SPATIAL URBAN MODEL FOR ENVIRONMENTAL PLANNING

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ABSTRACT:

Knowledge and creation of GIS DATABASE on area and distribution of Land Uses and its updating based on natural and man made changes plays an important role in the planning process at macro, meso, micro and local levels. An attempt has been made here to analyse the existing Land Use Pattern and Changes over a period of time with the aim of creation of the database for the process of planning at micro level. The specific objectives related to various aspects of Land Utilization are:

1. To prepare Land Use/ Land Cover Maps of the micro regions using Remote Sensing Data.
2. To create GIS database on the areas under various land use classes and change in the land Use pattern.

Bharatpur district of the state of Rajasthan (India) has been selected for the present study. Multi date Remote Sensing data, Survey of India Toposheets, Cadastral Maps and Census of India reports have been used as basic data along with Sampled Ground Truth Check Data. For analysis and creation of data ARC/INFO GIS Package has been employed. GIS package has also been used to relate the Land Use Information to the villages and arrive the tentative comparison of Land Use as reported in Census of India and as obtained from the Remote Sensing Data Analysis. Major findings of the analysis have been discussed in detail with the sole consideration, whether the GIS package employed has the quality of compatibility, reliability, cost effectiveness and time saving mechanism. Further the role of Remote Sensing Data along with the GIS as a tool has also been discussed or the future planning process..

1. INTRODUCTION

Information on the existing land use/ land cover pattern, its spatial distribution and changes in the land use pattern is a pre-requisite for planning, utilisation and formulation of policies and programmes for making any developmental plan. This information not only provides a better understanding of land utilisation aspects but also plays a vital role in developmental planning. Traditionally for regional planning exercises from macro to micro level, statistical data available under nine - fold revenue classification of land use, is used for studying and analysing the land use pattern at regional and intra regional level. Such an analysis sometimes is also supported by the spatial information through departmental maps and conventional sources. With the advent of remote sensing techniques, both aerial and satellite, it has been possible to prepare land use maps at various levels showing categories of land under different uses both in spatial and statistical form. An attempt has been made here to map land use/ land cover information with remote sensing data and to find out the changes in the land use pattern using a GIS package.

2. OBJECTIVES

The prime objective of the study is to organise an information system oriented towards regional planning at district level around a GIS package. The information system will be organised in sectors and will address issues related to all sectors relevant at district level (SAC, 1992). One of the issues is the optimum use of land resources. Towards this, the specific objectives related to various aspects of land utilisation are as follows:

To prepare Land Use/ Land Cover Maps of the micro regions using Remote Sensing Data.

B. To create GIS database on the areas under various land use classes and change in the land Use Pattern.

3. STUDY AREA

Bharatpur district of the state of Rajasthan in India, located between 26 deg. 40 min. to 27 deg. 50 min. North latitudes and 76 deg. 50 min. to 77 deg. 50 min. East longitudes has been selected for the purpose of study. The total area of the district is around 5085 sq. km. The district is divided into eight tehsils (talukas) viz. Kaman, Nagar, Nadbai, Deeg, Weir, Bharatpur, Rupbas and Bayana. Bharatpur town is the district headquarters which is well connected by rail and road network with Jaipur, Mathura and Delhi.

4. DATA USED

Multidate remote sensing data consists of Landsat - TM data (146-41) of October 1986 and IRS LISS - II data (28-48/49, 29-48/49) of March & October 1989 has been used for the study. Survey Of India Toposheets on 1:50,000/1:2,50,000 scale, Census of India reports and Cadastral maps were also used in the study.

