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Land Use Land Cover Change in Hanumangarh District of Indira Gandhi Canal Area Using Remote Sensed Data: A Tehsil Level Analysis

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Abstract: *The Indira Gandhi Canal is one of the biggest canal projects in India. The Indira Gandhi Canal Project was conceived with the noble aim of improving the living condition of human being and improves the local ecological conditions. Covering almost seven districts of Rajasthan, the canal has drastically caused a change in land use land cover in northern section more. This study focuses on Hanumangarh district, which is starting point of Indira Gandhi canal in Rajasthan. Secondary data from government sources have been substantiated with computed data from remote sensing. Unsupervised classification has been done for the satellite images in GIS environment. District level analysis shows remarkable changes in agricultural land areas and other land use and land cover categories over these years at tahsils level and district as a whole. These changes in land use and land cover in Hanumangarh district also show some negative impacts of canal irrigation in term of land degradation and associated factors over these years.*

Keywords: *Indira Gandhi Canal, Land Use Land Cover Change, Hanumangarh district.*

1. INTRODUCTION

The Indira Gandhi Canal is one of the biggest canal projects in India. The Indira Gandhi Canal Project was conceived in April, 1948 with the noble aim of improving the living condition of human being and to cater to the minimum needs of cattle populations in the region. IGNP owes its existence to the 'Indus Water Treaty' of 1958 between India and Pakistan, which allocated the water of three western rivers of Indus System Ravi, Beas, and Sutlej to India (Gulati, 1973). It starts from the Harike Barrage at Sultanpur, a few kilometers below the confluence of the Sutlej and Beas rivers in Punjab state. It runs south-southwest in Punjab and Haryana but mainly in Rajasthan for a total of 650 kilometers and ends near at Ramgarh, near Jaisalmer, in Rajasthan. Its construction started on the 31st March, 1958, inaugurated by then Home Minister Govind Ballabh Pant. It was built with the aim of converting part of the Thar Desert from wasteland to agriculturally productive land. The project area is classified as arid. It is thinly populated and requires large scale effective settlement of people to realise the benefits of transfer irrigable water. It consists of the Rajasthan feeder canal (with the first 167 km in Punjab and Haryana and the remaining 37 km in Rajasthan) and 445 km of the Rajasthan main canal which is entirely within Rajasthan. The IGNP traverses seven districts of Rajasthan: Barmer, Bikaner, Churu, Hanumangarh, Jaisalmer, Jodhpur, and Ganganagar. The Indira Gandhi Canal, a vast manmade river system, is a symbol and tribute to India's engineering skill (Rao, 1992).

2. LAND USE AND LAND COVER CHANGES BY INDIRA GANDHI CANAL

The land use and land cover pattern of a region is an outcome of natural and socio – economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Due to anthropogenic activities, the Earth surface is being significantly altered in some manner and man's presence on the Earth and his use of land has an effect upon the natural environment thus resulting into an observable pattern in the land use and land cover over time. Indira Gandhi canal region has witnessed remarkable expansion, growth and developmental activities such as building, road construction, deforestation and many other anthropogenic activities. Thus, main emphasis of this study is to find out changes occurred in land use and land cover in Hanumangarh district of Indira Gandhi Canal during 1977 to 2008.

Not long ago, a large part of the western region of the Indian state of Rajasthan was dominated by the sand dunes of the Thar Desert, one of the most inhospitable arid zones of the world. This vast wasteland was a testimony to the

effects of man's encroachment on nature. Many square kilometers of land consisted of nothing but shifting sand dunes and occasional patches of wild bush. Slowly, this lifeless image of the Thar is undergoing a major change as one of the longest man-made waterways in the world is being constructed to bring water to the desert. Indeed, the 649-km long Indira Gandhi Canal, originally called Rajasthan Canal the first phase of which was completed in 1986, has led to the cultivation of a variety of crops on what was once unproductive desert. Not only are new townships springing up in the area but banking and commerce are expanding and rapidly changing the lifestyle of the inhabitants (Rao, 1992). Over centuries the desert's inhabitants had developed systems of coping with the hardship of the desert environment. They were mostly pastoralists who also did extensive rain fed farming whenever the rainfall was adequate. Large tracts of land around every village were left for pastures and woodlots nourished by water catchments and storage facilities (Srivastava and Rathore, 1992). Low and erratic rainfall, extremes of seasonal temperature, high evaporation loss, meager ground water potential, and absence of perennial streams, salinity and duny and rocky/gravelly terrains are the major factors affecting the land use in hot arid region of India (Ram and Lal, 1998).

