

Cartographic Appraisal Of Land Use For Sustainable Development In Churu District, Rajasthan Using Remote Sensing And GIS

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ABSTRACT

Proper use and management of most fragile arid lands is essential to provide food and fodder to the constantly increasing human and livestock population. Through visual interpretation of IRS LISS-III data of February, 2000 supported with field survey, the lands in Churu district, Rajasthan have been classified and mapped according to their present uses on 1:50,000 scale and spatial database has been created under GIS environment. Out of the total 1.39 mha area of the district, cultivated lands (including fallow lands) constitute 92.15%, wastelands 1.26%, pastures/ grazing lands with water points 4.60%, forest 0.34% and settlement 1.57%. Irrigated double cropped area (3.80%) is concentrated mainly in southeastern part. Monocropped rainfed lands with 80-100% intensity of cultivation constitute 26.06%, 60-80% (35.79%) and 26.07% area with < 60% intensity of cultivation. The intensity of cultivation decreases from south east to north west with the decreasing rainfall and increasing density and height of sand dunes. Bajra, guar, moth, moong and til are important rainfed kharif crops. Wheat and mustard are taken with irrigation. Gram is taken on the conserved moisture predominantly towards the northern part of the district. Sandy wastelands occur mainly in north western part in Sardarshahr and Taranagar tehsils.

Trends in land use over time and space have been assessed by comparing the results of land use mapping of the district carried out at CAZRI (1980), wasteland mapping (CAZRI, 1998) and land use/ land cover mapping (CAZRI, 1990). Statistical data on land use and cropping pattern from 1957-58 to 1998-1999 have also been analyzed to correlate the changes. During the period, the area under culturable waste, other fallow lands and current fallow has declined by 93.8%, 67.8% and 43.61% respectively. Net sown area has increased by 47.69%. The net irrigated area has increased from just 123 ha to 48,502 ha by sinking more wells during the period in the interdunal areas. The acreage of bajra and guar has increased by 37.84% and 112%. Gram cultivation on the conserved moisture in inter-dunes and sandy plains has gone up from 23,000 ha to 5,45,286 ha. However, the intensification of agriculture caused tremendous reduction in natural biomass as well as acceleration of wind erosion/ deposition hazard. Important suggestions offered for sustainable use and management of lands are stabilization and management of sand dunes with transplantation and regeneration of suitable tree, shrub and grass species; reseedling and development of degraded pastures/ grazing lands; gap filling and regeneration of forest area and bringing an additional 2% area under forest cover. Judicious use and management of ground water, moisture conservation practices, in-situ water harvesting and adoption of agri-silvi-pasture system are other measures. More impetus should be given to pulses and oilseed crops. Long term land use planning is envisaged for area to be irrigated with proposed Sidhmukh canal system.

INTRODUCTION

Proper use and management of most fragile hot arid lands has now become very much essential to provide food and fodder to the constantly increasing human and livestock population. The intensification of agriculture and indiscriminate use of ground water resources enhanced wind erosion/ deposition hazard and rapid decline in natural biomass in hot arid ecosystem in general and particular in Churu district, Rajasthan which is entirely occupied by sand dunes and inter dunes. In order to facilitate sustainable land use planning, the lands of the Churu district (13,859 km²) are classified and mapped according to their present uses through visual interpretation of IRS LISS III data supported with field survey and other long term ancillary data. The spatial data base has been created under GIS environment. Cultivated lands

(including fallow lands) constitute 92.15 %, pastures/grazing lands 4.51 %, settlement 1.56 %, forest 0.26 % and wastelands 1.33 %. Irrigated double cropped areas (3.74 %) occur mainly in south eastern part of the region. Trend in land use over the time and space have been assessed by correlating the results of the land use survey carried out at CAZRI in 1980, 1986 and 1990 as well as analysis of land records data from 1957-58 to 2002-03. The area under culturable waste, other fallow lands and current fallow has declined by 93.8 %, 67.8 % and 43.61 %. The net sown area has increased by 41.69 % and net irrigated area from 123 ha to 48,502 ha. Cultivation of gram on conserved moisture has come in a big way. Acreage of *kharif* pulses, cropping intensity of irrigated lands and carrying capacity of permanent pastures and biomass cover from marginal and wastelands are declined. Zones of major

problematic areas are delineated. Technologies and measures are suggested for stabilization and management of sand dunes, reseeded and development of degraded pastures and improved farming practices for different types of cultivated lands.