5. METHODOLOGY

The overall methodology adopted for the land use mapping of the region is presented in fig. 1. A reconnaissance survey (pre

field survey) was conducted by taking traverses in the entire region to prepare an interpretation key. Different tone, textures and shapes of the objects found on the IRS LISS -II data were checked and an interpretation key was made. Using this interpretation key remote sensing data has been interpreted using High Magnification Enlarger (HME) and the information has been transferred to base maps prepared on scale 1:50,000 scale using Survey of India topographical maps. Standard land use and land cover classification has been adopted for mapping land use categories using RS data (Anderson et al., 1992; NRSA, 1989 AND Pathan S. K., 1992). The classification and coding scheme followed for the mapping is given in Table - 1. In all seventeen land use maps were prepared on this scale using multidate RS data viz. Landsat TM data form 1986 and IRS LISS II data for 1989. These maps show the spatial distribution, extent and location of various land uses in the district of Bharatpur. The classification accuracy of these maps has been assessed on the basis of simple random sampling method. The sample size was selected on the basis of the following equation (Fitzpatrick -lins and Chambers, 1977):

$$n = (p \times q) / d \times d$$

where,

n = Sample Size
p = Desired percent of estimated accuracy
q = Difference between 100 and p in percent
d = standard error in percent

The sample size was calculated based on the following parameters:

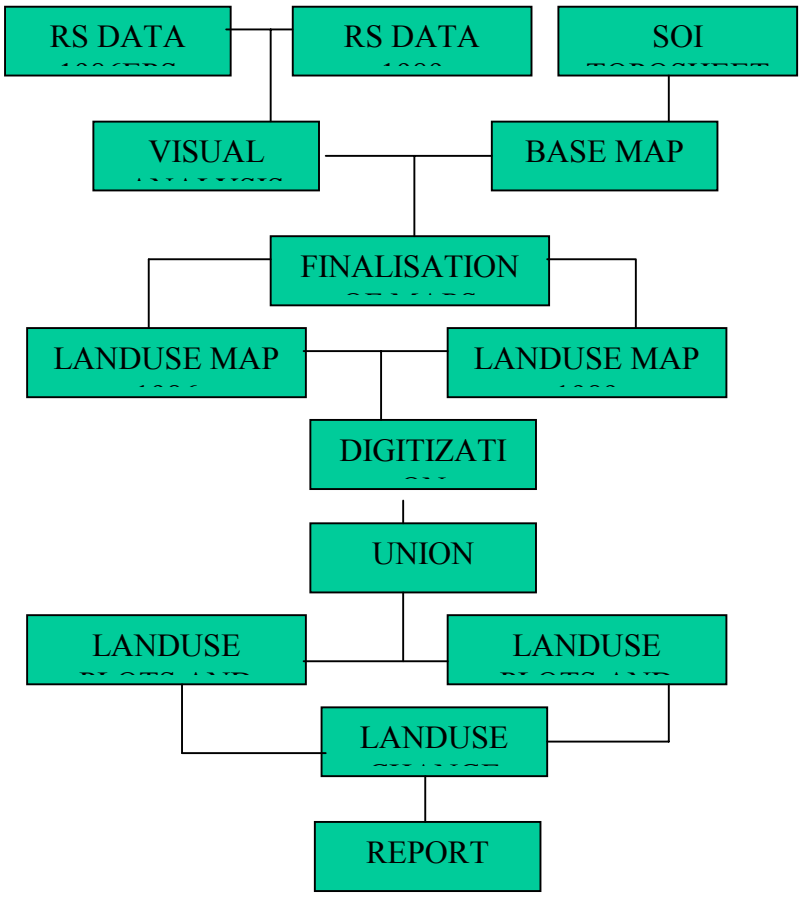
p= 85,
q= 100- 85 =15
d = 5% level of significance at 95% confidence level.

In all 51 points in different categories distributed throughout the district have been checked. A confusion matrix was drawn to assess the overall classification accuracy and mapping accuracy. It was found that the classification accuracy stands at 88% (Table - 2: Classification Accuracy Assessment).

ARC/INFO GIS package attached with VAX 11/750 available at Space Application centers has been employed for the land use analysis. The steps followed for the analyses are:

A. Formation of Titles,
B. Digitization,
C. Editing,
D. Creation of polygon topology, and
E. Union process, A spatial database was created using these steps.