Land use in arid and semi-arid areas in India is primarily conditioned by combination of natural, social, economic, technical, demographic and political constraints (Malhotra & Kalla, 1990). As a consequence of the sharp increase in human population, there has been a marked change in the land-use pattern. The incidence of arable farming has increased markedly. This has occurred primarily through a decline of fallow-farming system. This shows that lands are being cultivated far more frequently. Though the farmers possibly find this practice as a more productive means of utilizing the land, the practice is certainly causing an acceleration of sand-drift problem. The introduction of Indira Gandhi Canal network in the western part of the desert has resulted in dramatic changes in wind erosion scenario in the command areas within Ganganagar, Hanumangarh, Bikaner and Jaisalmer districts (Narain, 2000). Changes in land use and land cover are also reflected by change in settlement pattern. Prior to introduction of Indira Gandhi canal, clustered pattern of settlement was there and after the introduction of canal concentration of urban built up area increase. Chaudhary (1996) examine the settlement development in Indira Gandhi canal command area in Thar Desert. It was expected that the canal irrigation would put the economy of desert area on new footing by enabling intensive cultivation. Livelihood pattern of small farmer adjacent to Indira Gandhi canal area changed over time period. When the water was introduced and irrigation of crop lands started in most of the sandy interdunal plains, erosion was gradually reduced. The interdunal plains were formerly put under dry farming of rain fed summer crops, or were kept as long fallow/ grazing land. Now these lands are under double cropping, using canal water. Availability of irrigation facilities through canal and ground water wells, has led to more area being put to double cropping. When compared to the situation in 1956-57, the net area sown is noticed to have increased by 39.2 per cent, while the area sown more than once has increased by a staggering 422.9 per cent. Much of this increase is due to the Indira Gandhi Canal network (especially in the western districts of Ganganagar, Hanumangarh, Bikaner and Jaisalmer) (Narain, 2000). The net sown area has increased from 39.42% in 1960 to 51.56% in 2000 and projected to increase to 55% by 2025. In the same period the fallow land (19.49% to 13.15%) and area not available for cultivation (14.28% to 8.72 %,) has decreased substantially in Indira Gandhi command areas (Bhati, et al 2009).

3. METHODS AND MATERIALS

To give an insight into the changes caused by Indira Gandhi Canal in the Hanumangarh district, study chooses two time periods. Study does a district level analysis of land use land cover change followed by a tahsil level analysis to come out with a clear pattern of influence of the canal on the physical surface of the district. Among all the districts which are covered by the canal, Hanumangarh has seen a drastic change, and is therefore the focus of this study.

To come out with a conclusion, the study uses data from sources such as Land Use Land Cover Project Report Manual, National Remote Sensing Centre, Rajasthan Agriculture Statistics at a Glance (1970 TO 2009) Commissionerate of Agriculture, Rajasthan, Jaipur, Topographical sheets of Hanumangarh district, Multitemporal Remote Sensing data of the region (MSS, TM, ETM+)(ESDI,GLCF), District census handbook (Hanumangarh), Land Use Land Cover Project Report Manual National Remote Sensing Centre, Published maps from various sources (NATMO, GSI, etc.), History of IGNP handbook etc.

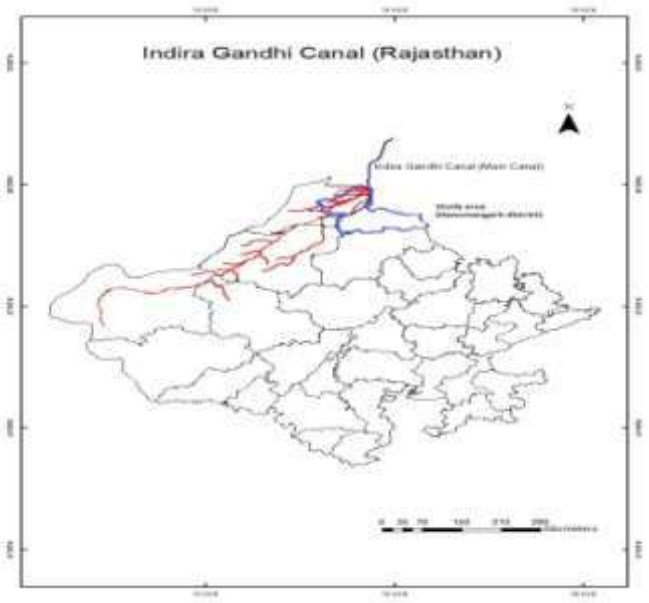

Figure no 1: *Indira Gandhi Canal in Rajasthan*

Remote sensing technique has been widely used in the field of change detection in land use land cover studies. Change detection in GIS is a process that measures how the attributes of a particular area have changed between two or more time periods. Change detection often involves comparing aerial photographs or satellite imagery of the area taken at different times. They can broadly group into four categories: visual interpretation approaches, pixel-level change detection (PLCD), feature-level change detection (FLCD) and object-level change detection (OLCD). In this study the temporal change in the region is shown by using the satellite image for the year of 1977, 1989, 1999 and 2008 having sensor of MSS, TM & ETM. Different images have been overlapped by the procedure of the change detection method, with the use of ARC-GIS & ERDAS IMAGIN.

