress periods.

Awareness levels about other benefits such as gum extraction, soil improvement and any products from pods for human consumption were either very low or none at all.

> ***Note:*** *Awareness and orientation programs about such products would help in converging with present research efforts and preparing the community to become stakeholders and avail benefits from future markets for such products.*

PROBLEMS FROM PROSOPIS JULIFLORA

Some of the key problems encountered with *P. Juliflora* are presented and discussed below:

Crop production

The major problem on farmlands from *Prosopis juliflora* is as a weed. Cost of weeding out the plant is highest in SR-2, SR-1 and SR-3 and lowest in SR-4, again reflecting on the scale of agricultural operations in the subregions. The farmers also put Prosopis on the field bunds as a biological fence. One common response was that nothing grows under its canopy. The estimated production losses due to the "canopy" were highest in SR-3 and lowest in SR-4. Some of the reasons could be the shade from the canopy, lateral root system of *Prosopis juliflora*, allelopathic effect of the plant and/or a combination of all these factors together. But the exact cause(s), if such losses are occurring, needs to be established through scientific/experimental data.

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> ***Note:*** *On the farmlands farmers manage the prosopis by weeding it out and plant the species on the field bunds as a fencing material. Management of the lateral root system of Prosopis juliflora can be taken up through the practice of trenches which prevents the lateral root spread.*

Livestock production

As was discussed in Chapters 2 and 3, large ruminants are more in SR-2 and SR-3 and goat husbandry is an important income source in all the subregions but more so in SR-1 (which has the highest mean income from goat husbandry). The major problems from *Prosopis juliflora* are loss of grazing lands, reduced availability of grasses and losses due to injury to animals. The average losses due to injury to animals are relatively higher in SR-2 and SR-3 and this is mainly due to injury to large ruminants.

Majority of the respondents indicated that availability of grasses reduced after appearance and invasion of *Prosopis juliflora*.

> ***Note:*** *These losses are mostly associated with Prosopis juliflora located on the common lands. Therefore, any form of management of the plant in these areas depends on collective action of the community. This also means strong enforceable social regulations with active support of village institutions.*

Human health

The most common form of ill effect is injury from thorns of *Prosopis juliflora* in the pathways. The infections due to injuries incapacitated the person to work, thereby, resulting in loss of workdays as well as treatment costs for the injury.

> ***Note:*** *These injuries can be prevented through protective measures as well as proper management practices such as periodic clearing of pathways.*

Common property resources

As observed from the discussions in previous sections, ill managed *Prosopis juliflora* forms dense thickets on grazing lands hampering the movement of animals. It also sKidney beaners growth of native trees species, shrubs and grasses that have fodder value and other non-market values.

Most of the drainage lines and tank beds are clogged with *Prosopis juliflora* in its shrub form. This in turn affects the flow of water into the tanks resulting in falling water levels and disuse of the tanks. This problem is more predominant in SR-2 and SR-3 where there are significant numbers of tanks.

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> ***Note:*** *Management of Prosopis juliflora on the village commons depends on collective action among the local community and also strong village level institutions to enforce such regulations.*
>
> *Community based monitoring of local ecology at periodic interval must be given due importance.*
>
> *Tank renovation activities with focus on maintaining drainage lines and tank bed needs involvement of all the stakeholders and a strong institutional mechanism.*

SCOPE FOR COMMUNITY INVOLVEMENT

Prosopis juliflora is managed to a certain extent on private farmlands, field bunds and homestead. But awareness about the plant characteristics and multiple uses of the tree is lacking, thereby, resulting in adhoc management practices. The major problem of management of *Prosopis juliflora* is on the common lands where there is no proper institutional mechanism in place to take charge in order to regulate or make decisions ensuring equity.

As observed in Chapter 4, almost 92% of the respondents, irrespective of the subregion, denied any knowledge or awareness of any specific training programs on managing *Prosopis juliflora*. So far majority of the households have not benefited from auctioning of *Prosopis juliflora* on common lands.