FIGURE-1: FLOW OF STEPS FOR



6. LAND USE ANALYSIS:

As has been discussed in methodology, RS data has been used and land use maps have been repaired on a SOI base at 1:50,000 scale. These have been incorporated into GIS database and statistics obtained on each class on a tehsil-wise basis. Table - 3 and Table - 4 show there land use statistics for the district during 1986 and 1989 respectively. Fig. 2 shows the spatial distribution, location and extent of land uses in Bharatpur district and changes in the land use pattern during 1986 - 1989. Though the GIS data base consists of the level - II details and categories mentioned earlier (Table - 1), this information has been abstracted to level -I for the purpose of obtaining an output commensurate to 1:2,50,000 scale. However, 1:50,000 scale outputs can also be obtained.

To illustrate the concept of the capability of a spatial database, land use categories for one tehsil - Bayana has been extracted & enhanced in scale from the GIS database and is shown in Fig. 3. Based on a systematic GIS database organization, it is possible to obtain different types of outputs for the whole district, for individual tehsils, on a SOI Toposheet basis, for an area of interest defined by a polygon etc.

The changes in the landuse pattern have been determined using the GIS package where the two date land use information have been integrated. The changes in the land use classes and the extent of each land use category is presented in Fig. 2 and Table - 5.

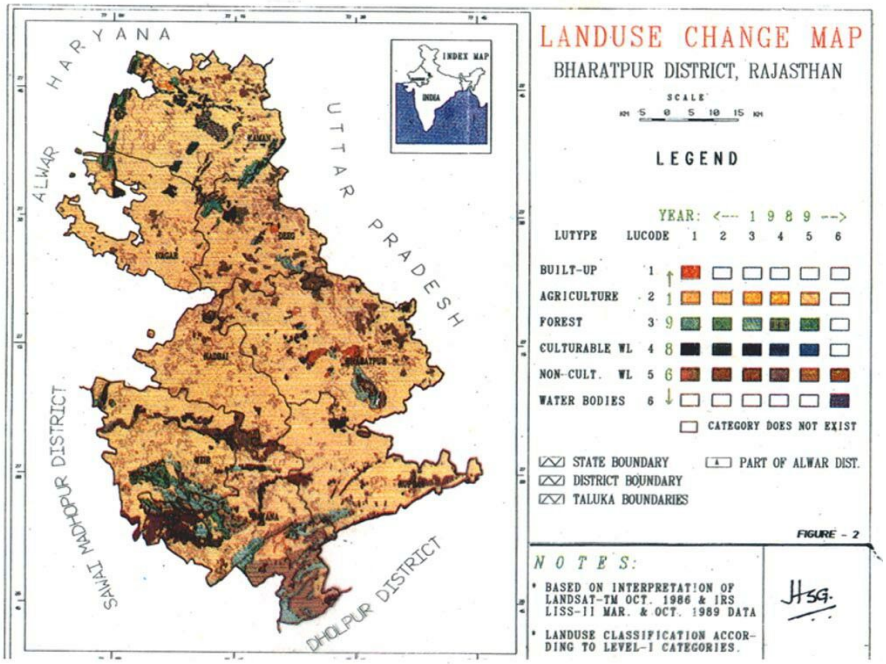


Figure 2: Bharatpur District, Project Report, p209

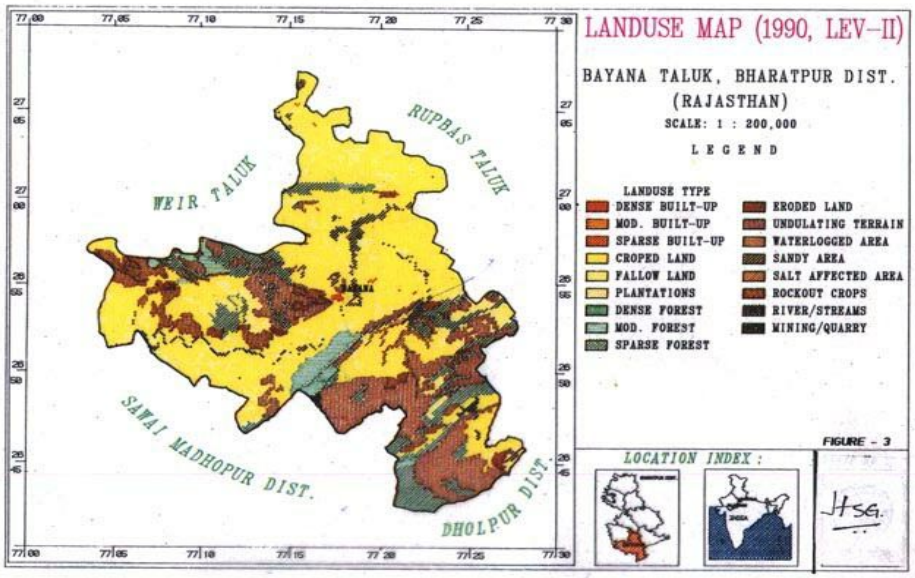


Figure 3. Bayana District – Landuse map

7. DISCUSSION ON MAJOR FINDINGS

7.1 CHANGES IN LAND USE DURING 1986 - 89.

In order to analyse the changes in land use pattern at regional and area level, time series data for a longer period would be desirable. In the absence of such time series data, changes in land use pattern have been studied during 1986 - 89 on the basis of remote sensing data which may be taken as indicatives of the trends in the emerging land use pattern. From Table - 5 it is observed that the district has registered an increase in cropped land from 3393 sq.km to 3615 sq.km during 1986 -89 which might have been facilitated by the reclaiming measures taken by the Government. The sandy area, waterlogged area and salt affected land amounting to about 164.95 sq.km, 37.53 sq.km and 7.06 sq.km respectively have been converted to agricultural use in 1989.

