G-1.1 Evaluation of Biotic Activities on Desertification in Arid and Semi-arid Area

Contact Person Tadakuni Miyazaki
Research Program Manager
Center for Global Environmental Research
National Institute for Environmental Studies
Environment Agency
16-2, Onogawa, Tsukuba, Ibaraki 305, Japan
Phone +81-298-50-2533, Fax +81-298-58-2645
E-Mail tsmiya@nies.go.jp

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Abstract For Vegetation research, two grazing land sites, one on semi-arid was selected in Pali and another in arid area at Chandan of Jaisalmer. At each experimental site, both herbaceous and woody species were studied as to their composition, cover, density and vigor, dry matter production, seed dynamics, and phenology. Mapping of land use and land degradation were carried out using NOAA AVHRR image data of Thar desert area. For socio-economic study, a survey of the awareness for desertification was undertaken at a sample village Khabra Kalan to understand the causal factors between desertification and human activities. To evaluate the influence of the human activities on a sand dune, the 3 dimensional measurement and the usage of the dune was investigated.

Key Words Desertification, Thar Desert, Carrying Capacity, Remote Sensing

1. Introduction

Land degradation, deforestation and desertification in the arid and semi-arid areas became the very critical environmental problems during the past decades. National Institute for Environmental Studies, Japan Environment Agency, has undertaken a joint research program with the Central Arid Zone Research Institute (CAZRI) at Jodhpur, India, to understand the various facets of desertification problems for effective control measures. The principal objectives of the research are the interactions between human activities and processes of desertification in the arid and semi-arid areas of Rajasthan State in India.

Here, the research activities of the collaborative research about vegetation research, land cover monitoring and socio-economic investigation for desertification of the arid and semi-arid lands in Rajasthan are introduced.

2. Location

Rajasthan state is the westernmost state of India and has arid to semi-arid climate. It forms a part of the Thar desert, or the Great Indian Desert, that extends into Pakistan in the west. In the east its boundary is roughly along the 500 mm average annual rainfall contour. Fig. 1 shows the boundary of the arid and semi-arid area in Thar desert.

For vegetation research, two sites, semi-arid Pali and arid Chandan, were selected in Thar desert. Average annual precipitation (1900 - 1981) is 450 mm in Pali and 150 mm in Chandan and the land form is flat and aggregated with old alluvial plain and sandy undulating buried pediment, soil texture is clay loam in Pali and sandy in Chandan

The test sites for remote sensing and socio-economic studies were selected in the

administrative sub-unit (Tehsil) of Osian which is located in Jodhpur district of arid western Rajasthan. Osian Tehsil has an average annual rainfall of 300 to 350 mm. The southern and south-eastern parts of the Tehsil have a dominantly flat sandy or rocky/gravelly terrain with hills, plateaus and shallow plains, the rest of it has sand dunes of 10 to 30 m average height, interspersed with shallow to moderately thick sandy flat or undulating plains. Agriculture largely depends on the rains, and consists of mono-cropping of pearl millet. Irrigation with ground water is restricted mostly to the southern and eastern parts where cultivation is practiced in winter as well.

Fig. 1 Rajasthan State and the boundary of arid and semi-arid area.

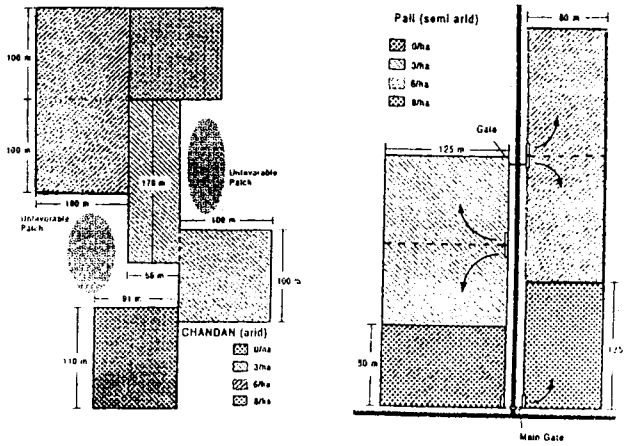


Fig. 2 Plots of Chandan and Pali.