> ***Note:*** *Lack of knowledge about the multiple uses of plant and its management among the community is one important reason for not fully understanding or realizing the value of the plant. Increasing awareness about the specie and training for its appropriate management that reduces its negative externalities would go a long way in making Prosopis juliflora a valuable bioresource.*

Most of the respondents indicated their willingness to contribute labor (average of about 8 days) for managing the species. There are also considerable numbers of respondents who are willing to contribute in terms of cash (average of about Rs.143/- per annum) for management activities on the common lands.

> ***Note:*** *It was observed that motivation exists for managing the plant at the community level. Given the wide spread availability of the plant and its potential uses, any form of human resource development activities that help in better management of the plant strengthens adaptive capacities of the local communities to climate variability.*

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CHAPTER-6

Suggestions and future strategies

This section deals with some practical suggestions that can be considered and taken up at various levels to address issues and problems faced by the vast spread of *Prosopis juliflora* (PJ). Recognising its fast growth and spread, over the years, some environmentalists have used expressions like 'invasion' and 'colonization' of land by this specie. And, during the course of this study, interestingly, based on the coppicing strength of this specie, the rural community has sarcastically termed it as a descendant of the 'Ravana Dynasty' where you cut one head; a new one appears and fills its place.

Based on the analysis presented in the previous sections and recognizing the changing scenarios including extreme climate variability, it is time to deliberately plan adjustments with ecological systems and human behaviours in order to reduce the risk to people's lives and livelihoods.

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POLICY ADVOCACY

A beginning can be made with 'government policies' that need to develop mechanisms in order to ensure that environmental damages are kept to the minimum extent possible. Some of the key elements of the policy should include:

- Controlled and well-managed growth and propagation of PJ as source of firewood for domestic needs especially cooking of food.
- Promoting village based 'woodlots' for meeting the fuel wood demands of the rural population.
- Protection to adjacent farmlands (arable) and *'gauchar'* i.e. village commons that are closely situated near forest lands.
- Protection to important water bodies including key drainage lines and streams.
- Treatment of all water bodies and important drainage lines.

With a view to optimize benefits that accrue from *Prosopis juliflora* and, simultaneously, to also overcome ecological and/or environmental degradation resulting from the vast spread of this specie, the authors would like to make suggestions in order to help develop strategies for programme/project interventions. These are as follows:

- Create awareness amongst all stakeholders for decentralized yet well-managed and controlled woodlots that provide augmented supply of goods (firewood, pods as feed concentrates, biomass for gassifires).
- Design programmes/projects to build and enhance capacities of local communities to not only creating their private assets but also to develop and manage well the public and community assets (viz. *gauchar, talab, naadis*) in order to sustain long-term gains.

- Provide strong incentives to local stakeholders (rural community) develop micro-plans keeping in mind the local challenges i.e. demands for PJ on one hand and arresting environmental degradation on the other. In other words, encourage supporting local ecosystems and bio-diversity and related production systems and sub-systems.
- Plan for 'adaptation activities' including traditional ones to address 'managing climate variability and risks' that are likely to affect rural livelihood options.
- Encourage and promote innovative institutional and financial mechanisms so as to take forward 'good management practices' including traditional ones that are self-enforcing and self-sustainable.
- Provide enabling and effective framework for cooperation among all stakeholders.
- Give and maintain space for alternatives and flexibility to adapt to local conditions.
- Strengthen linkages and synergies at programme/project level. In other words, plan for working towards convergence and complementing each other's initiatives and efforts.