Increase in cropped land may also be partly due to the improvement of irrigation facilities during 1986 - 89. With the increase of cropped land there should have been decrease in fallow lands but on the contrary it has also recorded a marginal increase particularly in the tehsils of Kaman, Bharatpur etc. Decrease in forest area indicates unhealthy trends of land use pattern almost in all the tehsils. Even area under dense forest cover has decreased from 44.98 sq.km in 1986 to 10.52 sq.km in 1989 in the district. The reduction in high and medium density forest cover has resulted an increase in the sparse forest cover and scrub land. On the other hand, reduction of original sparse forest cover 1986-89 has resulted in the increase of area under rock outcrops and waste lands. The reduction in forest cover may be due to the constant felling ot trees for fuel and fodder in the hilly tehsils of Bayana, Rupbas and Weir. There is some increase in the area under water bodies which may be because of the normal rainfall in the year 1986. The area under water bodies has increased specially in and around Baretha reservoir. The area under salt affected land and waterlogged area has decrease during 1986- 89 mainly due to the reclaiming measures taken by the Government. It is striking to note that eroded lands have increased by 12 sq.km during the three years period pointing to the degradation of forest cover resulting in erosion at foot hills and low lands. With the growth of settlements and non agricultural activities, built up area has also increased particularly around the town of Bharatpur. Obviously such growth in built up land has been at the cost of agricultural land.

7.2 COMPARISION OF LAND USE STATISTICS - REMOTE SENSING DATA VS CENSUS OF INDIA DATA

As a separate exercise, the land use mapped from the Remote Sensing Data of 1986 and the land use reported in the District Statistical Abstracts, 1985 - 86 for Bharatpur have been compared. Table - 6 shows the comparative figures of the land use / land cover. This comparison is to relate and illustrate the differences in the figures because of the differences in the classification schemes adopted. While the RS data analysis is based on the land use classification Table - 1, the Census adopts the revenue classification. As a result, the plan generation exercise has to keep this in mind and account for the mismatch in the land use figures of the two sources. Based on the above analysis, the following observations are noteworthy:

7.2.1 Land Under Agriculture:

The cropped land and fallow land together constitute the extent of land under agriculture. As may be seen from the statistical data and land use figures computed from the remote sensing data in Table - 6, proportion and extent of total agricultural land in 1986 was comparable (about 80%) in the district. The distribution of cropped area was highly uneven ranging from 46% in Bayana Tehsil to about 96% in Nadbai Tehsil. In Bharatpur, Deeg, and Nagar Tehsils cropped land was more than 80% and in the remaining three tehsils of Kaman, weir, and Rupbas, it was between 60 and 80 percent.

7.2.2 Land Under Forest:

Forest area interpreted from satellite imagery relates to actual forest cover and is generally less than the forest area given in the Statistical Year Book which, by and large, indicates total area under the control of the forest department. Interestingly, however, there is not much difference in Bharatpur district in the forest area in both sets of figures which works out to about 6% of the reporting area. However, at tehsil level, some differences are noticed between two sources i. e. statistical data show about 8% in Bharatpur tehsil as against 2% of the reporting area in the RS data. Revenue figures do not record area under forest in Nagar and Kaman tehsils whereas interpretation of RS data indicates about 1% and 3.3% of the reporting area under forest cover in these tehsils, respectively, Bayana and Weir tehsils had the highest and ense forest cover spread over in patches along the nalas, roads, railways and on isolated hillocks. Area under forest cover gradually decreases as one moves from south west to north east part of the district.

7.2.3 Other Uncultivated Land:

This category includes cultivable wasteland, permanent pastures and land under miscellaneous tree crops and groves. As for as land under this class is concerned there is vast difference between the two data sources. Statistical figures reported 3.25% of the reported area under this category against 7.1% in the RS data. This difference may be attributed to the categories of land included under this category. This category was reported to some extent in each of the tehsils where Bayana tehsil has one third of the reporting area. Weir, kaman and Deeg were the other tehsils having concentration of such lands. Cultural able wastelands in these tehsils are not presently under cultivation but the same can be reclaimed for agriculture and fodder crops through suitable measures. Area under permanent pastures and tree crops was also higher in those tehsils having higher proportion of cultivated wasteland, which may be ascribed to low fertility of land and concentration of livestock population. By adopting suitable measures these areas may be turned into rich grazing grounds as well as for raising of fodder crops.

7.2.4 Land not available for cultivation:

This category consist of land put to non agricultural use i. e. undulating terrain with or without scrubs, rock out-crops, built up land and water bodies. Comparison of two sets of data sources portrays a deceptive picture in this regard. According to statistical figures 11.5% of reporting area was classified as land not available for cultivation against 7.5% in RS data which appears to be on the lower side in view of the larger number of human settlements and other non - agricultural activities existing in the district. This is further substantiated by the fact that in all the tehsils, statistical figures recorded higher percentage of land under this category in all the tehsils against the RS data. It is observed that a smaller settlements

particularly rural ones, could not be interpreted clearly from RS data because of coarser spatial resolution and therefore, area under this category was reported less in RS data. There is also possibility of inter-mixing of sub classes of land use in an inappropriate major class thereby affecting the results. These areas concentrated more than 10% in tehsils of Nagar, Rupbas and Kaman and less than 10% (total geographical area of respective tehsils) in the remaining. As mentioned earlier, barren lands are more in Bayana tehsils accounting for about 15% of the total reporting area. Land under non agricultural uses including built up land, water bodies, transport network etc. was concentrated more in Bharatpur tehsil because of location of big urban settlements and other non - agricultural activities.

