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Increasing resilience of livestock migration in the arid areas of India

A case study of livestock mobility in the state of Rajasthan, India

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Executive Summary

The project on "Coping strategies for livestock smallholders in the fact of climate change and soaring feed prices: Case study of livestock mobility in the state of Rajasthan, India," was conducted to analyze existing and emerging trends with respect to livestock mobility. Following ICARDA's innovative 'systems' approach, this study was implemented by a multi-disciplinary team of range ecology and management research scientists, socio-economists, and spatial analyst (GIS) scientists from ICARDA, Oregon State University (USA), and the Central Arid Zone Research Institute (CAZRI) in India. The project, funded by the CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS), aimed to inform the formulation of policies and government initiatives that could improve the livelihoods of pastoralist communities. The project evaluation was completed taking into consideration the impacts of climate change, a growing demand for livestock products, and the promotion of modernization agendas as a pathway out of poverty. Researchers spent a year collecting geospatial data and recording GPS locations for two selected migratory herds in the region. Existing policies related to pastoralism were also reviewed.

Researchers provided the following conclusions and recommendations:

- Improving the condition of the common grazing lands and religious trust-owned pastures with community participation could provide better forage resources that fulfill the nutritional requirements of migrating animals.
- The interventions of state government through the provision of mobile veterinary services and quality medicines on different migratory routes will help reducing losses to livestock owners.
- Control of criminals shall provide a healthy space to livestock owners in different regions and ensure safety of people engaged in this enterprise.
- The provision of government services, such as watering camps and post processing facilities could potentially reduce grazing pressure in the present migration routes by dispersing herders to new areas.
- Increasing awareness of government provided veterinary services at key points along the migratory route through a promotional campaign would greatly benefit many migratory pastoralists.

It was also concluded that migration of animals reduces grazing pressure in herders' home villages and allows for herders to follow forage according to climate variability. This mobility provides resilience in the face of increasing climate variability.

1. Introduction

India contains substantial rangelands, with the majority located in the state of Rajasthan. The pastoral system of this area is centered on the use of large tracts of uncultivable and marginal land supplemented with seasonal use of rainfed cropland.

Despite living in the most harsh and drought-prone parts of the country, the pastoral communities in western Rajasthan make an important contribution to the state economy. These arid regions contribute 43.57 percent of milk, 83.62 percent of wool, and 53.44 percent of meat produced in the state. The 53.44 percent share of state meat production is comprised of 77.36 percent sheep, 52.60 percent goat, and 34.71 percent buffalo. The wool productivity (kg/head/year) of arid region sheep is 1.79, which is better than the overall state average of 1.60.

The state of Rajasthan also contributes to the national economy. It accounts for more than 15 percent of the total Indian sheep population (GoI, 2007) and about 40 percent of the total carpet wool production (GoI, 2006) in India.

It is clear that domestic animals are living assets for the pastoralists of western Rajasthan. Livestock provides resilience and food security to families that are on the margins close to poverty. Livestock also reduces vulnerability to external economic and environmental shocks. Overall, pastoralism increases household incomes and improves livelihoods for this vulnerable population.

Over the centuries, herders in western Rajasthan have developed traditional knowledge of animal husbandry and natural resource management. These communities move their animals in search of forage and water resources as a result of drought or seasonal change. Livestock mobility is critical for local livelihoods, trade, and coping with climate change (Clifton and Louhaichi, 2015).

Such mobility has been a source of conflict within Rajasthan. Instead of recognizing migration as a part of life for herders, the state has made continued efforts to sedentarize the pastoralist population. Since the colonial period, hostile relationships between sedentary populations and the migrating pastoralists has often resulted in violent interactions. The advent of planned economic development resulted in efforts from the state to modernize the migratory population by introducing them to high-yielding breeds and husbandry practices. More recently, pastoralists have been blamed for contributing to environmental degradation, even though studies exist to disprove the belief. In the end, legal measures were implemented to restrict pastoralism.

However, the alternative livelihoods suggested for migratory pastoralist were mainly suitable for farmers with sufficient capital and land. Efforts to curb migratory pastoralism were introduced without providing alternate fodder sources or productive assets. As a result, a culture of non-compliance with the new sedentary policy evolved. This culture was fueled by sporadic droughts threatening to further impact livelihoods and an increasing demand for sheep products (particularly mutton in urban centers). In the end, the number of sheep flocks migrating did not decline.

Specific actions could be taken to help facilitate the abandonment of pastoralism over time. The provision of institutional services – such as accessibility to fodder and feed resources, veterinary facilities, and market infrastructure to facilitate sheep production – would reduce the need to migrate. Providing opportunities for intensive farming as well as gainful non-farm and off-farm employment would also contribute to reducing a migratory lifestyle.

As pastoralism continues for the near future, conservation and regeneration of existing pastureland is of great importance. Advance degradation of rangelands contributes to threat of desertification. Overgrazing of community rangelands is resulting in a lack of adequate nutrition for domestic animals. Poor management practices and restricted access to health services are also contributing to low productivity in small ruminants. However, very little attention has been given to research effective management techniques of small ruminants in the dryland areas.

This study, entitled "Coping strategies for livestock smallholders in the face of climate change and soaring feed prices: Case study of livestock mobility in the state of Rajasthan, India," was conducted to analyze livestock migration with the following objectives:

- Analyze existing and emerging trends with respect to livestock mobility, in the general context of climate change, growing demand for livestock products, and the promotion of modernization agendas as a pathway out of poverty;
- Collect geospatial data and process GPS locations of migratory herds for two selected herds in the region for a whole year;
- Review the policy and legislative environment and synthesize the main institutional provisions in support of or against livestock mobility;
- Prepare local authority (governmental institutions) and pastoral communities to better plan and intervene in case of severe drought.

2. Methodology

2.1 Site Selection

Study sites were selected to maximize variability within the sample from the perspective of migration patterns and livestock production system. Key criteria employed to select locations include the following:

- Demographic composition of the location (in terms of migration, occupation groups, etc.).
- Distance from district headquarters/institute.
- Concentration of natural resources (livestock, grazing lands, forests, etc.).

Four districts from western Rajasthan (Pali, Jodhpur, Barmer and Jalore) with significant numbers of migratory cattle or small ruminant flocks were selected for study (Figure 1). A stratified random sampling method was used to select households within district, tehsil (administrative unit in a district with defined geographical boundaries), villages, and households. The study villages were chosen based on livestock population migrating from the villages to the different locations in the neighboring states. A complete inventory of all the migratory and non-migratory livestock households was undertaken in selected villages. The livestock households were categorized into small, medium, and large based on the cumulative square root method of stratification (Singh, 1975). Finally, 125 sample households, each from migratory and non- migratory categories, were selected on the basis of the probability proportionate to the number of households in each category. As cattle herders were migrating during the deficit period, all the 33 households rearing cattle were selected for the present study.

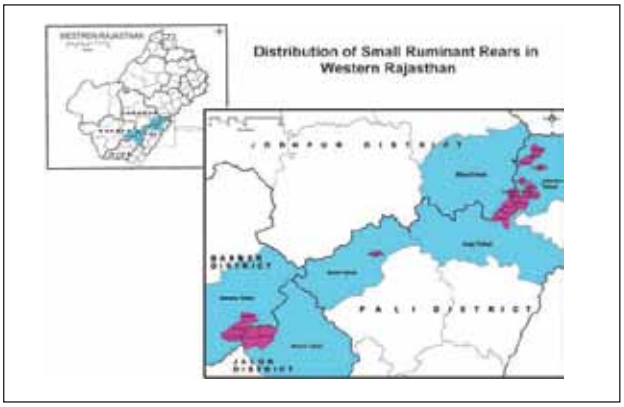


Figure 1: Map showing distribution of small ruminant rears in western Rajasthan

Table 1: Details of selected locations

District	Tehsil	Villages
Pali	Jaitaran	Jhajhanwas, Patwa, Rajandand, Devaria, Ber Kallan, Gharania, Nimbol, Nitiria, Kharadi, Malpuria
	Rohit	Mukunpura
Jodhpur	Bilara	Binjwaria, Barna, Atpara
Barmer	Shivana	Ramania, Moklsar, Motisara
Jalore	Aahor	Raithal, Bhurani

2.2 Methodology

The methodology of the study encompassed the following four components:

2.2.1. Review of secondary information: A comprehensive examination of relevant secondary information sources occurred. Researchers also conducted a careful review and analysis of the data and information gathered from various studies.