LOCATION AND ENVIRONMENT

Churu district with a total geographical area of 13,85,889 ha is located between 73° 51' 49" to 75° 40' 20" east longitudes and between 27° 24' 39" to 29° 00' 00" north latitudes. The district was reorganized on 1st April, 2001 by segregating its Sri Dungargarh tehsil to Bikaner district. It is bounded by Mahendragarh and Hissar districts of Haryana towards east; Hanumangarh district towards north; Nagaur, Sikar and Jhunjhunun districts towards south and south east; and Bikaner in the west. The district has 7 towns and 908 villages with a total population of 19,22,908 persons as per 2001 census.

Physiography and Drainage

The district is near rectangular in shape. Its physiography is marked by vast stretches of sandy flats and undulating sandy plains with their height ranging from 6 to 50 meters above mean ground level, suggest the ribbed appearance of seashore. The altitudes vary from 213 to 400 meters above MSL and the terrain in general slopes from south to north. Few isolated hill, which are typical monadnocks on the former peneplain surface like Gopalpura, Randhisar and Lodasar in Sujangarh tehsils and Biramsar in Ratangarh tehsils, are mainly composed of quartzite with a maximum height of 505 m above MSL. There are a number of saline flats or ranns (Playas) locally known as 'tals'. Important among them are of Chhapar and Parihara. There are no perennial rivers or stream in the district excepting the ephemeral 'Kantli' which hardly flows few km in southern part of Rajgarh tehsil dries up. In general the drainage is mostly internal.

Climate

The district experiences mainly arid climate with aridity index in the region varying from 75% to 83%. The average annual rainfall in the district is 363.2 mm. In general it increases from the north-west to south-east and varies from 261.2 mm in Dungargarh to 372.3 mm at Sujangarh. On an average there are 19 rainy days which varies from 17 at Dungargarh to 22 at Rajgarh. Coefficient of variation of annual rainfall varies from 40-50%. June is the hottest month with the mean daily maximum temperature at 41.3°C and at the mean daily minimum at 29°C in summer months. The weather is intensely hot with scorching dust-laden winds and the day temperature sometimes rises up to over 45°C. January is the coldest month with the mean daily minimum temperature at 4.8 °C and then mean daily maximum at 22.1 °C. During winter the minimum

temperature sometimes drops to a few degrees below the freezing point and frost occur. During monsoon the relative humidity is generally above 60% while during summer it goes below 30%.

Soils

Light brown sandy soils of plains with scattered dunes occur in more than two third area of the district. These soils are sandy to loamy fine sandy, very deep, non-calcareous and well drained surface horizon, a slightly calcareous, loamy fine sandy B horizon followed by a zone of lime accumulation, partly as concretion. The dune soils show hardly any pedogenic manifestation. The accumulation interdune soils have appreciably silt and free lime. The soils have brown to yellowish brown, loamy fine sandy, non-calcareous, very deep, surface layer and sandy loam, slightly calcareous to non-calcareous B horizon. In general the soils of the region are low in organic matters i.e. nitrogen, low to medium in phosphate and medium to high in potash.

METHOD AND MATERIALS

SOI toposheets on 1:50,000 scale have been used as base material. Through visual interpretation of IRS LISS III data of February, 2000 supported with field survey, the lands of the district have been delineated and mapped according to their present uses adopting the land use classification system of CAZRI (Sen, 1978) and interpretation techniques of satellite data of NRSA (1986, 1995). Using Arc/Info workstation the maps have been digitized and spatial database has been created. To assess the trends in land use, the results of land use survey of Churu district carried out at CAZRI (Sen *et al*, 1980), wasteland mapping (CAZRI, 1986) and Land use/land cover mapping (Balak Ram, 1991) are correlated. Land records data on land use, cropping pattern and crop production from 1956-57 to 2002-03 and other ancillary data have been analyzed to work out the changes over time and space. The changes in fact relate to unified Churu district prior to 2001. The suggestions for sustainable land use planning are based on the technologies developed at CAZRI from time to time.