8. CONCLUSION

- It is observed that the land use pattern in Bharatpur district is not similar to that of general and use pattern prevalent in Rajasthan State as a whole.
- Agricultural land is widely distributed through out the district. Its concentrations however relatively lower in southern tehsils particularly in Bayana and relatively higher in the north -eastern parts of the district comparison Kaman, Deeg, Bharatpur and Nagar tehsils.
- Forest cover is mainly in the south western parts of the district, in Tehsils of Bharatpur around Ghana Bird Sanctuary Area.
- Area under pastures is mainly confined to Kaman, Bayana and Weir tehsils while plantation and tree crops are more pronounced in tehsil of Weir.
- The culturable wasteland is relatively more concentrated in Bharatpur, Kaman and Bayana Tehsils and interestingly the barren lands are also comparatively more in the latter two tehsils because of rocky terrain and poor soil conditions.
- Category wise picture of the major land uses as revealed by RS data and statistical figures (Census of India), the extent of the total agricultural land and the forest cover in 1986 comparable. However, there are differences in the areas of cultural able and non- cultural able wasteland. This may be due to different definitions adopted in classifying land uses from both sources and also due to the presence of number of smaller settlements, which would not be interpreted clearly on RS data due to its coarser spatial resolution. Because of the adoption of the GIS database, the change analysis and administrative unit wise land use and change categorization were possible in an easy manner.

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TABLE 1. CLASSIFICATION SCHEME FOR LANDUSE ANALYSIS.

No.	Level I	Level II
1.	Urban or built up land	1.1 Dense Urban
		1.2 Moderate Urban
		1.3 Sparse Urban
2.	Agricultural land	2.1 Crop land
		2.2 Fallow land-
3.	Forest	3.1 Dense
		3.2 Medium
		3.3 Sparse
		3.4 Scrub/Degraded
4.	Waste lands	4.1 Salt affected land
		4.2 Gullied/ Eroded land
		4.3 Waterlogged Areas
		4.4 Undulating uplands with or without Scrubs
		4.5 Sandy Area
		4.6 Rock outcrops
5.	Water bodies	5.1 Rivers/Streams/Creeks
		5.2 Reservoirs/Tanks/Lakes
6.	Others	6.1 Habitation with plantations

TABLE - 2: CLASSIFICATION ACCURACY ASSESSMENT THROUGH COFUSION MATRIX

Catgory On ground		Category interprated from IRS LISS – II DATA										Total	Ommis-sions	Commis-sions
		1	2	3	4	5	6	7	8	9	10			
Built up	1	3	-	-	-	-	-	-	-	-	-	3	0	0
Crop	2	-	9	-	-	-	-	-	-	-	-	9	0	1
Fallow	3	-	-	7	-	-	-	-	-	-	-	7	0	1
Plantations	4	-	1	-	3	-	-	-	-	-	-	4	1	1
Forest	5	-	-	-	1	5	-	-	-	-	-	6	1	0
Undulating Terrain	6	-	-	-	-	-	7	-	-	-	-	7	0	1
Wst.,Scurb& Er.ld	6	-	-	-	-	-	1	3	-	1	-	5	2	0
Eroded land	7	-	-	-	-	-	-	-	-	-	-	-	0	0
Salt affected	8	-	-	-	-	-	-	-	3	1	-	4	1	0
Sandy	9	-	-	1	-	-	-	-	-	3	-	4	1	2
Water	10	-	-	-	-	-	-	-	-	-	2	2	0	0
Total		3	10	8	4	5	8	3	3	5	2	51	6	6

OVERALL CLASSIFICATION ACCURACY = POINTS CORRECTLY CLASSIFIED/TOTAL NO POINTS

= (45 /51) X 100 = 88%

TABLE - 3: LANDUSE STATISTICS OF BHARATPUR DISTRICT OF 1986

(Based on Landsat TM data, All figures are in sq.km)