This review identified various irregularities in migration patterns that require additional study to help improve range management of communal areas of Rajasthan. Three types of livestock mobility were identified – temporary (within district), semi-migration, and permanent. These three categories shaped the creation of the surveys and study approach. Review of the literature also showed an increase in permanent migration, a decrease in temporary migration, and a greater irregularity in rainfall patterns.

2.2.2. Discussions and triangulations with key informants/groups:
Target groups included researchers, extension workers, representatives of livestock associations, traders, cooperatives, representatives of government departments, and non-governmental organizations.

Data was collected using the Participatory Rural Appraisal (PRA) approach that integrates knowledge and opinions from rural people in rural development/research projects (Bhandari, 2003). Key informant interviews (discussions with people who have specialized local knowledge of migration strategies) and personal interviews, were used to gather information from those involved in the development and promotion of livestock in 2012-13. Data on the various aspects of the socio economic status of livestock owners, investment on animals, breeding, and other management practices were collected. Migration routes and problems faced by herders were also discussed. The information collected from the key-informant interviews and group interviews helped inform the creation of the household survey.

Figure 2: Discussion with key informants

Figure 3: Two examples of surveys for PRA involving local communities

2.2.3. Household surveys: Detailed information was collected by talking to 30 households in each village. The standard analytical and statistical procedures were used for data analysis. The linear regression equation was fitted by the ordinary least-squares method to find the relationship between migration of respondents (Y) and different factors like flock size (X1), age of respondent (X2), education status of owner of household (X3), total adult members of family indicating labor supply (X4), and size of operational land holding. This information was analyzed to understand significant relationships and identify the best policy approach to address migration and resource management.

2.2.4. Tracking livestock migration through GPS collar technologies: Understanding the spatial-temporal context of herds' mobility and herding dynamics of livestock in the state of Rajasthan is of value for animal energetics and range site or habitat type requirements. For this purpose, animal GPS collars were constructed that collect location data to determine the spatial/temporal movement of livestock under natural conditions (Gaur et al., 2013).

GPS units were constructed using a MMCX Active GPS Antenna, GPS data logger board, Micro Secure Digital (SD) memory card, and batteries which were enclosed in a polycarbonate waterproof case attached to sewn collar belting (Clark et al., 2006) (Figure 5). This GPS-based animal tracking technology, the Clark Animal Tracking System (Clark ATS Plus), has been used to determine patterns of ecosystem use by livestock and to identify key areas actively grazed by livestock. These collars log animal locations at one hour intervals and record position (latitude and longitude), date, time, fix quality, and animal velocity on secure digital cards in the collar (Clark et al., 2006). Collars were fitted on two cows and two sheep. An on-the-job training was performed and a step-by-step video was created to build capacity on this technology. A flow chart demonstrating the research methodology and approach can be seen in Figure 4. The methodology from Louhaichi et al. (2008) was adopted.

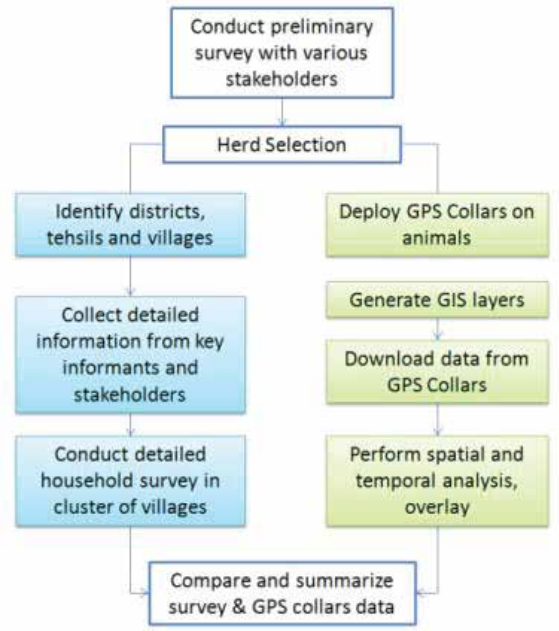


Figure 4: Flow chart showing adopted methodology

Researchers conducted a series of on-the-job training on collar construction, data acquisition, analysis and interpretation of collected information for Central Arid Zone Research Institute (CAZRI) collaborators. The intention was to ensure that the project is conducted in a fully-integrated fashion and that results meet the needs of all scientists involved. They also interacted with herders so they understand the responsibilities and benefits of project participation.

A video was recorded to illustrate step-by-step instructions on how to deploy the GPS collars (Figure 5).

Figure 5: Screen shots showing the video for GPS collars deployment

Ten GPS collars were shipped to India last summer. These units weighed slightly less than one kilogram and animals showed no apparent discomfort or stress when wearing the unit (Figure 7).

Figure 6: On-the-job training of CAZRI scientists on the use of GPS collars

Figure 7: Sheep and cow collared with GPS tracking units

3. Results

3.1 Socio-economic profile of households

The Raika, an indigenous group of livestock raisers, represent the majority of stock owners in western Rajasthan. Flock and herd size varies from 42 to 250 small ruminants and 35 to 220 cattle. Raika are dependent on livestock rearing for their livelihood. About 74 percent of the households have small land holdings (less than two hectares) with the option to grow only one rainfed crop in the absence of irrigation. The survey also indicates a low education level among sample households as 88 percent of cattle herders and 90 percent of sheep flock owners are illiterate. Average family size of cattle herders is 5.6 and sheep herders is 5.4. As male members of migratory households move outside, female members look after the agriculture fields. Further, female members supplement their family income by general labor work on other farmers' fields or obtaining employment under government sponsored employment schemes in the village.

Rearing of small ruminants depends on labor inputs of all family members. Work is divided between the adult male and female of a family with children helping in all kinds of activities. The male members of family take the animals for grazing; female members are responsible for cleaning of sheds and feeding of Khejri. Women's participation in long distance migration is declining due to education of children at villages and security problems in the migrated regions. In case of cattle rearers, all family members generally move together and female members actively participate in management of animals during migration.

3.1.1 Sources of income

The traditional sheep breeding system had been oriented only towards wool production, but over the last few decades this has changed. Wool prices are stagnant, but the demand for meat is increasing. As a result, the Raika now breed their animals for good growth rates, rather than wool quality. They have pursued this by crossing their local animals with breeds from adjacent regions that have higher growth rates and better meat potential.

The Raika depends on middlemen to market live animals. Demand for slaughtered animals is high, and Muslim agents regularly visit the Raika homesteads looking for animals to buy. In the wool market, the middlemen are also from the Muslim community. Many are upset with the high margins obtained by the middleman, but it is difficult to operate without them because the sheep breeders are generally too occupied with herding and rearing duties.