3. Vegetation Research

Thar desert is one of the most densely populated desert of the world and the population of this area is 19 million in 1971. According to the census held in 1983, total livestock population in western Rajasthan area of the Thar desert was 23.3 million, an increase of nearly 4.2 million over the livestock population in 1977. Under these circumstances, it is necessary to clear the effect of grazing by herbivores on plant community to make a proper management of range land and to detect the mechanism of desertification.

(1) Methods

In each of arid and semi-arid area, two 1 ha plots and two 2 ha plots were established in protected experimental field at the end of monsoon season in September 1993 (Fig. 2). All plots were enclosed by barbed-wires to exclude live stocks. To create different intensity of grazing pressures, we introduced sheep with densities of 3 and 6 heads/ha (2 ha plot), 8 heads/ha and zero for control (1 ha plot). The vegetation coverage was measured by line-interception method, ten 10 m long line per ha in each plot were set and at each line, the diameter of all plants which attached to the lines were measured.

(2) Results

1) Floral composition

The grassland in semi-arid region (Pali) has richer flora than in arid region (Chandan), Total number of species observed was 64 species in Pali and 34 in Chandan (Table 1). In Pali, non leguminous forbs are prevalent more than half (34 species), this value s more than double

as that of Chandan. Grass species were more dominant (43%) in Chandan than in Pali (23%).

2) Seasonal change

The total coverage of grassland changed significantly in the course of season in both region (Fig. 3 & Table 2). In Chandan, the coverage increased rapidly from 5% to 35% from August to September then decreased quickly. On the contrary, in Pali, there was no such tendency, the total coverage was steady around 15%. The reason for this difference was mainly owning to the coverage of legumes. In Chandan, the coverage of legumes rose from 0% in January to 29% in August, it contributed 89% to total coverage but only a few percentage in Pali. The coverage of grasses in Pali was more fluctuated than in Chandan, decreasing from January to September. The coverage of non leguminous forb was quite small and constant in Chandan, but that values in Pali gradually increased from January to September, then decreased in October.

Table 1 Coverage of appeared species in experimental area of Chandan and Pali

Flora in Chandan

SPECIES		
Lasiurus sindicus	grass	p
Cymbopogon jawarncusa	grass	p
Cenchrus setigerus	grass	p
Aristida funiculata	grass	a
Brachiaria ramosa	grass	a
Cenchrus biflorus	grass	a
Cenchrus ciliaris	grass	a
Cenchrus prieurii	grass	a
Dactyloctenium sindicum	grass	a
Eragrostis poaeoides	grass	a
Latipes senegalensis	grass	a
Tragus roxburghii	grass	a
Boerhavia diffusa	forb	p
Cassia italica	forb	p
Cassia pumila	forb	p
Citrullus colochynthis	forb	p
Corchorus tridens	forb	p
Blepharis sindica	forb	a
Cleome viscosa	forb	a
Dicoma tomentosa	forb	a
Farsetia hamiltonii	forb	a
Gysekia pharnacoides	forb	a
Mollugo cerviana	forb	a
Tribulus terrestris	forb	a
Cucumis sp.	forb	
Indigofera anabaptesta	legume	a
Indigofera cordifolia	legume	a
Indigofera hochstetteri	legume	a
Indigofera linifolia	legume	a
Tephrosia strigosa	legume	a
Aerva persica	shrub	p
Crotalaria burhia	shrub	p
Dipterygium glaucum	shrub	p
Polygala erioptera	shrub	a
Acacia nilotica	tree	p
Prosopis cineraria	tree	p