MANAGEMENT OF PROSOPIS JULIFLORA

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While examining the 'promotion process' of this specie adopted by the Forest Department under different schemes of the State Government during the sixties, seventies and early eighties, it is apparent that there was no clear focus on 'management practices' that should have been taken up and followed as part of planned programme and activities so as to help the rural community derive optimum benefits. The 'extension agencies' of the State Departments never actually oriented and/or trained the rural community in management practices. For effective and efficient management of PJ, all stakeholders – especially the rural community will have to take steps, at various levels, for different kinds of management. For this to succeed, principles of 'participatory processes' must be encouraged and promoted at all levels.

The different kinds of management that need to be practiced are discussed in brief below:

a. Technical

The technical management has several aspects and dimensions. Based on the multiple use and benefits of PJ, the community will have to undertake steps accordingly. For example, this specie would require different management plan and treatment when opting for firewood. This implies area (land surface – whether private or public) on which it is growing or is likely to be put to use/covered, the number of plants/trees (for optimum benefit) required to meet the demand of fuel wood, spacing between plants/trees, the right technique of cutting in terms of when to cut i.e. according to seasonality calendar, at what height to cut the branches so as to minimize coppicing.

b. Social

It is high time that the rural community takes full responsibility of formulating social norms, rules and regulations for managing PJ. Of course, one will have to take into consideration the multiple use and benefits of PJ. The sets of rules and regulation would vary in terms of land/area (whether public or private), objective / purpose and usage of the same especially in the context of village commons, status of natural resources base and livelihood options available in the village.

These sets of rules and regulations can be enforced through the Panchayat Raj Institutions and existing people's institutions, at the village level, that have been promoted and strengthened under various programmes and projects implemented by the State and/or civil society and non-governmental organizations (NGOs).

c. Financial

Once the rural community through its people's institutions takes the responsibility to manage PJ at the village level, indeed, it will have financial implications of sorts. For example, there will be matters and issues of membership fee/dues, various costs including those pertaining to recurring expenditure and maintenance of assets created, mobilizing resources and cost sharing, and maintenance of records.

These implications will have to be well managed, by the community and the people's institutions, in order to sustain their livelihood solutions that are directly based and linked to natural resources and its management. In due course management systems must evolve and the same ought to be put in place for long-term gains and benefits.

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PROSOPIS JULIFLORA ON COMMON PROPERTY RESOURCES

Some suggestions for addressing issues pertaining to common properties that are impacted by the growth and spread of *Prosopis juliflora* are presented in this section.

Village commons vis-à-vis Livestock

The linkages and inter-dependency between livestock (both big and small ruminants) and the village commons also popularly known as *"Gauchar"* cannot be ignored. The deteriorating conditions of the village commons resulting from invasion of *Prosopis juliflora* have greatly affected the balance between big and small ruminants. As a consequence, the numbers of big ruminants have decreased while the numbers of small ruminants have increased across all villages in the district. This to a large extent can be attributed to disappearing local grasses.

Restoration of village commons as *'gauchar'* or pasturelands with a view to address biodiversity and help bring back natural succession of the local grasses should be taken up in earnest and given top priority. This is possible through efficient and better management of the commons by the rural community. The wild growth of PJ needs to arrested and controlled so as to allow for regeneration of local flora including palatable perennial and annual grasses.

The revival of local grasses will encourage the livestock-keepers to rear and raise cattle once again and which in turn will greatly improve livelihood options and enhance their household income levels.

Also, in the context of managing climate risk, restoration and better management of *'gauchar'* will help increase both physical as well as natural capitals that are much needed for local livelihood base.

Drainage lines and water bodies

Apparently, there is sufficient data to suggest that a majority of natural drainage lines and water bodies viz. village tanks, ponds and *naadis* are much infested by PJ. These have taken the shape of PJ thickets. It is observed and noticed that uncontrolled and unmanaged growth of PJ has not only retarded but, in several places, has also blocked the flow of surface water run-off from reaching the related water bodies. Not surprisingly, coupled with low, erratic and depleting rainfall trends, very little water reaches the tanks and ponds that would enhance infiltration and percolation rate and thereby recharging groundwater aquifers, which in turn would help further recharge open wells and/or bore wells/ in the region.