RESULTS AND DISCUSSION

Present Land Use

Tehsil wise area under different land use categories is given in Table 1 and their spatial distribution in Fig 1-6. Their salient characteristics and distribution pattern are discussed below

Cultivated lands

Out of the total district area cultivated lands (including fallow lands) constitute 92.15 %. The irrigated and often double

cropping lands constitute 3.74 % and occur mainly in southern part of Rajgarh tehsil comprising the Kantli river alluvial zone between Dadrewa, Khudiawas, Janau, Sukhania, Timau and Thirpali Chhoti. In other region these are concentrated in interdune plains in small pockets in between Jeevandesar, Udasar, Pularsar and Kheenwansar in Sardarshahr tehsil; Ghantel, Juharpura, Depalsar, Untwalia and Dabla in Churu tehsil; Sandwa, Gopalpura and Sobhasar in Sujangarh tehsil; and Chainpura, Rajaldesar, Hudera and Parihara in Ratangarh tehsil. Wheat, mustard, gram and groundnut are important irrigated crops. The ground water yield is poor. A well can hardly irrigate 2-4 ha land which too depends on the occurrence of adequate rainfall. There are 1487 tube wells and 52.32 wells which together irrigate about 54 thousand ha area. Rainfed monocropped lands with 80-100 % intensity of cultivation constitute 25.76 % district area occurring mainly in flat older alluvial plain and interdunal plains in Rajgarh, Sujangarh and southern part of Taranagar tehsils. Bajra, cowpea, moong, moth and guar are important crops produced over such lands. Besides, gram is produced on the conserved moisture in a big way in northern part of the district in Rajgarh, Taranagar and Sujangarh tehsils. Rainfed lands with 60-80 % intensity of cultivation constitute 35.33 % occurring throughout the district and dominantly in Churu, Taranagar and Sardarshahr tehsils. Such lands are associated with sandy undulating interdunal areas. Bajra, guar and moth are important crops produced over such lands. Lands with 30-60 % intensity of cultivation comprise low to medium sand dunes and narrow interdunal area. These lands constitute 25.57 % district area occurring dominantly in Ratangarh, Sardarshahr and Churu tehsils. Guar and moth are the only crops being produced in such lands. Lands below 30 % intensity of cultivation are marginal lands associated with high sand dunes which are cropped during good rainfall year. Guar is mainly taken over such terrain.

Wastelands

Sandy wastes are dominant wastelands in the district occupying 1.05 % area in form of high to very high active and partially stabilized sand dunes and barchan dunes. Aeolian hazard is more wherever biotic pressure is more and lands belong to government. Such lands are mainly encountered in western part of Sardarshahr and Sujangarh, north western part of Taranagar and Churu tehsils. Saline waste (0.15 %) occurs in small pockets in Tal Chhapar, Sujangarh town, Parihara and near Rajawala and Bijasar villages in Sardarshahr tehsil. Salt is produced in Tal Chhapar area. Rocky/stony/gravelly wastes constitute 0.13 % area and occur chiefly in Sujangarh tehsil near Gopalpura, Randhisar and Lodasar villages and Biramsar and Ratangarh tehsil. Mining of stone is being done for construction of roads and houses.

Misc. Land Uses

Permanent pastures or CPR are important land use systems of this arid zone comprising 4.51 % area. This includes *gochar*, *oran*, *agor* and *bir*. These lands are fairly distributed throughout the region but most dominantly in Rajgarh, Sardarshahr and Sujangarh tehsils where these lands occupy 5.04 %, 5.00 % and 4.06 % of their respective area. Due to heavy biotic pressure, pasture lands are in highly degraded conditions with negligible grass cover. Important tree and shrub species occurring over these lands are *Capparis deciduas* (Kair), *Salvadora aleoides* (Jal), *Ziziphus nummularia* (Bordi), *Leptadenia pyrotechnica* (Khemp) and *Calotropis procera* (Akra). Forest area occupy only 0.26 % and occur in Chhapar in Sujangarh, Ratan Nagar and Karanpura in Churu; near Taranagar town, near Rajgarh town and Karampur; Biramsar in Ratangarh; and Shimla and Ghadsisar in Sardarshahr tehsil. These are mainly scrub forest. Village pond or 'nadi' are the only water bodies in the district but most of them are not mappable. Altogether an area of 2635 ha has been mapped under this category. Settlement constitutes 1.56 % area. Size of village settlement and density is more towards eastern and southern parts of the region.