Flora in Pali

SPECIES			SPECIES		
Cenchrus setigerus	grass	p	*Euphorbia granulata*	forb	a
Dichanthium annulatum	grass	p	*Gracilia sp.*	forb	a
Eleusine compressa	grass	p	*Leucas sp.*	forb	a
Eremopogon foveoratus	grass	p	*Polygala sp.*	forb	a
Aristida spp	grass	a	*Sesamum indicum*	forb	a
Brachiaria ramosa	grass	a	*Tribulus terrestris*	forb	a
Brachiaria sp.	grass	a	*Trichodesma ampelxicaule*	forb	a
Cenchrus biflorus	grass	a	*Vernonia cinerea*	forb	a
Dactyloctenium aegyptim	grass	a	*Vicoa sp.*	forb	a
Digitaria sp.	grass	a	*Cucumis sp.*	forb	
Eragrostis ciliaris	grass	a	*Peristrophe sp.*	forb	
Eragrostis poaeoides	grass	a	*Pulicaria sp.*	forb	
Eragrostis tremula	grass	a	*Alysicarpus sp.*	legume	
Tetrapogon sp.	grass	a	*Heylandia sp.*	legume	a
Tragus roxburghii	grass	a	*Indigofera anabaptesta*	legume	a
Aerva persica	forb	p	*Indigofera cordifolia*	legume	a
Boerhavia diffusa	forb	p	*Rhynchosia minima*	legume	a
Bouchea marrubifolia	forb	p	*Tephrosia strigosa*	legume	a
Cassia pumila	forb	p	*Calotropis procera*	shrub	p
Convolvulus rottlerianus	forb	p	*Cappari desidua*	shrub	p
Corchorus depressus	forb	p	*Lepidagethis trinevis*	shrub	p
Crotalaria medicagenia	forb	p	*Mlmosa hamata*	shrub	p
Evolvulus sp.	forb	p	*Pergularia daemia*	shrub	p
Heliotropium marifolium	forb	p	*Solanum albicaule*	shrub	p
Ipomoea sp.	forb	p	*Zizypus sp.*	shrub	p
Phaseolus trilobus	forb	p	*Prosopis cinereria*	tree	p
Sehima nervosum	forb	p	*Prosopis juliflora*	tree	p
Ageyratum sp.	forb	a			
Anticharis sp.	forb	a			
Celosia argentia	forb	a			
Cleome viscosa	forb	a			
Corchorus tridens	forb	a			
Dactyliandra welwitschii	forb	a			
Dicoma tomentosa	forb	a			
Digera sp.	forb	a			
Echinops echinatus	forb	a			

a: annual p: perennial

3) Effect of grazing

The effect of grazing on coverage of grassland community was also significant in both region (Fig. 3 & Table 2). In arid region, coverage of 8 sheep/ha was less than one sixth of the control plot in September. While the coverage in control plot rose immediately to the level of 32% from July to September then drop calmly, the value was steady at around 6% in 8 sheep/ha plot.

Fig. 3 The seasonal change of total grassland coverage and effect of grazing in Chandan and Pali.

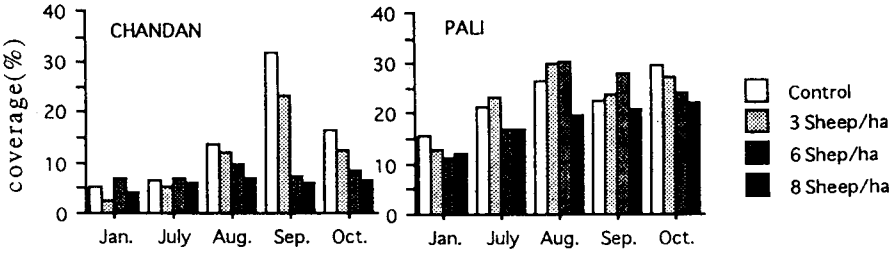


Table 2 ANOVA testing treatment (grazing pressure) and seasonal change of diversity in Chandan and Pali

CHANDAN	DF	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	3	2513.063	837.688	17.573	<0.0001
Season	4	5085.046	1271.261	26.668	<0.0001
Treatment * Season	12	4590.905	382.575	8.025	<0.0001
Residual	279	13300.002	47.670		

PALI	DF	Sum of Squares	Mean Square	F-Value	P-Value
Treatment	3	925.041	308.347	6.889	0.0002
Season	4	6420.188	1605.047	35.858	<0.0001
Treatment * Season	12	1424.144	118.679	2.651	0.0022
Residual	277	12398.824	44.761		

In semi-arid region, there was not clear trend in the effect of grazing on total coverage shown in arid region in each month. From the point of life cycle, there were effect of grazing on the coverage. The grazing reduced the annuals coverage in arid region, on the other hand, coverage of annuals gradually increased with the gradients of grazing intensity. The coverage of perennials in 8 sheep/ha plot was slightly less than that of the control plot.