SN.	LAND USE	KAMAN	NAGAR	DEEG	NADBAI	BH'PUR	WEIR	BAYANA	RUPBAS	TOTAL
1.	DENSE URBAN	0.98	0.47	2.23	0.94	5.42	0.58	0.45	2.47	13.54
2.	MODERATE URBAN					2.36				2.36
3.	SPARSE URBAN	0.82	1.04	2.11	1.62	9.47	1.32	0.88	----	17.26
4.	CROP LAND	497.14	397.56	358.55	333.54	706.46	356.95	275.59	464.45	3393.26
5.	FALLOW LAND	118.09	38.24	54.68	95.33	111.47	108.67	107.43	33.61	667.52
6.	DENSE FOREST	----	----	----	----	6.26	10.89	27.83	----	44.98
7.	MEDIUM FOREST	3.38	1.76	7.82	----	10.63	14.16	34.92	----	72.67
8.	SPARSE FOREST	21.38	2.84	20.61	----	3.67	36.40	70.82	12.12	167.84
9.	ERDOD LAND	2.20	----	----	0.90	2.61	1.25	21.02	0.48	28.46
10.	UNDULATING TERRAIN	14.44	0.97	4.91	----	14.65	16.78	154.24	15.93	221.92
11.	WATER LOGGED	2.92	9.30	10.90	0.09	6.89	7.30	0.39	13.13	50.92
12.	SANDY AREAS	10.71	2.10	28.60	8.11	45.34	33.14	92.16	9.62	229.78
13.	SALT AFFECTED	32.69	5.56	8.93	2.85	1.62	----	----	1.15	52.80
14.	ROCK OUT CROP	36.88	11.88	7.63	----	----	7.68	7.34	0.52	71.93
15.	WATER BODIES	0.63	0.56	0.15	----	1.68	7.91	15.34	5.50	31.77
16.	HABITATION & PLAN.	----	----	----	----	4.60	----	----	----	4.60
17.	MARSHY LAND	----	----	----	----	13.52	----	----	----	13.52
18.	MINING AREA	----	----	----	----	----	----	0.75	----	0.75
TOTAL	AREA	742.26	472.30	507.12	443.38	949.65	603.03	808.40	558.94	5085.13

TABLE 4: LANDUSE STATISTICS FOR BHARATPUR DISTRICT OF 1989
(based on IRS LISS – II data,all figures are in sq. km)

SN.	LAND USE	KAMAN	NAGAR	DEEG	NADBAI	BH'PUR	WEIR	BAYANA	RUPBAS	TOTAL
1.	DENSE URBAN	0001.34	0000.46	0003.15	0000.74	0004.31	0000.57	0000.63	0002.44	0013.64
2.	MODERATE URBAN	----	----	----	----	2.46	----	----	----	2.46
3.	SPARSE URBAN	1.02	1.54	2.31	1.92	13.06	1.52	1.06	----	22.43
4.	CROP LAND	501.51	402.30	387.41	342.80	731.12	393.90	380.14	476.56	3615.74
5.	FALLOW LAND	127.50	39.87	65.19	97.08	135.56	113.66	106.64	33.88	719.38
6.	DENSE FOREST	----	----	----	----	9.08	----	1.44	----	10.52
7.	MEDIUM FOREST	2.35	----	9.10	----	8.68	4.39	19.48	----	44.00
8.	SPARSE FOREST	----	----	3.65	----	2.08	5.88	74.71	15.47	101.79
9.	ERODED LAND	3.54	----	1.59	0.91	5.42	2.99	23.59	2.72	40.58
10.	UNDULATING TERRAIN	16.97	3.19	5.82	----	11.40	32.26	152.65	14.94	237.23
11.	WATER LOGGED	2.03	4.44	5.79	----	5.36	----	----	0.70	18.32
12.	SANDY AREAS	8.54	0.95	2.49	----	2.06	23.40	11.08	4.05	52.57
13.	SALT AFFECTED	24.56	----	0.16	----	----	----	----	2.17	26.89
14.	ROCK OUTCROP	52.87	15.32	20.54	----	----	18.81	14.46	0.54	122.54
15.	WATER BODIES	----	4.16	0.13	----	5.89	5.69	21.77	5.39	43.03
16.	HABITATION & PLAN.	----	----	----	----	4.63	----	----	0.80	4.71
17.	MARSHY LAND	----	----	----	----	8.59	----	----	----	8.59
18.	MINING AREA	----	----	----	----	----	----	0.75	----	0.75
	TOTAL AREA	742.23	472.23	507.33	443.45	949.52	603.07	808.40	558.94	5085.17