Land Use Changes

Quantitative changes in dominant land use system from 1957-58 to 1998-99 are presented in table 2. The area under culturable waste has declined by 93.81 %, other fallow lands 67.8 % and current fallow lands by 43.61 %. Consequently the net sown area has increased by 47.60 % by putting marginal lands under plough particularly in Sardarshahr and Taranagar tehsils. The net irrigated area has increased from just 123 ha to 48,502 ha during the period by sinking more wells in interdunal areas in Sardarshahr, Sujangarh, Dungargarh and Churu tehsils. Due to constant and excessive withdrawal of ground water in southern part of Rajgarh tehsil, the cropping intensity has substantially declined. The area under settlement and roads etc. has increased by 12.86 % through urbanization and population growth. In forest area, there has been an absolute increase of 0.46 %. No specific change has occurred in area under permanent pastures but their carrying capacity has tremendously declined. The livestock population has increased by 115 % particularly by sheep and goats. In cropping pattern the acreage of bajra has increased by 37.84 % and guar by 112 %, wheat from 511 ha to 19,364 ha and gram from 13,293 ha to 5,45,286 ha. There has been an absolute increase of 13,330 ha area under groundnut. The acreage of kharif pulses like moth has declined by 43.47 %. Cultivation of gram on conserved moisture has mainly come up in the interdunal areas of northern part of the district in

Sardarshahr, Taranagar and Rajgarh tehsils. However its annual acreage depends on the amount and distribution pattern of rainfall.

Land Use Problems

Wind erosion/deposition is major problem of the region. More than 70 % district area is affected by moderate to severe wind erosion/deposition. Decline in fallowing practices, bringing sand dunes under cultivation and clearance of fields for large scale gram cultivation, are the main causes of this hazard which is constantly increasing in northern part of the district. Saline, very deep and very limited ground water potentials are another problem to sustain the agriculture. Only 404 km² area of the district has been estimated as ground water potential zone which is already over drafted. The present practice of sinking tube wells in certain pockets is also not economical. Frequent droughts further reduce the agricultural efficiency. Presence of hard amorphous lime and gypsiferous strata in the interdunal depressions hampers the productivity and cropping intensity. Closely spaced highly dune terrain is another constraint making the region more fragile. Looking in to the human and livestock population of the district, the water bodies are very inadequate. The forest cover is too very poor. Agricultural extension activities are negligible and farmers are far away from the innovative technologies.

SUGGESTIONS FOR MANAGEMENT AND DEVELOPMENT OF DEGRDED LANDS

Stabilization and management of sand dunes

Cultural operation should be first stopped to stabilize sand dunes. For the checking of sand movement the grass species of higher sand binding capacity of nutrition value like *Cenchrus ciliaris*, *Lasiurus indicus*, *Panicum turgidum*, *P. antidotale*, *Cymbopogon jwarancusa* along with several top feed trees and shrub species like *Prosopis*, *Acacia tortilis*, *A. Senegal*, *Calligonum*, *Zizyphus*, *Colophospermum*, *Dichrostachys* etc, may be planted. To check initial movement of sand, micro wind breaks should be erected in chess board pattern using locally available brushwood material like *Aerva pseudotomentosa*, *Tephrosia purpurea*, *Calligonum* and *Leptadenia* etc. These are to be established at right angle to the prevailing wind direction. The spacing between the strips should be kept 2 m at the top and 3-4 m at the bottom. Combination of trees and grasses in silvi-pastoral system is the most ideal approach as it provides sustainable production of forage for a longer period of the time.

Reseeding and development of pastures/ grazing lands

Such areas need enclosures as its first pre requisite for development. The whole grazing land may be divided into four

to six grazing compartment. One compartment may be developed at a time. Developed grasslands may be grazed according to carrying capacity or the grass may be cut and feed to animals. According to site characteristics several soil conservation measures like bunding, furrowing and trenching etc. may be carried out. The grass species recommended for district Churu are *Cenchrus ciliaris*, *Cenchrus setigerus*, *Lasiurus indicus*, *Panicum antidotale* and *Cymbopogon jwarancusa* etc. Mixture of these grasses shall be ideal for reseeding the grazing lands. Here again it may be carried out through rooted slip or pelleted seeds or direct seed broadcasting or by dibbling method. Here top feed trees and shrubs include *Prosopis cineraria*, *Acacia senegal*, *A. tortilis*, *Zizyphus nummularia*, *Colophospermum mopane* and *Calligonum polygonoides*. 6-9 months old saplings raised in polythene tubes may be utilized for transplanting 30-50 trees /ha.

Gap Filling and Regeneration of Forest

In notified area the seed nucleus of the desired species already exists, but due to grazing practices the newly germinated saplings fail to survive. As such grazing is to be completely checked. Soil conservation measures like contour furrowing, bunding and trenching shall improve the moisture status. In order to hasten the process of development of gaining higher plant density, the shrubs and tree saplings raised in polythene bags may be transplanted. The species recommended on such sites are *Acacia senegal*, *Anogeissus pendula*, *Prosopis cineraria*, *P. juliflora*, *Acacia tortilis*, *Albizia lebbek*, *Salvadora oleoides*, *Calligonum*, *Zizyphus* and *Capparis sp.* etc. In case of silvipastoral system is to be followed, the grass species like *Lasiurus indicus*, *Cymbopogon jwarancusa* and *Cenchrus* species may be sown through pelleted seeds.