Small ruminants are utilized for meat, wool, dung, and milk; the production system is market-oriented. Herders process milk into ghee, but the yields are generally low. Dung is usually traded for grain with sedentary farmers. The sale of male lambs, ghee, and milk (for cattle rearers) are the major sources of income. The major breeds of sheep in the project area are Marwari and Sonadi, the cattle breed is Kankrej. The main source of cash income is from the sale of lambs for slaughter. Female lambs are kept for reproduction although adult sheep are sold for slaughter. Small ruminants' milk is mainly used for home consumption or converted into ghee. The average sale price of lambs at the age of three to five months varies between Rs 2,000 to 3,500 per animal (approximately 31-55 USD/animal). Cow milk is converted into ghee and sold in the village itself at Rs 400 per kg (approximately 6 USD/kg) while during migration in Haryana and Uttar Pradesh (U.P.) milk is sold at Rs 20-25 per kg (approximately 0.3-0.4 USD/kg).

3.1.2 Grazing and feed management

The Raika are largely landless and fulfill the nutritional requirements of their flocks on various forms of common property. During dry season (October–May) sheep are grazed on agricultural and gauchar (common land). In the rainy season (June-September) sheep are commonly taken to the forest for grazing. During the winter season, small ruminant herders generally rent harvested crop fields for grazing their animals. They also pay farmers for harvesting fodder from trees in their fields. Herd sizes for cattle are large and grazing takes place on fallow fields in the home village or surrounding villages. In general, sheep rearers have good knowledge of fodder and water resources. Concentrate feed like Guar/crushed Bajra or its flour is soaked in water and is given to lactating animals only. The quantity of feed varies from one person to another depending upon availability of cash for purchase of concentrate from market. In general lactating cattle are given one half to one kg of concentrate feed during the evening time only. The recently calved cattle are given 5 kg of jaggery (gur) at some interval within 10-15 days of parturition.

3.2 General overview of known migration patterns

The state of Rajasthan accounts for more than 15 percent of the total Indian sheep population (GoI, 2007) and about 40 percent of the total carpet wool production in India (GoI, 2006). The data analyzed over a period of 15 years from 1996-97 to 2011-12 indicated that the total migration of sheep did not show any definite trend and was highly unstable (Figure 8). The lowest migration of sheep was 8.6 lakhs[1] in 1997-98 and the highest was 32.9 lakh in 2005-06. The mean value of the total migration over the entire period was to the tune of 20.3 lakhs, of which about 29 percent was accounted for by temporary migration and the rest from permanent migration.

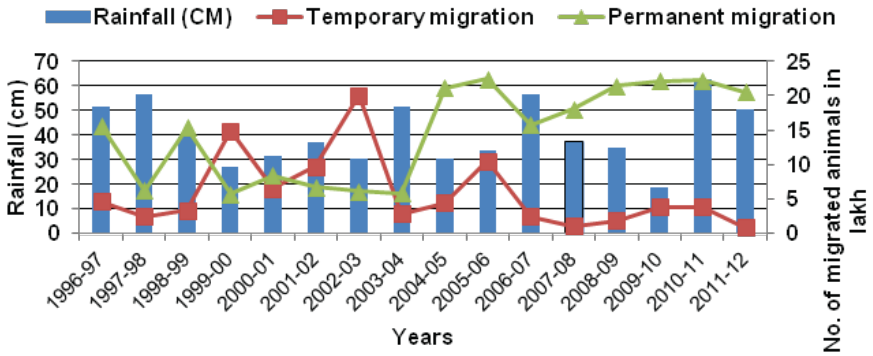


Figure 8: Trend in migration of sheep in Rajasthan: 1996-97 to 2011-12 (in lakhs)

3.3 Migration information from the PRA

The results of Participatory Rural Appraisal (PRA) and the secondary literature survey revealed that the main communities who rear sheep and goats in western Rajasthan are Raika (Dewasi/Rebari), Sindhi Muslim, Jat, Rajputs, Gujjar and scheduled castes and tribes. The flock size varies from 40 to 250 heads of small ruminants and 50 to 220 heads for cattle. Migration of small ruminants is a regular feature in western Rajasthan. The degree of mobility depends on flock/ herd size, and the location of the family or village, as well as on the amount of fodder produced in a given year. In general, three kinds of livestock migration are prevalent in the selected villages:

- Temporary (within district): People with lower flock size generally migrate for a short period from their native village to grazing areas in neighboring villages within the district when the local pastures are exhausted, mainly during November to June.
- Semi-migration: People having large flock sizes face difficulty in maintaining the animals especially during off season (November to July/August) and they migrate out of the district or state. They typically migrate out of the district or state during the dry season, but return to their native area in the following monsoon season.

[1] A lakh or lac (/ˈlæk/ or /ˈlɑːk/; abbreviated L) is a unit in the South Asian numbering system equal to one hundred thousand (100,000; Scientific notation: 105). In the Indian numbering system, it is written as 1,00,000 (source: http://en.wikipedia.org/wiki/Lakh)

- Permanent migration: In this kind of migration animals are permanently moved from the home tract to other districts or states. Family members rotate herding responsibility, each staying for few months with the herd. For long distance migration, about 10-20 persons join together and move simultaneously with their animals seeking safety and uniting against other management related problems and threats on the way. An experienced person within the group is appointed as a leader who visits in advance different locations where animals are to be taken for grazing. Animals are not brought back to native villages. The impetus behind permanent migration is the lack of pasture lands for large flocks in western Rajasthan and better forest and water resources in Madhya Pradesh and Uttar Pradesh. In addition, herders get better prices for their animals in these regions and some farmers also pay pastoralists for herding services (dung fertilization of fields).

Migration strategy of livestock owners revolves around availability of fodder and water resources in the native region. In good rainfall years, they may delay their departure by 1-2 months. The departure of herds is linked with crop harvesting in other regions. During the migration, animals graze on fallow harvested fields of farmers. The regression analysis indicates a significant positive effect of flock size and adult family members in relation to migration. The other factors, such as the age of respondents, education status and operational holding size were found to be negatively associated with migration (Table 2).

Table 2: Linear estimates of factors influencing livestock migration

Variable	Description of variable	Coefficient	Standard error
Constant		0.516***	0.0927
X1	Size of flock (#)	0.0049***	0.0004
X2	Age of respondent (yrs)	-0.0095***	0.0009
X3	Education status of owner of household (years of schooling)	- 0.0621**	0.0341
X4	Total adult members in family (#)	0.0318***	0.0136
X5	Size of operational land holding (ha)	-0.0122*	0.0094
N		250	
R^2		0.5375***	

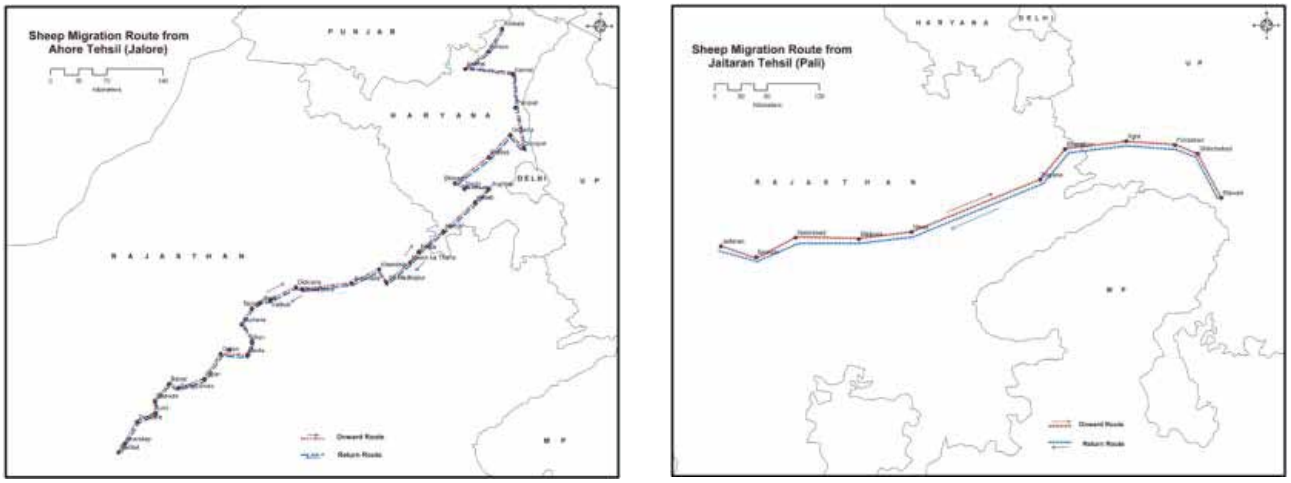
3.4 Migration of small ruminants and cattle

Interviews revealed that migration routes are well established. People from southern parts of Jodhpur, Barmer and Jalore district generally move towards Gujarat state. They pass through Bali, Abu-road, Palanpur, and reach up to river beds in Baroda, and Surat where they spend about two- three months. Similarly sheep from northern parts of Jodhpur and Pali are migrating through Sawai Madhopur or Hindaun towards Punjab, Haryana, Madhya Pradesh, and Uttar Pradesh. Refer to Figures 9 and 10 for an illustration of migration routes collected in interviews.