4) Population dynamics

The coverage dynamics of plant populations different among plants life forms and life cycles between regions. *Lesiurus sindicus* and *Cenchrus setigerus* which were the dominant perennial grass species in arid and semi-arid regions respectively, showed different response to grazing. Though, *L. sindicus* did not show clear relationship between coverage change and grazing intensity, *C. setigerus* decreased with grazing gradient. In semi-arid region, two perennial grasses, *C. setigerus* and *Eremopogon fovoelatus* have same trend, they had rapid drop during hot summer and marked increase at the end of monsoon season. Two annual legumes, *Indigofera coradifolia* and *I. linifolia*, suffered most severe grazing in Chandan, but in semi-arid region *I.coradifolia* showed opposite response to grazing. The coverage of *Lepidagathis trinevis* showed clear negative response to the grazing, it decreased gradually with grazing increased. An annual non leguminous forb, *Triblus terretris* showed unique response to grazing. In arid region this species increased with increase of grazing intensity, on the contrary, it decreased with increases of grazing in semi-arid region.

(3) Discussions

In this vegetation research, the grazing effect was more marked in arid region, the coverage decreased with the increases of grazing intensity. Main reason of this decrease was owning to the decreases of annual legumes. Sheep showed selective grazing behavior, they grazed chiefly forbs, but grasses were not affected severely by grazing. Especially, in arid

region, *Indigofera cordifokia* and *I. linifolia* which dominant seasonally in monsoon period were grazed severely. Without grazing, these species occupied 89% of total coverage in September, then the value decreased to 72% in 3 sheep/ha. In 6 and 8 sheep/ha treatment sheep grazed intensively, the values dramatically decreased to less than one tenth (8.9% and 7.9%). The coverage of *Aristida mutablis*, *Cenchurs biflorus* and *Triblus terrestris* increased with existence of sheep. On the contrary in semi-arid region, the effect of grazing less marked and sheep grazed less selectively as compared to arid region. Two perennial grasses, *Cenchrus setigerus* and *Eremopogon foveoratus*, perennial forb, *Lepidagathis trinevis* and *Triblus terrestris* decreased with the increase of grazing. It must be noted that the response of *I. cordifolia* was quite different in two region, and the dynamics of *Triblus terrestris* was opposite.

4. Remote Sensing Study

The following themes were decided for field investigations: (a) measuring the spectral response characteristics of different surfaces; (b) to find out the nature of soils, the surface sediments and vegetation. Measurements of spectral characteristics and sampling for soil and vegetation status were carried out on different types of land surfaces and land covers in the southern and western parts of the Tehsil, such as flat rocky surfaces, flat sandy plains, sand dunes with and without vegetation, areas with and without crops and natural vegetation, etc.

(1) Spectral Measurement of the Ground Objects

Since remote sensors operate by detecting or sensing energy levels of emitted and/or reflected radiation over various ranges of the electromagnetic spectrum, it is necessary to make ground measurements of the spectral reflectance from natural surfaces to understand the relationships between spectral reflectance and other surface parameters. In this experiment, a portable spectro-photometer was used to obtain the spectral characteristics of the different ground objects in the experimental field. The portable spectro-photometer has 17 interference filters and a photo cell and detects the reflected light from a target with the spectral range from 400 nm to 1050 nm within 1 min.

(2) Soil and Vegetation Analysis

Vegetation at the test site was investigated using some quadrates, in which coverage (%) and height (cm) of each species were measured. Table 3 shows the results of the vegetation investigation at a test site. Soil was investigated by soil sampling and measurement of soil color and soil hardness at the site. The EC, pH and concentration of Na+, K+ and NO3- were measured in the laboratory. Table 4 shows the results of the soil analysis. Furthermore, landuse, grazing pressure, human impact, vegetation type, landform, integrated land type, soil type, soil texture and soil depth were described for each site.

(3) Satellite Data Analysis

Monitoring the surface conditions and their change in the arid area is essential to the management of the environmental problems in both regional and global scales. An outline of the vegetation mapping and land-cover change detection around west India from NOAA AVHRR data are introduced here.

Four NOAA AVHRR LAC imageries with low cloud-cover were selected for Indian region from January 1986 to February 1992. Four false color and vegetation index maps were produced. The vegetation index was calculated using band 1 and band 2 of the images. The Calibrated Vegetation Index, CVI = 260 ⊥ (A2-A1)/(A2+A1) + 15, where A1 and A2 denote the albedo in band 1 and band 2, was adopted as the Normalized Difference Vegetation Index. The produced false color map are shown in Fig. 4 and Fig. 5.