Management of salt affected lands

Accumulation of salts in the form of white encrustation does not permit any vegetation to develop. Only peripheral zone of saline depression may be seen with few halophytic species. In order to develop such areas trenching or bunding may be carried out at a regular interval of 5 to 6 m. This shall help in leaching of salt from the raised bunds where few salt tolerant shrubs and tree species like *Haloxylon salicornicum*, *Suaeda fruticosa*, *Tamarix articulata*, *Prosopis juliflora* and *Salvadora oleoides* may be raised through direct seed sowing or transplanting of saplings. In silvipastoral system pelleted seed of grasses like *Sporobolus marginatus*, *Cenchrus setigerus* and *Dichanthium annulatum* or their rooted slip or polythene raised seedlings may be transplanted for successful establishment.

Ecological Improvement of Rocky/Stony/Gravelly Wastelands

In order to spread the water evenly and in lower depth the slopping lands need the soil conservation measures like counter furrowing and trenching at a regular interval of 3 to 5 m. The opening of furrow at each counter level shall increase the moisture regime and help in gathering the soil as well. To hasten the processes of succession, reseeding with desirable grasses like *Cenchrus ciliaris*, *Cenchrus setigerus*, *Cymbopogon jwarancusa* and *Sehima nervosum* through pellets or rooted slips may be carried out during rainy season. Transplanting of saplings trees and shrubs like *Acacia senegal*, *Salvadora oleoides*, *Capparis decidua*, *Maytenus emarginata* etc. may also be carried out.

CONCLUSION

IRS LISS III geocoded data proved very useful to delineate and map the present status of the land use. Rainfed agriculture is most dominant land use system of the district. Irrigated area is confined in southern part of Rajgarh tehsil. The intensity of cultivation and crop productivity decreases from south east to north-west. Pastures are in highly degraded condition. Over the last four decades the area under culturable waste and fallow lands has substantially declined. At the same time the net sown area and irrigated area are increased. Cultivation of gram on the conserved moisture has come up in a big way in northern part of the district. However such a intensification of agriculture has intensified aeolian hazard. Wind erosion/deposition, frequent droughts as well as saline very deep and

poor ground water potentials are main constraints in making proper use of lands. However technologies are there to make sustainable and rational use of different categories of lands with improved farming practices and co-operation from farming communities as well as support and political will of the government.

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Table 1: Land Use (tehsil wise) in Churu District, Rajasthan

(Based on Field Survey and interpretation of IRS LISS-III data of Feb, 2000)