Shepherds stay in herding camps known as “dang”. Dangs comprise anywhere between eight and 20 flocks. While on migration, the Raika keep in mind two basic requirements: fuelwood for cooking and sufficient water for the sheep and their own needs. The particular fields in which they camp may be private, government, or village land. The Raika tend to prefer fields which have irrigation, especially from tube wells for sheep as well as their own drinking, cooking, and washing needs. Farmers also have a clear preference for having shepherds hold sheep in fields because livestock manure improves crop yield.

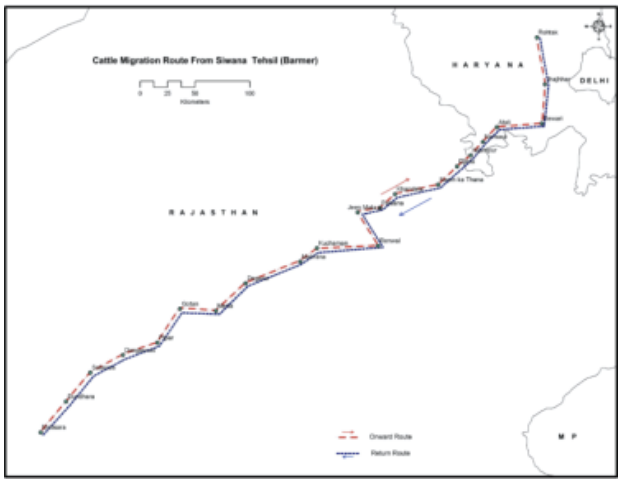
Usually, the stockmen set out on their journey in winter (December/January) and return to their homes in early monsoon (July). In drought years almost every livestock holder is forced to go on migration.

Figure 9: Sheep migration routes based on the PRA survey



Raithal (Jalore) → Khandap (Barmer) → Dundara → Luni → Salawas → Banar → Dangiawas → Pipar (Jodhpur) → Gotan → Jogimagra → Merta → Raan → Kuchhara → Tarnav → Jayal (Nagore) → Katodi → Deedwana → Dolatpura → Nasalkotria → Jeenmata (Neem Ka Thana) → Khandela → Sri Madhopur → Neem Ka Thana (Sikar) → Patan → Nangal Chaudhary (Alwar) → Narnol (Harayana) → Chiriabagot (Haryana) → Dudwa → Jharli → Kosali → Jhajhhar (Haryana) → Rohtak → Bhiwani → Dadri → Gohana- Sonipat → Panipat → Pehwa → Karnal → Kaithal → Nilakheri → Ambala. Shepherds return by the same route.

Figure 10: Cattle migration route from Siwana tehsil on the PRA survey



Motisara (Barmer) → Dunhdhara (Jodhpur) → Sikarpura (Luni) → Salawas → Dangiyawas → Gotan → Pipaar → Merta → Degana → Kuchaman → Makrana → Renwal → Jeen Mata ji → Khandela → Palsana → Neem ka Thana → Dabla → Nijampur (Rajasthan-Haryana border) → Narnol → Atali → Koond → Rewari → Jhajhhar → Rohtak. Shepherds return by the same route.

3.5 Migration information found from the GPS collars

In March 2013, data was downloaded from the GPS units. Out of the 10 original GPS units, only four units collected data that could be used. The remaining units were either deployed inside a research station or were not functioning (electric wires had been cut, GPS antennas improperly connected, and/or batteries were exhausted)[2]. The four units were in different sheep and cow herds (one unit per herd). Two additional units were fixed so that two additional herds could be tracked.

Figure 11 displays the migratory route in Rajasthan. GPS data analysis indicated that animals travel roughly 6 to 17 km per day, especially if farmer fields are close together. Each day the animals move from 8:00 am to 7:30 pm, and there is no movement at night. If there is not enough forage they travel longer.

Figure 12 shows the distance traveled daily (by hour) for cows and at different times in the day. Peak travel occurred at 5pm when cattle would travel 1300 meters. A buffer of 20 km was established around the path for cattle and a 5km buffer was placed around known well points.

An outline of the buffer can be seen in Figure 13. The 5km buffer around well points can be observed in Figure 15 and the 20 km buffer for cattle migration can be seen in Appendix 1. This is helpful to identify priority areas for cattle movement for targeting of needed veterinary services and filling in gaps for water needs.

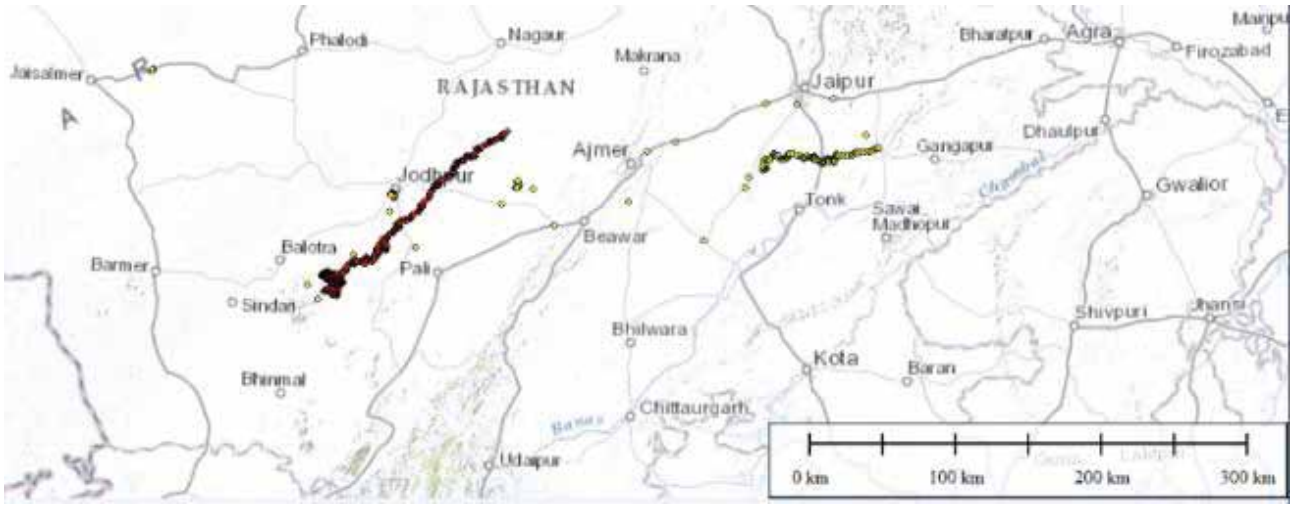


Figure 11: Cow (red) and sheep (yellow) migration routes in Rajasthan state based on GPS collars