Table 3 Results of the vegetation analysis in Khabra Kalan

	Plot1-2	Plot3-4
Number of plots	5	5
Total species	22	24
Average total cover	48.7	51.1
Average highest hight	77.7	65.2

Table 4 Results of the soil analysis in Khabra Kalan

Plot number	Land use	Relief	Soil Hardness
1	Two year old fallow	Hammock-Upper	1.7-1.9kg/cm2
2	Two year old fallow	Hammock-Lower	1.2-1.4kg/cm2
3	Two year old fallow	Flat	3.0-4.0kg/cm2
4	Two year old fallow	Flat	2.6-3.2kg/cm2
5	Tractor plowed Bajra field	Flat	
6	Tractor plowed Bajra field	Hammock	
7	Tractor plowed Bajra field	Flat	1.4-2.0kg/cm2
8	Camel plowed Bajra field	Flat	1.2-1.9kg/cm2
9	Camel plowed Bajra field	Flat	

Physical properties

	Three phase distribution(%)			Water content(%)			Permeability
	A	L	S	pF1.5	pF2.0	pF3.0	(cm/S)
1	30.99	11.93	57.08	21.72	12.19	5.21	3.8*0.001
2	31.94	11.89	56.17	22.54	13.00	4.77	3.3*0.001
3	32.12	11.42	56.46	22.05	14.80	6.76	2.2*0.001
4	32.74	11.06	56.20	22.14	12.93	5.24	3.0*0.001
5	34.60	12.37	53.03	25.21	14.44	6.62	4.6*0.001
6	40.49	14.75	44.76	23.94	14.08	9.57	1.9*0.001
7	37.31	12.27	50.42	23.84	14.12	8.17	3.4*0.001
8	33.64	13.45	52.91	23.87	10.93	5.99	4.5*0.001
9	35.83	12.70	51.47	24.19	14.50	6.17	5.2*0.001

Chemical properties

	pH(*)		EC	Exchangeable base			
	H2O	KCl	(microS/cm)	Ca	Mg	Na	K
				(cmol(+)/kg)			
1	9.04	8.13	39.90	7.09	0.58	0.13	0.26
2	9.03	8.19	50.20	7.38	0.61	0.10	0.26
3	8.92	7.92	53.80	9.26	0.65	0.12	0.21
4	9.16	8.05	50.00	15.52	0.60	0.12	0.19
5	9.07	8.13	62.10	22.50	0.65	0.15	0.23
6	9.00	8.08	60.20	17.76	0.68	0.14	0.25
7	8.97	8.01	59.00	15.83	0.68	0.14	0.17
8	9.02	8.11	52.30	4.84	0.57	0.08	0.24
9	8.84	8.14	61.20	5.25	0.61	0.09	0.22

(*) soil:water=1:5

	Phosphate			Total-C*	Total-N	C**	C/N ratio
	Available		Total	(T-C %)	(T-N %)	(C %)	C***/N
	Truog	Olsen					
	(mg P2O5/100g)						
1	0.592	0.341	2.729	0.114	0.007	0.012	14.6
2	0.877	0.534	4.004	0.160	0.008	0.011	18.6
3	0.199	0.222	1.432	0.215	0.012	0.010	17.1
4	0.203	0.194	1.283	0.233	0.009	0.006	25.2
5	0.196	0.240	1.576	0.224	0.010	0.003	22.1
6	0.227	0.268	1.271	0.363	0.012	0.010	29.4
7	0.192	0.194	1.128	0.280	0.013	0.007	21.0
8	0.154	0.249	1.120	0.127	0.009	0.010	13.0
9	0.205	0.249	0.988	0.174	0.010	0.011	16.1