In order to augment agriculture production and productivity in the region it is imperative that the local communities treat drainage lines, local streams and water bodies. The first step would be to ensure removal of PJ from these.

In addition, with a view to managing climate risk it is relevant that efforts are invested in capturing rain run-off and that traditional water systems are revived and strengthened.

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INSTITUTIONAL ASPECTS

Some key suggestions for institutional dimensions are discussed briefly in this section. These are:

Community based people's institutions

Going by the lessons learnt from several development initiatives and efforts in not too distant past, it is evident that local peoples's institutions (PIs), for example, village development committee / breeders' association / self-help groups for micro-finance / watershed development societies are effective in empowering the community and in decentralized local governance. Of course, this requires a set of guiding principles to be observed and strictly followed by all members of the interest groups in the community. Effective and efficient groups can be formed if all members agree to function democratically and decision-making is more by consensus and that participative processes are demonstrated at all levels.

An ideal PIs is one, which is village based, has full representation of all households, focuses on village development activities, elects a working committee or task force and is financially empowered to plan and implement development activities. Such vibrant groups or institutions can put or apply pressure on *'gram panchayat'* institutions to function efficiently with responsibility in a sustained manner.

It is suggested that while designing programmes/projects to combat the menace of this specie and address issues of well-managed and controlled growth of PJ, the civil

society and NGOs can promote and strengthen such or similar people's institutions in the villages that they choose to work in the region.

Linkages and synergies

It would advisable and appropriate to work in close harmony with the various actors in development and cooperation. Various 'extension agencies' of the State are actively implementing several schemes and development programmes in the rural areas. The civil society and the NGOs can collaborate with the State in some of these schemes and complement each other.

There is plenty of scope for convergence. For example, micro-plans can be developed for improving production and productivity of village commons and this can be tied or linked with watershed development initiatives. Similarly, under joint forest management, committees and groups can be formed to work towards village 'woodlots' for firewood and fuel wood needs of the rural community.

Financial implications and various costs (especially labour) for different interventions can be tied up and covered under the National Rural Employment Guarantee Scheme of Government of India (GoI), which is now spread to cover all districts in the country.

Human resources development

Given the present the mindset of the rural community and their apathy towards this particular specie, and going by the suggestions/responses received from them during the course of the study, it is strongly recommended that the State and the civil society at large design comprehensive HRD interventions to orient and train the rural community in management practices of PJ. This is one thing that has been totally missing and neglected in the past efforts.

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One can make a modest beginning with awareness building programmes in the form of mass campaigns and from there move on to specific trainings on aspects and dimensions of technical nature (read elsewhere). At this stage, of course, one cannot ignore the social, managerial and financial aspects that are involved.

There is also the need to integrate traditional local wisdom and knowledge, which is fast disappearing and the young and upcoming generation in the rural areas, is not able to comprehend as they have only witnessed the degradation processes.

Simple learning materials and teaching aids can be developed to get messages across to the rural community at large. Separate courses and curriculums can be designed and integrated with ongoing school programmes for children, who when they grow up will better manage their village natural resource base.

While developing such programmes/projects, one must see through the lenses of 'managing climate variability and related risks.

While closing this section, it would not be out of place to conclude that the time is ripe to change gears and embark on mass awareness building, trainings for collective action and problem solving and building blocks of knowledge management for improved and strong livelihood solutions.

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CHAPTER-7

Way forward

INTRODUCTION

In Ajmer district, *Prosopis juliflora* was propagated extensively during the 1960s in the afforestation and roadside plantations schemes. The higher survival rates of *P. juliflora* prompted the decision makers in the forest department to aggressively promote the species to increase vegetative cover in the degraded forest lands and greening of Aravallis. *Prosopis juliflora*, now, dominates the local ecology. The causes of its dispersal are both due to human factors and its natural ability to survive and propagate. But irrespective of the reasons, in the present scenario, it can be considered as a significant bio-resource found on all types of landforms.