TABLE - 5: CHANGE MATRIX OF LANDUSE CLASSES BETWEEN 1986 –1989
(Based on RS data, All figures are in sq.km)

SN.	1986/1989		B	D	F	DF	MF	SF	ER	UN	WL	SA
SLT	ROC	WB	TOTAL									
1.	Built up land	B	37.76	--	--	--	--	--	--	--	--	--
--	--	--	37.76									
2.	Crop land	C	2.25	3313.40	72.73	--	--	--	--	--	--	--
--	--	4.87	3393.30									
3.	Fallow land	F	3.23	92.80	568.06	--	--	--	--	0.37	--	--
--	--	3.07	667.52									
4.	Dense forest	DF	--	--	--	10.52	23.16	11.30	--	--	--	--
--	--	--	44.98									
5.	Medium forest	MF	--	--	--	--	20.84	39.58	--	12.25	--	--
--	--	--	72.67									
6.	Sparse forest	SF	--	--	--	--	--	50.91	--	102.67	--	--
--	14.26	--	167.84									
7.	Eroded land	ER	--	--	--	--	--	--	25.14	--	--	--
--	--	3.32	28.46									
8.	Undulating land	UN	--	--	62.88	--	--	--	--	63.32	--	--
--	95.72	--	221.92									
9.	Water-logged	WL	--	37.53	--	--	--	--	--	--	26.91	--
--	--	--	64.44									
10.	Sandy Area	SA	--	164.95	--	--	--	--	15.44	--	--	
46.39	--	--	--	229.78								
11.	Salt Affected	SLT	--	7.06	15.71	--	--	--	--	--	--	
3.18	26.89	--	--	52.80								
12.	Rock out-crop	ROC	--	--	--	--	--	--	--	58.62	--	--
--	13.31	--	71.93									
13.	Water bodies	WB	--	--	--	--	--	--	--	--	--	--
--	--	31.77	31.77									
Total			0043.24	3615.70	719.38	10.52	44.00	101.80	40.58	237.23	26.91	52.57
26.89	123.29	43.03	5085.17									

TABLE - 6: COMPARISION OF LAND USE CATEGORIES FROM STATISTICAL AND REMOTE SENSING DATA
(All figures are in Sq.km, Figures in brackets indicate percentage)

SN	TEHSIL	TOTAL	AREA	AGRI. LAND		FOREST LAND		OCT. LAND		NOCT	LAND
		CENSUS	RS	CENSUS	RS	CENSUS	RS	CENSUS	RS	CENSUS	RS
1.	KAMAN	734.1	742.3	597.0	615.2	---	24.8	28.5	48.5	108.5	53.7
2.	NAGAR	471.0	472.3	416.9	435.8	---	4.6	6.3	17.0	47.8	15.0
3.	DEEG	500.9	507.1	432.8	413.3	9.5	28.4	9.3	48.4	49.3	17.0
4.	NADBAI	446.7	443.4	419.8	428.8	---	---	3.0	10.9	23.9	2.6
5.	BHARATPUR	954.8	949.7	826.8	821.0	75.8	20.7	16.8	56.8	82.9	57.1
6.	WEIR	614.0	603.0	460.0	465.6	64.8	61.5	34.9	41.7	54.1	34.3
7.	BAYANA	803.9	808.4	442.3	383.0	151.4	133.6	51.3	113.6	158.9	178.8
8.	RUPBAS	549.1	559.0	469.9	498.1	6.5	12.1	14.7	24.4	58.1	24.4
	TOTAL	5074.5	5085.1	4065.7	4060.8	308.0	285.5	164.8	361.0	583.5	382.9
		---	---	(80.1)	(79.9)	(6.1)	(5.6)	(3.3)	(7.1)	(11.5)	(7.5)