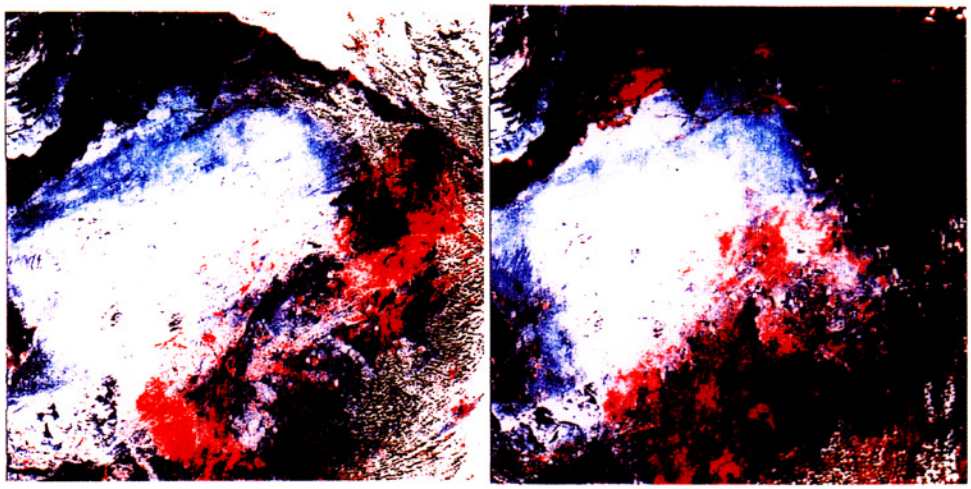
Classification of land cover of the Thar desert area was examined using principal component analysis to the AVHRR image. Moreover, land-cover change detection with multi-temporal AVHRR images was examined. The method of the spectral signature similarity was applied to the AVHRR images from two different years to enhance the difference in the spectral signatures and to detect the land-cover changes. The rate of changed area was 20.46 %.

(4) Discussions

The spectral signatures of different targets of the arid and semi-arid areas were collected at

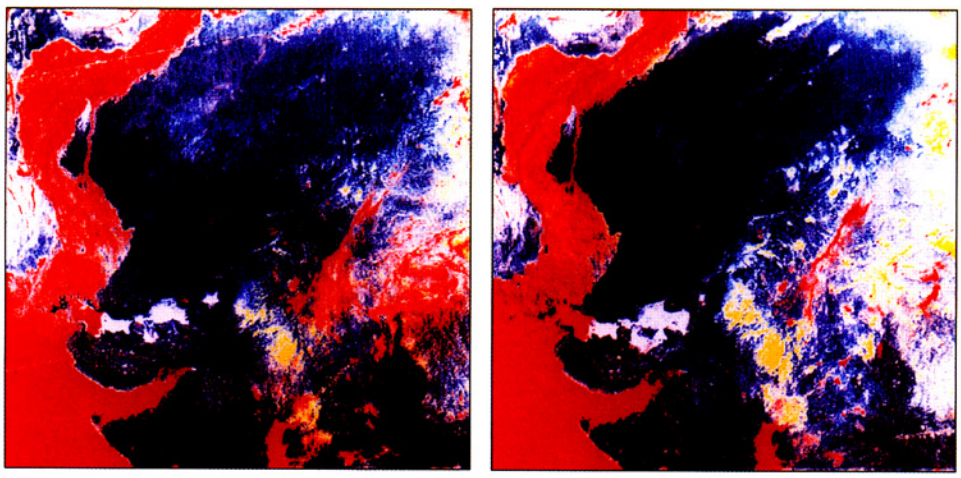
several test sites with the characteristics of the targets of soils and vegetations. The spectral signatures showed significant difference of different targets. However, spectral signatures of those targets in different seasons would be required to classify the land cover more accurately.

The mapping of vegetation distribution and its change in appropriate spatial resolution and temporal interval provides the basis for the effective management in desertification. This preliminary study indicated the usefulness of the NOAA AVHRR LAC data for the large scale vegetation monitoring. However, it was also shown that the combination of the high spectral resolution data such as Landsat TM, Spot, and IRS with AVHRR data would be required for more practical monitoring of the arid and semi-arid areas.



(a) (b)

Fig. 4 False color image of NOAA AVHRR, (a) Jan. 8, 1989, (b) Oct. 7, 1989.



(a) (b)

Fig. 5 False color image of NOAA AVHRR, (a) Jan. 7, 1986, (b) Feb. 4, 1992.

5. Socio-economic Study

(1) Village and method of social survey

A case study was undertaken to investigate the perception of desertification in village Khabra Kalan. Data were collected by personal interviews through specially designed schedules. The interviews were taken by Indian researchers. Altogether 64 sample farm families representing various castes were interviewed.