At the household level, *Prosopis juliflora* has both benefits and costs. The survey analysis reveals that it greatly contributes to fuel wood security. It is acknowledged as an excellent fencing material and also for providing shade to animals. In some locations, it also generates income through the charcoal making process. There are many other uses of the specie about which, the community is largely ignorant. But at the same time, unmanaged and random cutting of these trees on the common lands resulted in formation of dense thickets that obstructed livestock movement. This, coupled with the fact that it smothers grass and other plant species around it, resulted in reduced availability of fodder impacting both livestock production and local ecology. It also clogs drainage lines and tank beds resulting in reduced water inflows. All these factors indicate the need for appropriate management of this bio-resource, especially, given the increasing climate risks and scarcity of local resources.

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Management of prosopis on the common lands requires collective action that involves multiple stakeholders at different levels. This section provides a brief outline of the roles of key stakeholders and important technological interventions / innovations needed to improve the efficiency in its use and for optimize benefits.

MAJOR COMPONENTS OF MANAGEMENT

For effective and efficient management of this species, the key components are presented in the box on the following page.

- **Awareness:**
  - There are multiple uses of *Prosopis juliflora* that require appropriate specific mgt. practices firewood, charcoal, other uses). At the local level, the community is largely ignorant about the uses and management practices.
  - Information about local ecology and related issues to be integrated into the school curriculum/ syllabus
- **Trainings:**
  - There are a number of training components that include technical, HRD, social, financial and managerial aspects.
- **Linkages, synergies and convergence** with Government schemes and programs including those planned and implemented by Civil Societies and NGOs:
  - NREGA- Identification of activities based on *Prosopis juliflora* and preparation of appropriate microplans
  - Interventions and programs of Forest department and Watershed Development Programs (emphasis primarily on developing woodlots for ensuring fuel security, supply of construction material)
- **People's institutions** at village level vis-à-vis Panchayat : Clearly articulated roles and responsibilities

MULTI-STAKEHOLDER APPROACH

In order to maximize gains from this specie, it would be appropriate to opt for participatory processes and collective action at various levels. Hence, a multi-stakeholder approach is suggested. The matrix below provides the snapshot of the different stakeholders and their respective roles.

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Stakeholder	Roles/activities
NGOs	- Awareness building about the specie - Motivating the community - Community mobilization / organization - Facilitating preparation of microplans - Trainings to enhance capacities of the People's institutions - Policy advocacy
Academia/ Research organizations / Resource personnel	- Developing training modules and learning material - Conduct training of trainers - Training on technical aspects of management practices - HRD - Organizational strengthening in the context of People's institutions
Government agencies: Forest department Watershed Development Programs Revenue department NREGA	- Management of Prosopis in forest and revenue lands with support / coordination with people's institutions - Training on technical aspects of management practices - Involvement in preparation of micro-plans with Panchayat/community members (eg. Tank restoration programs, clearing drainage lines, Soil and water conservation measures on panchayat /government /revenue lands)

Peoples institutions and Panchayats	In the context of commons and Govt. revenue land if permitted by the department: - Establishing norms for cutting and auctioning of prosopis/ user fee - Contributions (labor/ monetary) for maintenance prosopis on commons - Managing the income generated from the resource - Monitoring the local ecology vis-à-vis *Prosopis juliflora* / ensuring technical dimensions, for effective and efficient management of Prosopis, are observed and followed. In other words, technical discipline is maintained for optimum benefits.

STRATEGIES FOR BETTER USE OF *PROSOPIS JULIFLORA*

As mentioned elsewhere in this report, *Prosopis juliflora* has multiple benefits. The community is already aware of its several uses. However, it is also ignorant about some other uses. It is therefore important to focus on improving the scope of its use as an income generating option. Simultaneously, there is a need to improve efficiency of the relevant technologies that are currently in use in order to optimize benefits of *Prosopis juliflora*.