| Land Use Categories | Sujiangarh | | Ratangarh | | Sardarshahar | | Churu | | Taranagar | | Rajgarh | | Total | |
|----------------------------|------------|-------|-----------|-------|--------------|-------|--------|-------|-----------|-------|---------|-------|---------|--------|
| | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % |
| A. Cultivated Lands | | | | | | | | | | | | | | |
| A ₁₁ | 10456 | 3.88 | 5728 | 3.37 | 6655 | 1.73 | 4906 | 3.07 | 483 | 0.27 | 23684 | 10.76 | 51912 | 3.74 |
| A ₁ | 114703 | 42.57 | 14252 | 8.39 | 8852 | 2.30 | 3515 | 2.20 | 78697 | 43.45 | 137001 | 62.22 | 357020 | 25.76 |
| A ₂ | 79205 | 29.40 | 51060 | 30.04 | 153856 | 39.94 | 86057 | 53.80 | 77117 | 42.58 | 42293 | 19.21 | 489588 | 35.33 |
| A ₃ | 42158 | 15.65 | 79786 | 46.94 | 172464 | 44.77 | 46624 | 29.14 | 12681 | 7.00 | 648 | 0.29 | 354361 | 25.57 |
| A ₄ | 1569 | 0.58 | 7058 | 4.15 | 10214 | 2.65 | 4490 | 2.80 | 990 | 0.54 | 0 | 0 | 24321 | 1.75 |
| Total | 248091 | 92.08 | 157884 | 92.89 | 352041 | 91.39 | 145592 | 91.01 | 169968 | 93.84 | 203626 | 92.48 | 1277202 | 92.15 |
| B. Wastelands | | | | | | | | | | | | | | |
| Sandy Waste | 2841 | 1.05 | 1766 | 1.04 | 5764 | 1.50 | 2489 | 1.56 | 1571 | 0.87 | 188 | 0.09 | 14619 | 1.05 |
| Saline Waste | 940 | 0.35 | 0 | 0 | 1126 | 0.29 | 0 | 0 | 0 | 0 | 0 | 0 | 2066 | 0.15 |
| Rocky/Stony Waste | 647 | 0.24 | 18 | 0.01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 665 | 0.05 |
| Stony/Gravelly Waste | 939 | 0.35 | 107 | 0.06 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1046 | 0.08 |
| Total | 5367 | 1.99 | 1891 | 1.11 | 6890 | 1.79 | 2489 | 1.56 | 1571 | 0.87 | 188 | 0.09 | 18396 | 1.33 |
| C. Misc. Land Uses | | | | | | | | | | | | | | |
| Pastures | 10934 | 4.06 | 7393 | 4.35 | 19273 | 5.00 | 7983 | 4.99 | 5776 | 3.19 | 11099 | 5.04 | 62458 | 4.51 |
| Forest | 1092 | 0.41 | 0 | 0 | 1169 | 0.30 | 828 | 0.52 | 39 | 0.02 | 530 | 0.24 | 3658 | 0.26 |
| Settlement | 3923 | 1.45 | 2785 | 1.64 | 5732 | 1.49 | 3068 | 1.91 | 2977 | 1.65 | 3055 | 1.39 | 21540 | 1.56 |
| Water body | 37 | 0.01 | 17 | 0.01 | 107 | 0.03 | 09 | 0.01 | 786 | 0.43 | 1679 | 0.76 | 2635 | 0.19 |
| Total | 15986 | 5.93 | 10195 | 6.00 | 26281 | 6.82 | 11888 | 7.43 | 9578 | 5.29 | 16363 | 7.43 | 90291 | 6.52 |
| G.Total | 269444 | 100 | 169970 | 100 | 385212 | 100 | 159969 | 100 | 181117 | 100 | 220177 | 100 | 1385889 | 100.00 |

A₁₁ Double cropping with intensity of cultivation > 100 %

A₁ Monocropping with intensity of cultivation 80-100 %

A₂ Monocropping with intensity of cultivation 60-80 %

A₃ Monocropping with intensity of cultivation 30-60 %

A₄ Monocropping with intensity of cultivation <30 %

Table 2: Trend in Land Utilization in Churu district, Rajasthan (1957-58 to 1998-99)