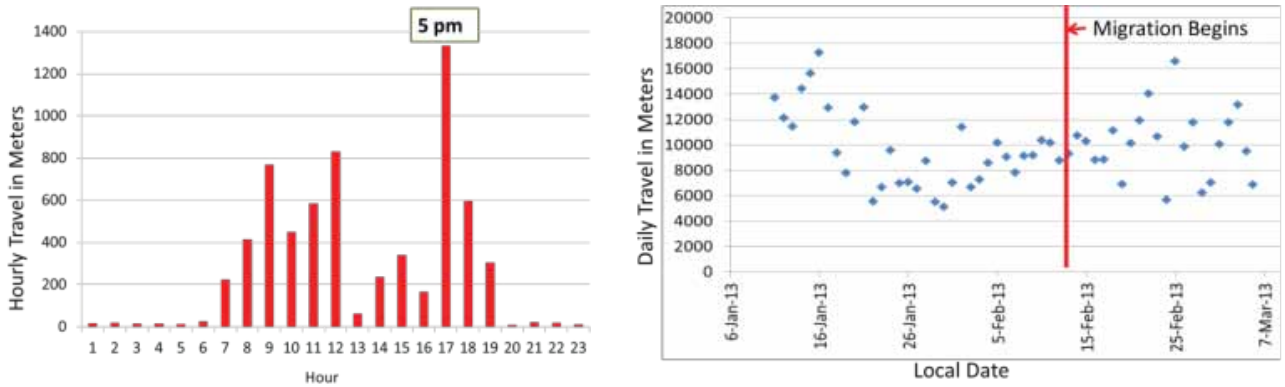


Figure 12: Distance traveled daily by cattle herds

Cattle travelled an average of 7.09 km day-1 before migration began, 8.8 km day-1 during migration, and 8.71 km day-1 averaged across the entire observation period.

[2] Incentives were offered to herders to place GPS units on their animals.

3.6 Migration routes

Individuals from Jodhpur, Barmer, Pali, and Jalore districts generally migrate towards Uttar Pradesh, Madhya Pradesh and Haryana. The exact routes of cattle migration, time taken to reach watering points, as well as the total distance travelled has been mapped and calculated through GPS Collars. Analysis of a 20 km land use/land cover buffer on the migration route reveals that 0.06 percent of the urban land, 29.06 percent of cropland and 48.57 percent of fallow lands were utilized by migrating animals for grazing and resting purposes.

Peculiarly, tracked migrating animals did not enter into the forest areas. Based on animal tracking data, animals drink water once a day and if available, maybe twice a day. Sometimes, they have to cover 18-22 km, from the migration route, to locate a water source. Migration routes depended on the availability of water and pasture land. Water was predominantly from wells or retention basins. Cattle watered near noon every day. The animals on average travelled 7.09 km before migration, 8.8 km during migration and 8.71 km/day across the entire observation period. The spatial distribution of the cattle herd before migration can be seen in Appendix 2. Cattle in particular traveled approximately 10 km/day. The overall distance travelled by animals was 1550 km from 9th January to 28th June 2013.

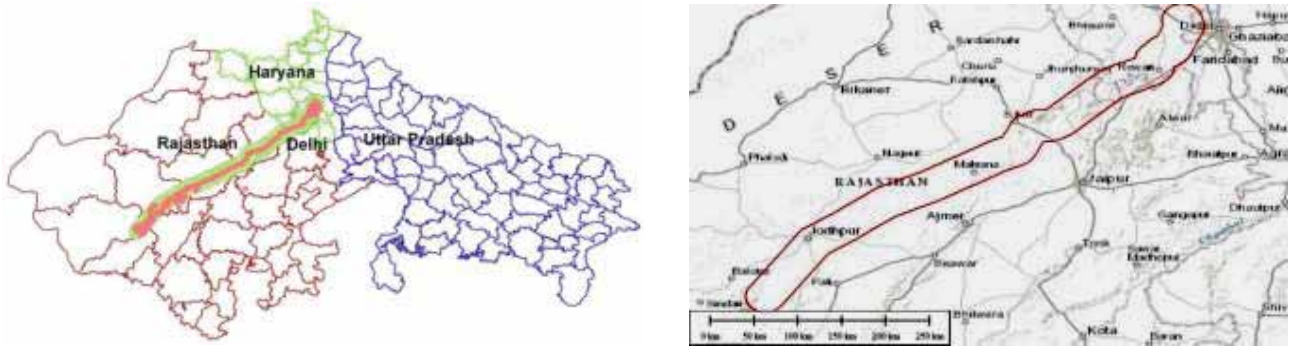


Figure 13: Livestock migration route buffer

The migration route is determined by its proximity to markets (off the main road) and access to water. Figure 14 provides an illustration of a watering camp. After main water sources were identified, a five kilometer buffer was placed around points with water access (Figure 15). It is notable that there are many areas (white spaces outside the blue buffer) that are not being utilized for grazing due unavailability of water.

Migration routes and the length of time spent in an area are determined by water. Figure 16 shows the travel route between watering points. Each red dot signifies an hour's interval as points are taken every hour. The migration pattern is a linear route to watering points without much deviation. Sheep traveled 4km and 5km before arriving at a watering point. After which sheep traveled 12.5 km over multiple hours to reach the next watering hole.

Figure 17 shows a greater density of red points where there are watering camps (circled in orange), showing that animals resided longer in sites with water. There are areas that pastoralists would like to utilize, however are unable to do so due to unavailability of water. Increasing water access could reduce grazing pressure in areas that are experiencing over grazing. The white areas in Figure 15 should be a priority in developing new watering facilities.