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A. Income generating options from *Prosopis juliflora*:

- Scope for supply of firewood to local small businesses: Even though there are cases where households do generate some income from sale of *Prosopis juliflora* wood to nearby hotels / businesses, there is still ample scope for such markets if we take into consideration the many road side hotels and dhabas, brick kilns and foundries in the district.
- Charcoal making: The wood of *Prosopis juliflora* generates high quality charcoal that also has industrial use. At the household level, charcoal-making helps to a certain extent in meeting immediate household needs under stress conditions. While Gram Panchayats also benefit from auctioning of the trees on the common lands to traders, who by and large are from outside the village. As such, traders are more proactive in the charcoal making process and tend to realize higher profits from this occupation by supplying the product to larger traders located at the state capital as well as outside the state of Rajasthan. Barring a few exceptional cases (panchayat at village Jajota), at present, it is apparent that profits from charcoal-making do not trickle down to the place of origin / household level. It is, therefore, recommended that increased awareness levels among village communities about its value would help them in negotiating better price with the trader.
- Scope for bio-mass based gasifiers: Biomass from *Prosopis juliflora* is suitable and also recommended for use in gasifiers. Looking at the widespread availability of the specie in the district, there is scope for establishing bio-mass based gasifier units that help meet domestic power requirements. More importantly power generated from gasifiers could be used in community centers, primary health centers, dispensaries during power cuts and failures, and also in the

village schools to help student community, who often are denied study time opportunity when night falls.

A 'Draft Policy' was issued by the Government of Rajasthan, Energy Department, in 2009 for promoting generation of electricity from biomass. Biomass power projects of 5MW to 20MW capacity on combustion technology and up to 1 MW capacity on gasification technology become eligible for registration under this policy. Promotion of *Prosopis juliflora*, as energy plantation under this policy, is mooted on Government land (barren lands, wastelands, panchayat lands and degraded forestlands) for use as supplementary fuel to Biomass power plants. A maximum of 300 hectares/MW land in all categories shall be permissible for development of *Prosopis juliflora*. Even though this is envisaged to meet energy needs through Clean Development Mechanisms (CDM) and also to generate local employment, it has to be kept in mind that majority of rural households are dependent on the same resource for meeting domestic fuelwood needs. Therefore, it is important to develop a proper institutional mechanism to secure domestic fuelwood needs before such a policy is finalized. Another spin-off could be that the pressure on other alternative flora might increase in order to meet domestic fuelwood needs, which may result in ecological imbalance. At the same time, it is also important take into consideration the negative externalities from *Prosopis juliflora* in terms of its invasiveness, if it is promoted as energy plantation.

Hence, before such units are put in place, it would be advisable to undertake a proper technical and economic feasibility study that examines the demand for such energy and the locally available bio-resources. In addition, it is also imperative to assess the extent of collective action for both i.e. the location of the unit as well as preparedness to manage and maintain such units on the long run before embarking on such a venture.

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- Furniture making: The bole of a matured *Prosopis juliflora* can be used to make good quality furniture items. For this purpose, the farmers can selectively identify and nurture those trees that grow either on the periphery of the farmlands and / or homesteads.
- Construction material: The wood from *Prosopis juliflora* can be used as small beams and purloins while constructing semi-pucca hutments, cattle sheds and temporary shelters erected by the roadside for tea shops or smithy works.

B. Technologies for efficient use of energy including those that help reduce emissions from burning *Prosopis juliflora*

Several studies and trials elsewhere suggest that improved smokeless chulla design helps to reduce smoke emissions, thereby, preventing the users from various health hazards. It is suggested and recommended that at the household level the smokeless chullas are taken up in earnest when using *Prosopis juliflora* as fuel wood. In those areas where the use of improved smokeless chullas has not become common, the NGOs should first create awareness among the households and subsequently motivate them to opt for such design of chullas.