| Year | Culturable waste (%) | Other fallow land (%) | Current fallow (%) | Net area sown (%) | Total cropped area (%) | Area sown more than once (%) |
|---------|----------------------|-----------------------|--------------------|-------------------|------------------------|------------------------------|
| 1957-58 | 13.70 | 14.94 | 11.03 | 54.56 | 54.92 | 0.36 |
| 1958-59 | 12.57 | 15.54 | 10.20 | 55.87 | 55.99 | 0.12 |
| 1959-60 | 11.70 | 15.38 | 10.45 | 56.47 | 56.83 | 0.36 |
| 1960-61 | 11.97 | 14.12 | 8.78 | 59.19 | 59.66 | 0.47 |
| 1961-62 | 10.79 | 11.74 | 9.55 | 61.15 | 61.33 | 0.18 |
| 1962-63 | 11.03 | 12.34 | 8.07 | 61.80 | 61.92 | 0.12 |
| 1963-64 | 10.02 | 11.74 | 8.12 | 63.37 | 63.67 | 0.30 |
| 1964-65 | 9.55 | 9.43 | 6.64 | 67.62 | 67.74 | 0.12 |
| 1965-66 | 8.13 | 8.13 | 11.27 | 65.48 | 66.67 | 1.19 |
| 1966-67 | 6.94 | 8.19 | 7.72 | 70.15 | 70.21 | 0.06 |
| 1967-68 | 5.87 | 7.82 | 7.29 | 71.96 | 75.16 | 3.20 |
| 1968-69 | 5.28 | 9.02 | 11.51 | 67.08 | 67.08 | N |
| 1969-70 | 5.98 | 9.66 | 8.65 | 69.41 | 69.53 | 0.12 |
| 1970-71 | 4.33 | 8.78 | 6.58 | 73.13 | 73.72 | 0.59 |
| 1971-72 | 4.74 | 7.41 | 7.47 | 73.19 | 73.49 | 0.30 |
| 1972-73 | 4.74 | 8.01 | 7.98 | 72.06 | 72.66 | 0.60 |
| 1973-74 | 4.45 | 7.71 | 6.17 | 74.50 | 75.03 | 0.53 |
| 1974-75 | 3.08 | 5.63 | 9.19 | 74.73 | 75.09 | 0.36 |
| 1975-76 | 2.91 | 6.94 | 6.52 | 76.33 | 77.81 | 1.48 |
| 1976-77 | 2.79 | 7.47 | 6.88 | 75.50 | 75.92 | 0.42 |
| 1977-78 | 2.85 | 7.59 | 7.30 | 75.03 | 77.22 | 2.19 |
| 1978-79 | 2.59 | 7.62 | 8.15 | 74.23 | 75.94 | 1.71 |
| 1979-80 | 3.80 | 11.53 | 25.31 | 51.90 | 52.41 | 0.51 |
| 1980-81 | 2.91 | 7.66 | 5.40 | 76.57 | 82.64 | 6.07 |
| 1981-82 | 2.47 | 5.84 | 5.68 | 78.55 | 90.17 | 11.62 |
| 1982-83 | 1.81 | 6.03 | 7.63 | 77.07 | 79.26 | 2.19 |
| 1983-84 | 1.81 | 6.13 | 6.76 | 77.84 | 79.95 | 2.11 |
| 1984-85 | 1.70 | 7.71 | 10.15 | 72.97 | 73.67 | 0.70 |
| 1985-86 | 1.72 | 8.43 | 6.77 | 75.64 | 77.83 | 2.19 |
| 1986-87 | 1.67 | 6.83 | 6.57 | 77.46 | 78.85 | 1.39 |
| 1987-88 | 2.43 | 9.79 | 23.13 | 0.18 | 57.17 | 57.35 |
| 1988-89 | 1.51 | 6.26 | 4.31 | 80.48 | 83.34 | 2.86 |
| 1989-90 | 1.61 | 7.31 | 7.31 | 78.59 | 80.38 | 1.79 |
| 1990-91 | 1.39 | 4.88 | 5.23 | 81.03 | 83.65 | 2.62 |
| 1991-92 | 1.28 | 5.08 | 7.30 | 78.93 | 79.60 | 0.67 |
| 1992-93 | 1.02 | 4.77 | 6.17 | 80.93 | 81.62 | 0.69 |
| 1993-94 | 0.94 | 3.98 | 5.62 | 81.96 | 83.28 | 1.32 |
| 1994-95 | 0.89 | 4.04 | 4.90 | 82.69 | 84.78 | 2.09 |
| 1995-96 | 0.89 | 5.28 | 7.43 | 81.07 | 82.76 | 1.69 |
| 1996-97 | 0.24 | 4.51 | 5.57 | 81.54 | 85.43 | 3.89 |
| 1997-98 | 0.80 | 4.28 | 4.96 | 82.46 | 100.57 | 18.11 |
| 1998-99 | 0.85 | 4.81 | 6.22 | 80.58 | 99.84 | 19.26 |