Figure 14: Illustration of a watering camp

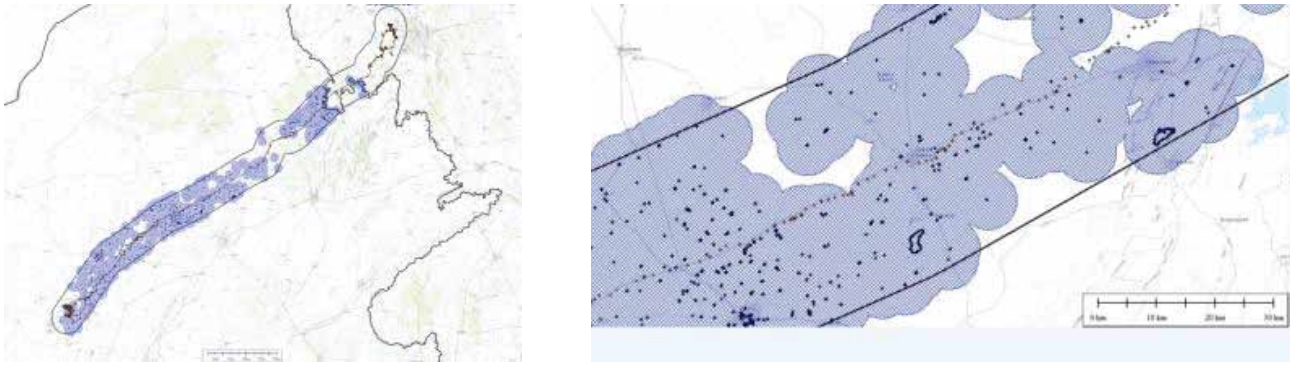


Figure 15: Five km buffer on known watering points

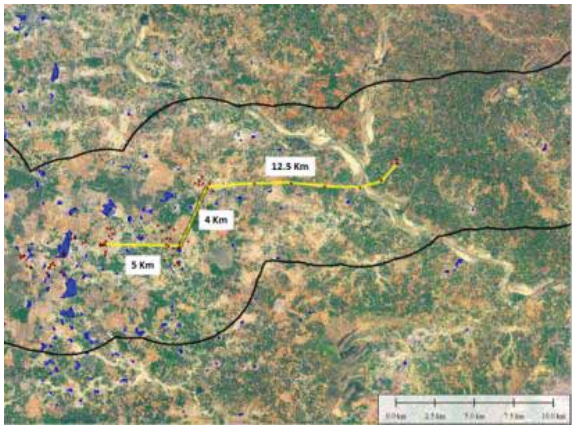


Figure 16: Distance traveled by sheep between watering points

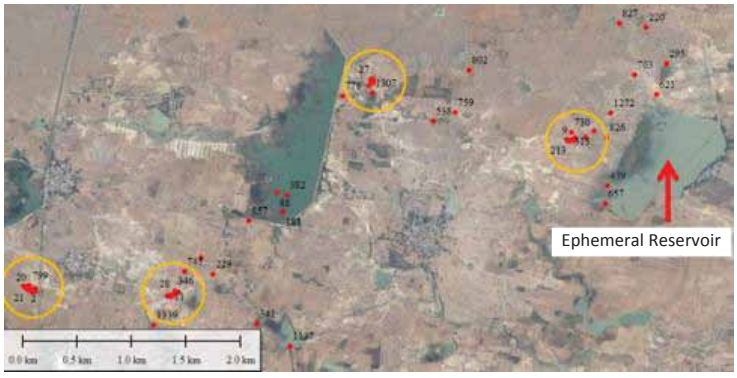


Figure 17: Sheep movement details near water camp areas circled in yellow

3.7 Survey information on management/land use

Information on the use of different land types was collected to increase the knowledge about the herders' access to resources[3]. This is of particular importance due to their reduced access to communal areas. Land use classification maps can be observed in Appendix 3. GPS point counts were made by land cover type. Preference or importance of the land type was calculated by dividing the percentage used by the percent available.

Table 3 shows the land type that is available and the usage rate by cattle. Cropland and follow land comprised of the majority land type utilized by cattle, totaling 78.5 percent. Fallow land was used in higher proportions (48 percent) than cropland (29 percent). Grasslands, deciduous trees, and scrub forest lands only accounted for 8.4 percent of the area utilized by cattle for forage. While gullied land, salt effected wasteland, and inland seasonal wetlands were not a high percentage of the total area, these areas were used very heavily in proportion to their total available area (Louhaichi et al., 2014 and 2015).

Table 3: Land use (available land versus cattle use) by migrating cows

Land Use/Land Cover Class	% Cattle Use	% Available	Relative Use Index
Fallow	48.57	27.03	1.8
Cropland	29.06	51.5	0.56
Salt Affected Wasteland	7.76	0.7	11.09
Scrubland	4.89	4.87	1
Grass/Grazing	4.56	3.05	1.5
Gullied or Ravenous Land	1.91	0.83	2.3
Rural Settlement	1.19	1.31	0.91
Plantation	0.78	0.1	7.8
River/Stream/Canals	0.54	0.96	0.56
Sandy Areas	0.36	1.48	0.24
Inland Wetland	0.18	0.06	3
Urban	0.06	1	0.06
Water Bodies	0.06	0.24	0.25
Deciduous Trees	0	2.87	0
Forest Plantation	0	0	0
Scrub Forest	0	2.44	0
Barren Rocky	0	1.44	0
Rann	0	0	0

[3] According to the respondents, most common health problems in livestock are bloat, foot-and-mouth disease, diarrhea and respiratory diseases (coughing and breathing problems). In small ruminants PPR, pneumonia, liver fluke, diarrhea and FMD are most prevalent diseases.

Cattle and sheep grazed in similar land classification types with a few differences. Sheep land cover preferences can be seen in Table 4.

Unlike cattle, sheep relied of scrubland for the majority of their forage (41.6 percent). Similar to cattle, sheep rely heavily on cropland (30.2 percent) and fallow land (17.4 percent). Sheep relied more on gullied ravenous land than cattle. While sheep have a tougher palate and can graze on shrubs more than cattle, both relied heavily on follow land, scrubland, and cropland. Cattle utilized salt affected wasteland, while sheep did not and both utilized grass or grazing land but at a much smaller percentage than one would assume.

Table 4: Land use by migrating sheep

Land Use/Land Cover Class	% Sheep Use	% Available	Relative Use Index
Scrubland	41.6	9.3	4.5
Cropland	30.2	65.7	0.46
Fallow	17.4	14.2	1.23
Gullied Ravenous Land	4.6	3.3	1.39
Grass or Grazing Land	3.7	9.3	0.4
Water Bodies	2.3	1.5	1.52
River Stream & Canal	0.2	1.7	0.14

4. Discussion

4.1 Management of livestock and constraints

Domestic animals in western Rajasthan are highly dependent on common grazing, fallow lands, and post harvested crop fields. Jodha (1986) documented the role of common grazing lands in the rural economy in a study based on 82 villages in seven Indian states. Jodha found that while common pastures were not highly productive, they provided an important resource for poor people lacking access to private lands and other productive resources. Grazing in common village pastures and forests was estimated to account for 31 percent of livestock feed consumption in India (World Bank, 1999).

The decline of the common lands disproportionately harms the poor, who depend more than others on these lands (Osman et al, 2001). The expenses for the purchase of fodder were almost negligible. Cattle provide only one-two kg of concentrate feed to their lactating animals. Small ruminant owners provided strategic supplemental feed to weaker sheep and lambs during the winter season for four to five days. Herders migrating outside their home villages rarely consult veterinarians and treat sick animals themselves using traditional pharmacopeia or directly purchasing the medicines from agents or nearby markets. The constraints to animal production faced at the village and during migration, as identified and ranked are explained in Table 5.

Table 5: Constraints faced by the respondents

Constraint	Rank
Rapid decline of common grazing lands (Gochar and Oran) due to encroachment	I
Lack of good quality fodder grasses on rangelands	II
Lack of livestock health services and quality veterinary medicines	III
Harassment and exposure to criminal elements during migration	IV
Restrictions to livestock grazing on land controlled by the forest department	V
Farmers' unwillingness to allow grazing on their fallow lands and harvested fields	VI
Proliferation of *Prosopis juliflora* (Sw.) DC. (angrezi babul) in common lands	VII
Theft of animals during stay in other districts/ states	VIII
Communication gaps between migratory herders and government officials	IX

Insights gained from the study:

- Livestock migration reduces grazing pressure in herders' home villages and allows them to follow forage according to climate variability. This mobility increases the communities' resilience to climate change.
- Dissemination of near real-time information about the condition and abundance of forage resources and availability of crop aftermath/fallow fields is expected to facilitate the migration process and increase efficiency.
- Provision of government services in the present migration routes, such as post processing facilities, and watering camps in new areas could potentially reduce grazing pressure by dispersing herders to new areas and increase incomes.
- Increased awareness of government veterinary services at key points along the migration route can be generated through a promotional campaign.

Additionally herders mentioned other factors as well that caused constraints. The rapid decline in the quality and quantity of water and grazing resources along with climate variability was an additional constraint. Herders expressed reluctance to their dependence on middlemen for marketing of products and expressed a need for infrastructure for processing and the production of value-added livestock products.

4.2 Summary of key policy recommendations

A final workshop was held that brought stakeholders impacted by policies to restrict pastoralism and the decision makers together. More than 45 officials from various ICAR institutes, CWDB, line departments and 50 pastoralists from four districts of Western Rajasthan (Pali, Jodhpur, Barmer and Jalore) attended the workshop. The meeting allowed individuals to express concerns and explain the needs of migratory pastoralists. It also raised awareness of existing government services that many participants were unaware of. For example, many were unaware of the places among livestock corridor where governmental veterinary services are provided.

A write up of this meeting can be seen in Appendix 4. Key policy recommendations from the meeting are explained below.