The village Khabra Kalan is spread over an area of 1,638 ha and had a population of 922.

Rainfed agriculture and traditional farming are largely practiced by the farmers. Besides agriculture, animal husbandry is also practiced. The population of the village Khabra Kalan mainly belonged to Hindu religion.

(2) Results of the survey

1) Mechanism and factors of desertification

A. Human factor of desertification

Villagers perceived important factors of desertification: (1) over-cultivation of land (148 points), (2) plowing by tractor (80 points), and (3) indiscriminate cutting of trees, bushes/shrubs (69 points).

B. Human population

The average number of total births during the last ten years was male: 1.63 and female: 1.53. The average number of total death was male: 0.37 and female: 0.53. The preferable number of children were male: 2.19 and female: 1.39 (Fig. 6).

C. Livestock population

The average size of herd was 15.8. The average number of draught animals used for transportation was 0.3, milch animals 2.3, young 2.1, others 11.1. Of the total livestock population goat constituted 6.2, followed by sheep 4.8 and cows 1.8.

D. Energy use

Annual requirement of wood was 43 kg/year for agricultural implements and 143 kg/year for housing. Energy requirement was 9.8 kg/day of fuelwood, 2.0 kg/day of fodder, 3.9 kg/day of cow-dung, 8.6 liters/day of Kerosene and 4.4 kW/month of electricity.

E. Water use

The main source of drinking water was well, tubewell and tanks. The average distance from house to the water point is 1.8 km. The average consumption of water in a day was 126.6 liters.

F. Land area

Land owned by grandfather was 44.0 ha, followed by father 17.8 ha, and the present generation 10.1 ha (Fig. 7).

G. Agricultural style

Mixed cropping is practiced by 52 households (84 %). Crop rotation is practiced by 54 households (84 %). Average years of keeping land fallow is 1.8 years. 47 households (77%) leave the stubble in the field. For plowing, tractor is used by 64 households (100 %), wooden plow: 5 households (8 %) and iron plow: 1 (2 %) (Fig. 8).

2) The effects of desertification on the human activities

All crop yield including Bajra which is the staple food in the region had decreased. However, the area under crops increased. The effect of declining land productivity is (1) occurrence of famine and malnutrition (155 points), (2) deterioration in living condition (79 points) and (3) shortage of fodder for livestock (67 points). 49 persons (79 %) answered that they had experienced the deficit of animal fodder. 2 persons (3.1 %) answered that they had moved with livestock during last drought year.

3) Countermeasures for desertification

People put the highest points to (1) soil improvement through conservation (108 points), (2) control of human population by family planning measures (99 points) and (3) long term fallowing system of land (67 points). Each household has spent Rupees 7,610 for soil conservation during the past five years. Trees were planted by 36 households (56 %) during the last three years.

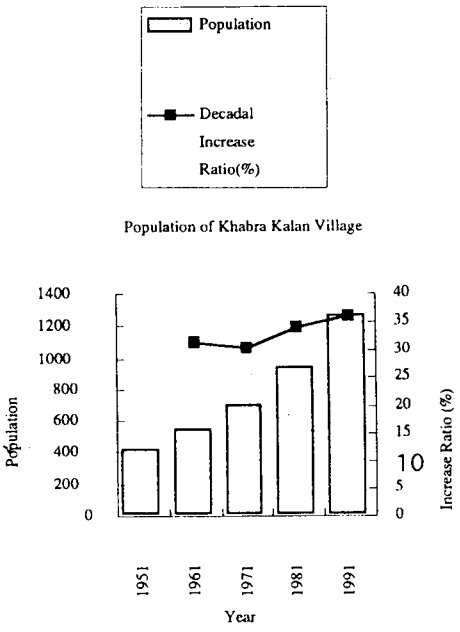


Fig. 6 Population trend of Khabra Kalan.