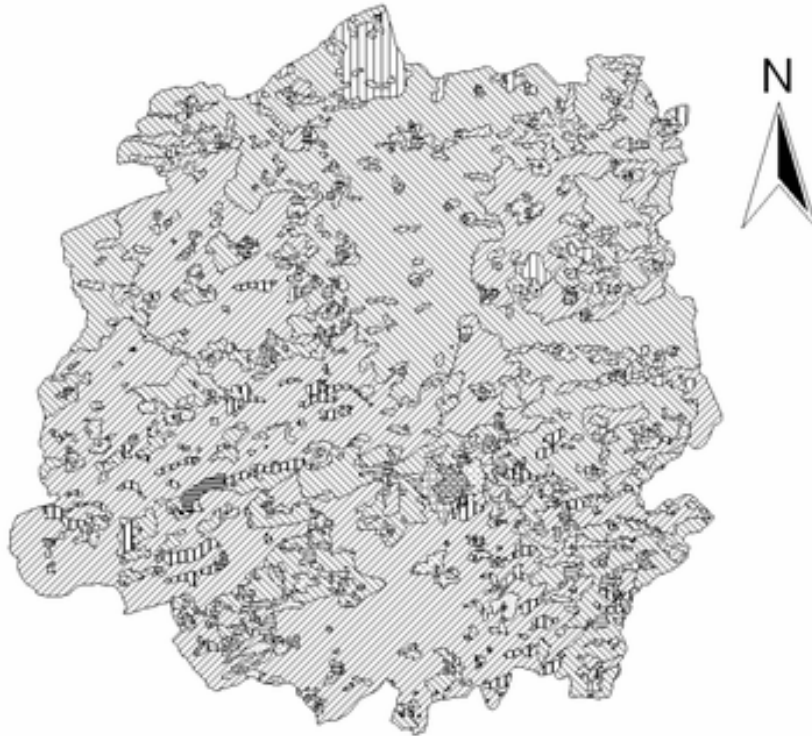


Fig. 1 Land Use in Sardarshahar tehsil



Fig. 2 Land Use in Churu tehsil



Fig. 3 Land Use in Ratangarh tehsil



Fig. 4 Land Use in Sujangarh tehsil

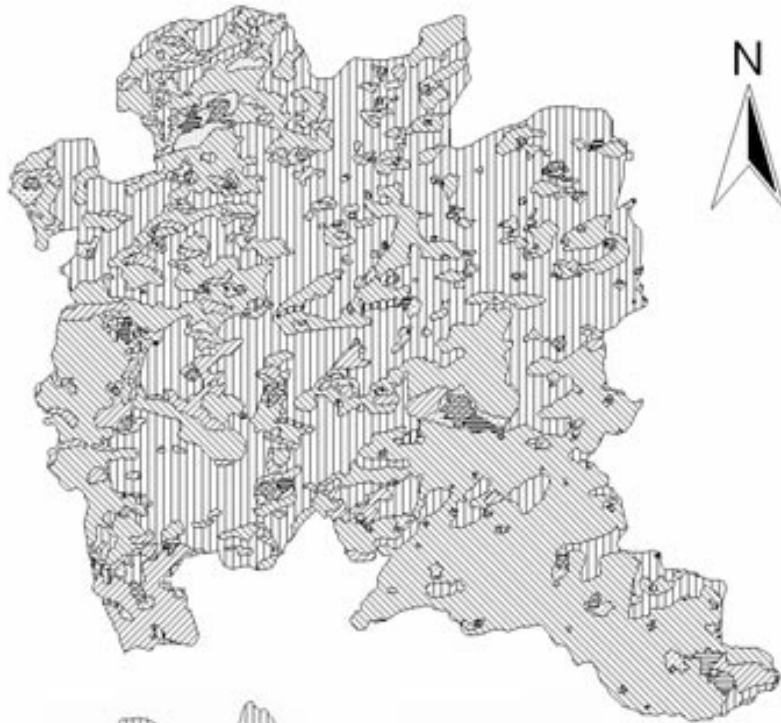
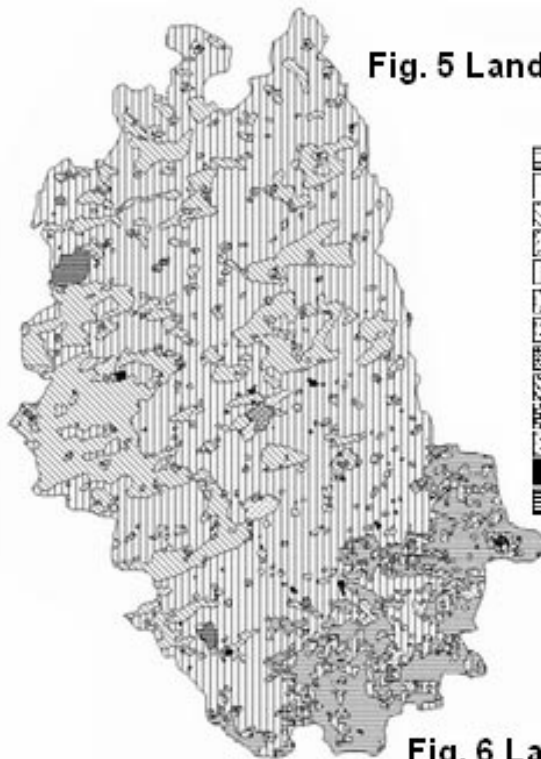


Fig. 5 Land Use in Taranagar tehsil



LEGEND

-  Double Cropping area IOC > 100%
-  Monocropped area IOC 80-100%
-  Monocropped area IOC 60-80%
-  Monocropped area IOC 40-60%
-  Monocropped area IOC 20-40%
-  Sandy Waste
-  Saline Waste
-  Rocky/Stony Waste
-  Stony/Gravelly Waste
-  Settlement
-  Pastureland
-  Waterbody
-  Unclassified Forest

Fig. 6 Land Use in Rajgarh tehsil