Rangeland improvement

- Improving the productivity of common grazing lands will provide better forage resources to fulfil the nutritional requirements of migrating animals.
- Creation of livestock watering points on different migratory routes will help to enhance the productivity and reduce grazing pressure by dispersing grazing to new areas.
- Dissemination of near real-time information about the condition and abundance of forage resources and availability of crop aftermath/fallow fields will facilitate the migration process and increase efficiency.

Defend livestock corridors

- Improving animal health care and veterinary services: The interventions of state agencies through the provision of mobile veterinary services and quality medicines on different migratory routes will help reducing losses to livestock owners.
- Provision of market infrastructure in production regions to facilitate the sale of animals at remunerative prices. Processing facilities to provide value addition to animal products.
- Develop identification and traceability systems for better livestock management.
- Control of criminals shall provide a healthy space to livestock owners in different regions and ensure safety of people engaged in this enterprise.
- Special programs should be in place for the protection of women and children while men are away.

5. Conclusion and key recommendations

The migration of domestic animals in western Rajasthan is an age old practice that allows livestock keepers to maintain their herds because of the availability of better fodder and water in neighboring states. The deterioration of common grazing lands has made it difficult for large herd owners to maintain the animals in their native areas round the year. Though livestock keepers have their own management system that determines routes to be followed and areas for grazing, they face difficulties in obtaining institutional health services, quality medicines at reasonable price, and protection from criminals on migratory routes.

Improving the condition of common grazing lands and religious trust-owned pastures with community participation can provide better forage resources that fulfill the nutritional requirements of migrating animals. The interventions of state government through the provision of mobile veterinary services and quality medicines on different migratory routes will help reducing losses to livestock owners. Further, control of criminals shall provide a healthy space to livestock owners in different regions and ensure safety of people engaged in this enterprise.

Livestock migration reduces grazing pressure in herders' home villages and allows for herders to follow forage according to climate variability. This mobility provides resilience in the face of increasing climate variability. The provision of government services, such as watering camps and post processing facilities could potentially reduce grazing pressure in the present migration routes by dispersing herders to new areas. The government has made great strides by providing veterinary services at key points along the migratory route; however, increased awareness of such services through a promotional campaign could be extremely beneficial because many migratory pastoralists are unaware of such services.

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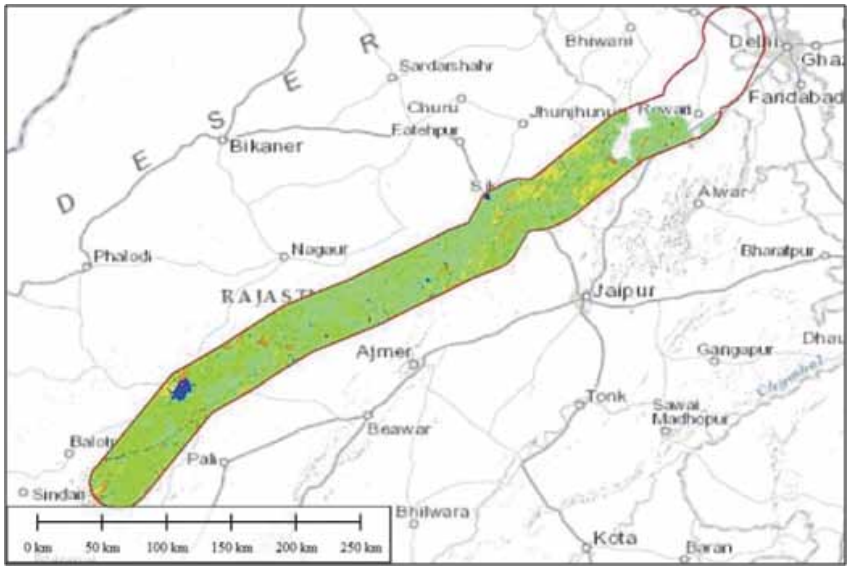
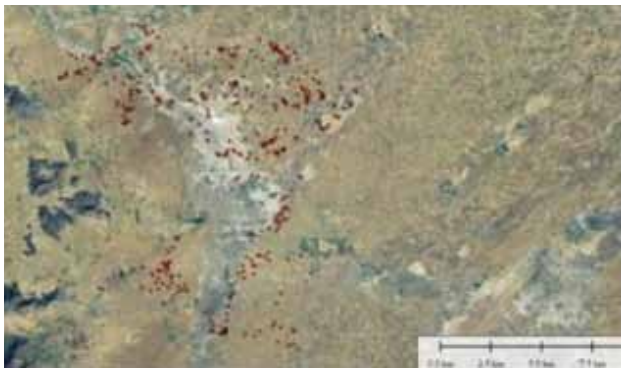
Appendix

Appendix 1: Cattle migration buffer with land use classification



Appendix 2: Spatial distribution of cow herd before migration

Spatial distribution of cows

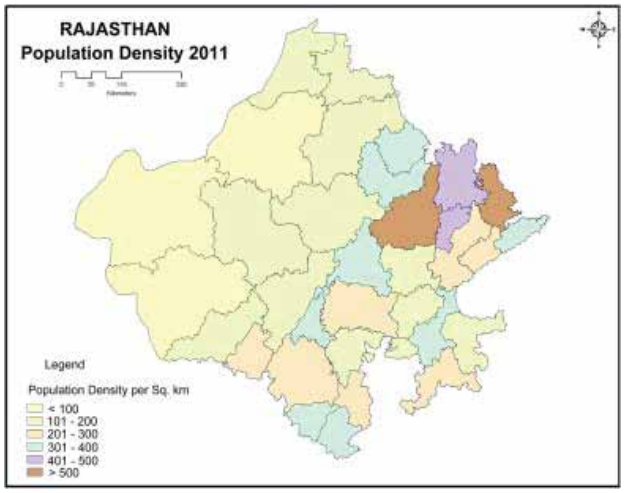


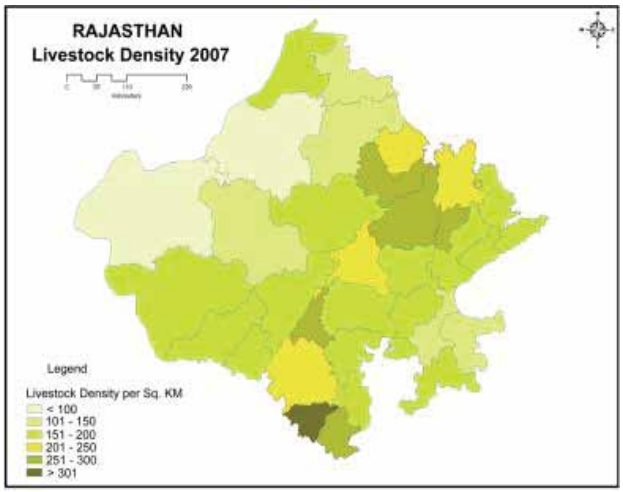
Map showing clumps of several small herds of cow grazing fields nearby the village

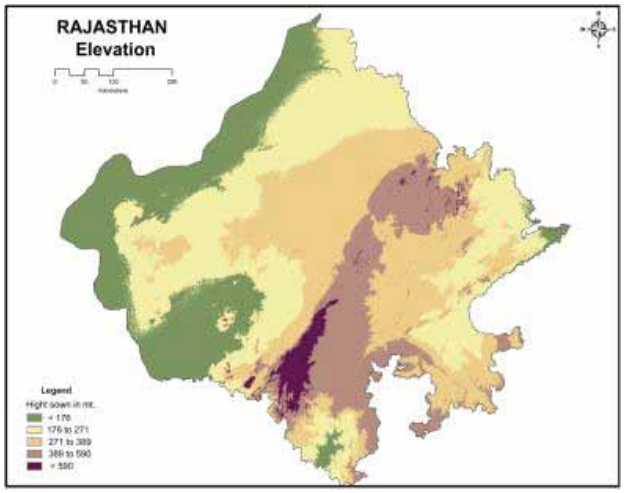
GPS locations of cow overlaid over topographic layer (landscape is almost flat)