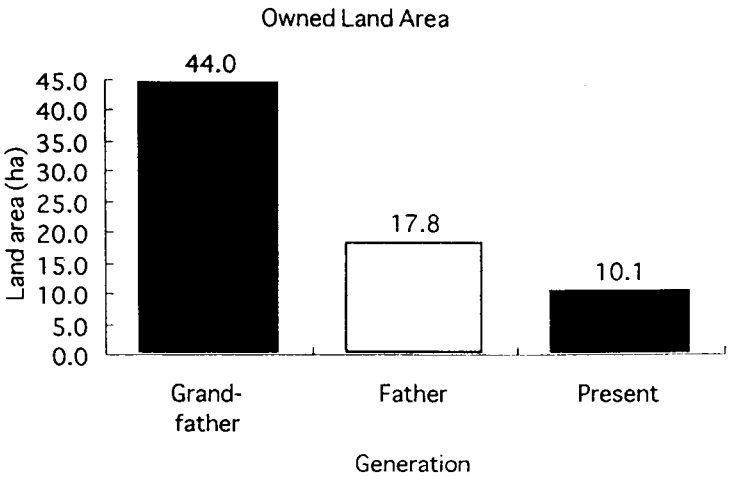


Fig. 7 Trend of owned land area of Khabra Kalan.

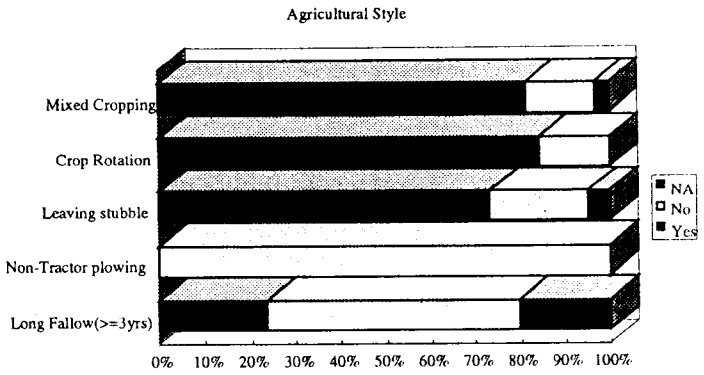


Fig. 8 Agricultural style of Khabra Kalan.

4) Research on dune movement

In order to investigate the effect of sand dune movement by the human activities, Global Positioning System (GPS) was used to determine in details the location co-ordinate of an inland parabolic sand dune in Khabra Kalan village. The study was carried out in two phases. The first one was to determine the true height of the dune at its crest. This was done through the carrier phase mode. A height difference of 33.18 m was obtained between the crest of the dune and its leeward base. This was followed by a mobile tracking mode when a hand-held antenna was moved, along with the receiver, systematically across the dune's arms and slopes to receive the signals from at-station satellites, while the other antenna was fixed at the crest of the dune. The gathered data was first converted into longitude, latitude and height, and then further converted into grid co-ordinates, using the information from a large scale, aerial photo-based topographical sheet. At the same time, the usage of the dune by the local farmers was investigated to understand the relationships between dune movement and human activities.

(3) Discussions

Human factor affecting desertification can be considered from two aspects. The first aspect is a factor affecting land directly. Villagers perceived the following factors of desertification: (1) over-cultivation, (2) tractor, and (3) indiscriminate cutting of trees. The traditional rainfed agriculture of this region has features of (1) plowing by livestock, especially camels, (2) long term fallowing (one year for cultivation and three years for fallow), (3) mixed cropping, (4) leaving the stubble in the field and through such careful land use they made

sustainable land use possible.

However, from the result of the survey, mixed cropping and leaving the stubble in the field are still being practiced, but tractors are used instead of camels by all households and fallowing period has decreased from 3 years to 1.8 years.

Judging from the result of people's perception - the soil conservation as the first item and long term fallowing system as the third for measures of desertification, it is estimated that the importance of soil conservation is fully understood by villagers. Actually villagers have spent Rupees 7,610 for soil conservation during the last five years. If the income level of the villagers was taken into account, villagers have spent rather a large sum on it.

The second important factor is the increasing population. Recently the death ratio, especially that of infant and old ages, have drastically decreased through improvement in health care and food condition. Moreover, the preference for fertility and early marriage lead to population increase. Furthermore, the inheritance system which divides the land evenly among the male successor is a key factor of decreasing land area per household.

Indian government has been promoting family planning measures. It is also recognized as an anti-desertification measure by the villagers. However, only 27 % households are practicing it, and most of the family planning measures are adopted by females only.

Due to the increase in population and the inheritance system, the land holding size has decreased from 44.0 ha to 10.1 ha over the last 40 to 50 years.

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