Similarly, technological innovations could be considered for improving efficient use of energy and reduction in emissions especially in the following:

- Scope for improvements in conventional charcoal making process
- Improvement in Brick kilns
- Improved stoves (*Bhatti*) at road side hotels and dhaba level

STRATEGIES FOR ADAPTATION TO CLIMATE CHANGE

Efforts and initiatives for conservation of local ecology and respecting biodiversity together with the above mentioned strategies would help in coping with extreme climate variability/ change and thereby secure rural livelihoods in particular and quality of life in general.

It will be in the interest of all concerned if the management of *Prosopis juliflora* is given due attention which so far has been missing or lacking in the different schemes and programs that were taken up while propagating this specie. Given the spread of *Prosopis juliflora* on Government, community and privately owned lands, and its multiple uses, a multi-stakeholder approach and strategies has been suggested. Hence, while planning and implementing recommended and suggested management practices, all parties concerned must ensure that these programs / activities are so designed that they are in line with adaptation to climate variability / change.

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Annexure

A-1: Selection criteria used to select the villages for the study along with list of selected villages

Subregion	Major soil types	Major vegetation types	Forest Area (Hactares)	Village Name	River sub-basin
Subregion I	Sandy loam / light medium	Prosopis cineraria (Kejri)	145.18	Relawatan	
		A. nilotica	220.21	Kadel	
		Capparis decidua	342.87	Babayacha	Upper catchment Roopnadi
		Anogeissus pendula / latifolia	-	Seengla	Middle catchment Roopnadi
		Moringa olifera	108.28	Jajota	Lower catchment-Roopnadi
		A. senegal			
		Zizyphus mauritiana (Ber)			
Subregion II	Light Brown Medium	Acacia leucophloea (Orinja)	233	Moondalao	
		Acacia nilotica			
	Alkaline soils	Neem	413	Dhanma	
		Capparis decidua	-	Maoshiya	
		A. senegal	-	Hatti patta	
		Zizyphus nummularia			
Subregion III	Clay loam to clay Heavy	Acacia leucophloea (Orinja)	183.05	Soonpa	
		Acacia nilotica	496.19	Ren	
		Neem	1033	Ratakot	Upper catchment-Dai/ Khari
		Capparis decidua	62	Barol	Middle catchment-Dai/ Khari
		A. senegal			
		Zizyphus nummularia			
Subregion IV	Shallow rocky and hilly soils	Butea monosperma	58.56	Ateetmand	
		Anogeissus latifolia/pendula	-	Singhadia	
		Rhus Mysurensis	105.93	Nai kalan	
		Acacia leucophloea (Orinja)	-	Khera-dhand	
			-	Shivpura ghata	
			212	Keloo	

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A-2: Prosopis use ranking – Subregion-wise

	SR-1	SR-2	SR-3	SR-4
	Mean	Mean	Mean	Mean
Fuelwood_rk	1.01	1.00	1.03	1.11
Fencing_rk	2.13	2.65	2.62	2.24
Feed_livestock_rk	3.43	3.78	4.19	4.85
Shade_animals_rk	3.77	3.40	3.40	3.65
construction_material_rk	4.56	4.83	4.75	5.09
wage_employment_rk	4.89	5.40	6.23	4.26
Income_charcoal_rk	6.75	3.89	4.45	4.45

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A-3: Mean plot size (in hectares) for weeding out *Prosopis juliflora*

Subregion	N	Mean	Std. Deviation	Minimum	Maximum
SR-1	22	0.8	0.9	0.0	3.6
SR-2	103	1.2	1.6	0.0	9.1
SR-3	94	1.1	1.6	0.1	12.7
SR-4	62	0.3	0.4	0.0	2.7
Total	**281**	**1.0**	**1.4**	**0.0**	**12.7**