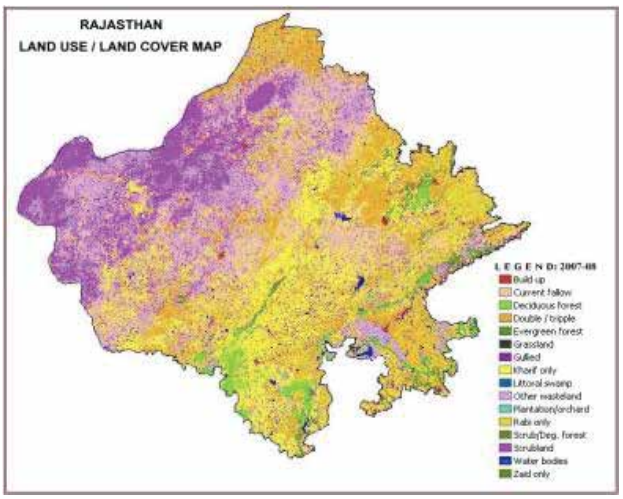
Spatial distribution of animals

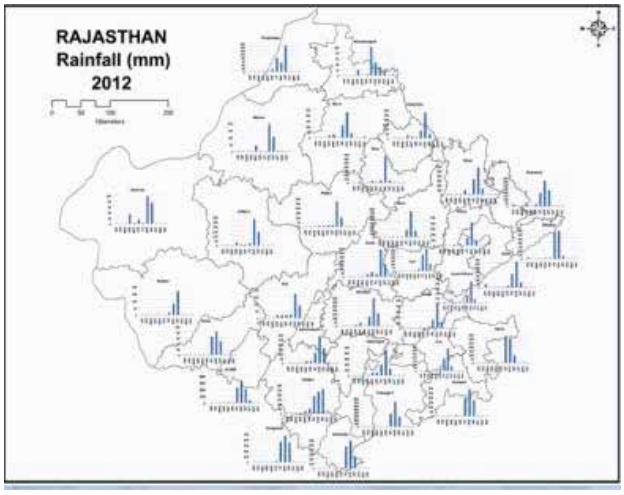
Appendix 3: GIS layers generated by CAZRI GIS unit to overlay animal GPS collar points











Appendix 4: Final workshop on livestock migration in Rajasthan state

On the 29th May 2014, the Central Arid Zone Research Institute (CAZRI) organized a workshop on 'Coping Strategies for Livestock Smallholders in the Face of Climate Change and Soaring Feed Prices: Case Study of Livestock Mobility in the State of Rajasthan, India' in collaboration with International Center for Agricultural Research in the Dry Areas (ICARDA), Jordan. More than 45 officials from various ICAR institutes, CWDB, line departments and 50 pastoralists from four districts of Western Rajasthan (Pali, Jodhpur, Barmer and Jalore) attended the workshop (list of participants enclosed).

The workshop started with welcome note by Dr. A K Misra. Dr. M. Louhaichi, Research Scientist, ICARDA, Jordan discussed the ICARDA-CAZRI collaborative project on livestock mobility and emphasized the need of disseminating real-time information to the pastoralists for water points, routes, animal health care centres, abundance of forage resources and availability of crop aftermath/fallow fields for increased efficiency of migratory livestock. Dr. Mahesh Katara, CEO, Rajasthan Livestock Development Board (RLDB), Jaipur, was the chief guest of the function. Dr. Katara underlined the importance of pastoralism practiced in Rajasthan in providing meat and milk on almost zero input. Mr. K. K. Goel, the Executive Director of the Central Wool Development Board (CWDB) highlighted the various sheep and wool development schemes of the board for the benefit of pastoralists migrating to far distances in search of fodder. Dr. M.M. Roy, the Director of CAZRI chaired the inaugural session of workshop and stressed the importance of improving productivity of common grazing lands and the creation of watering points along the established migratory routes to enhance productivity of such livestock production systems.

The 1st technical session was chaired by Dr. Mahesh Katara, the CEO of the Rajasthan Livestock Development Board in Jaipur. Dr. A.K. Misra, the Head of the Division of Livestock Production Systems and Range Management at CAZRI presented the outcome of the project and discussed in depth various issues related to sheep and livestock migration, including marketing. Dr A K Patel, the Head of the Arid Region Campus of the Central Sheep and Wool Research Institute in Bikaner, talked about the 'Management of range pasture in hot arid zones to minimize migration'. He highlighted the issues and constraints faced by the sheep farmers in spite of several schemes that are in operation for sheep development. Further, he mentioned that productivity of natural rangelands is very low due to high stocking pressure, and there is a need to improve productivity of the rangelands, and proper grazing schedules need to be followed during different seasons for optimum utilization of available biomass. Dr. A Suresh, Senior Scientist (Agriculture Economics), Indian Agriculture Research Institute, New Delhi, discussed about 'Migration and other issues of policy relevance to sheep farming in Rajasthan'. He mentioned that migration and pastoralism are in conflict with the state, and considered as a source of law and order problem and impediment to development. Despite the state efforts, the proportion of sheep migration has not declined.

The 2nd session was chaired by Dr. J P Singh the Head of the Regional Research Station at CAZRI in Jaisalmenr. The issues and challenges faced by the pastoralists were discussed and views of pastoralists and line departments, NGOs, etc were taken. The following recommendations emerged as the outcome of the workshop:

1. Improving the productivity of common grazing lands that could provide better forage resources for meeting the nutritional requirements of migrating animals.
2. Creation of livestock watering points on different migratory routes and market infrastructure in production regions to enhance productivity and facilitate the sale of animals at remunerative prices.
3. Dissemination of near real-time information about forage availability and water resources to facilitate greater efficiencies in the migration process.
4. The interventions of state agencies through provision of mobile veterinary services and quality medicines on different migratory routes for reducing losses to livestock owners.
5. Provision of a Livestock Credit Card in the line of Kisan Credit Card. Access to credit enabling the migratory farmers to adopt recent production technologies, and for better education to their children.
6. Develop identification and traceability systems for better livestock management, and proper care of family members particularly women and children residing in their native places.
7. As the grazing charges vary very much (Rs 0.50 – Rs 8.00) in different states, a more uniform system should be considered to the benefit of such interstate migratory livestock communities.

The workshop ended with the vote of thanks by Dr. A K Misra to the chair and all the participants who attended the workshop. He also expressed his sincere thanks to Dr. Mounir for providing the necessary support for organizing this workshop.

About ICARDA and the CGIAR

ICARDA
Science for Better Livelihoods in Dry Areas

Established in 1977, ICARDA is one of the 15 centers supported by the CGIAR. ICARDA's mission is to improve the livelihoods of the resource-poor in dry areas through research and partnerships dedicated to achieving sustainable increases in agricultural productivity and income, while ensuring efficient and more equitable use and conservation of natural resources.

ICARDA has a global mandate for the improvement of barley, lentil and faba bean, and serves the non-tropical dry areas for the improvement of on- farm water use efficiency, rangeland and small ruminant production. In Central Asia, West Asia, South Asia, and North Africa regions, ICARDA contributes to the improvement of bread and durum wheats, kabuli chickpea, pasture and forage legumes, and associated farming systems. It also works on improved land management, diversification of production systems, and value-added crop and livestock products. Social, economic and policy research is an integral component of ICARDA's research to better target poverty and to enhance the uptake and maximize impact of research outputs.

CGIAR

CGIAR is a global agriculture research partnership dedicated to reducing rural poverty, increasing food security, improving human health and nutrition, and ensuring more sustainable management of natural resources. It is carried out by the 15 centers who are members of the CGIAR Consortium in close collaboration with hundreds of partner organizations and the private sector. www.cgiar.org