Time taken for this study is 1977 to 2008, as later on other secondary development factors too emerged to influence the land use land cover of studied area. This time period has been chosen because it is directly connected with the various phases picture of canal, but later on agglomeration, economic, social and other physical factors too caused favorable change in land use land cover.

Land use and land cover category for Hanumangarh district is divided into five categories:

1. *Barren and wasteland:* The land which may be classified as the wasteland such as barren hilly terrains, desert lands, ravines, etc. normally cannot bring cultivation with available technology. In this category waterlogged and saline area is also included.
2. *Forests*: It is important to note that area under actual forest cover is different from area classified as forest.
3. *Urban built up area (Land put to non agricultural uses):* Land under settlements (rural and urban), infrastructure, industries, shops, etc. are included in this category. An expansion in the secondary and tertiary activities would lead to an increase in this category of land use. It refers to that part of land use which covers the area used for making houses and associated features.
4. *Canal area:* This area mainly under in urban built up area, but for delineation purpose there is new category.
5. *Agriculture area:* In this category there is mainly covers net sown area, current fallow land and other than current fallow land.

4. RESULTS AND DISCUSSIONS

Hanumangarh district is located in northern part of Rajasthan and having 28°45’ and 29° 57’ latitude and 74° 17’ and 74° 31’ longitude, cover area 9659.09 sq.km of Rajasthan. It is bounded on north western by Ganganagar and

Bikaner districts and south eastern by Churu district along touching state boundaries of Punjab and Haryana by north-eastern side. At district level, there land use and land changes measured for four time periods, to determine the impact of canal over these years. In Hanumangarh barren land in 1977 was 52310 hectare, which composes 5.94 % of total area. Barren land reduced in year 1989 & 1999 respectively 3.74 % & 2.91 % and in absolute term, area reduced to 25678 hectare in 1999, but afterward it increased both in absolute and percentage terms. It is mainly contributed by increasing land degradation processes like waterlogging and salinity problem arise in the various blocks of Hanumangarh district. This is mainly contributed by unscientific and unplanned agriculture practices adopted at these regions, along with substrata barrier of various minerals, which prevents the water percolation and capillary action is responsible for water logging and salinity causes in agriculture fields in Hanumangarh district.

Table no 1: *Hanumangarh - Land use and land cover (area in %)*

	YEAR			
Category	1977	1989	1999	2008
Barren land	5.94	3.74	2.91	4.40
Agricultural Land	87.51	89.04	87.71	83.76
Settelment	2.91	3.16	4.43	5.46
Forrest	1.62	2.00	2.42	3.59
Canal	2.02	2.06	2.53	2.79

Source: *Computed from unsupervised classification of Hanumangarh district (Landsat Imagery, UTM Zone 43)*

Agriculture area is higher in Hanumangarh district, is mainly contributed by the intensive canal system existing in the district. It was 770930 hectares in 1977, increased to 784467 hectares in next time period, but afterward it start some reverse trend in agriculture area and decreased to 737871 hectares in 2008, mainly contributed by increasing barren land and other categories areas over these years. It was expected that the canal irrigation would put the economy of desert area on new footing by enabling intensive cultivation. Problem of water logging and salinity increased especially in canal irrigated areas in Hanumangarh district. Nohar & Bhadra tahsils show highest barren land changes during this time period. Chaudhary (1996) examine the settlement development in Indira Gandhi canal command area in Thar Desert. Urban built up area increased over these time periods in district, contributed by increasing infrastructural activities over these years. It was 2.91% area in 1977, increased to 5.46% in 2008. Urban built up area increased by 1.87 times in these 31 years, which were second highest changes in these categories over these years. Forest areas shows highest improvement in area over these years, it was 14304 hectares in 1977, increased by 2.21 times and reached to 31668 hectares in 2008. This is mainly contributed by various afforestation drives adopted at the canal areas along with increase the people participation in agro-forestry and other activities. Canal systems includes distributaries, minors and sub minors, etc, increased over these time periods in the Hanumangarh district, which shows the outreach of canal irrigation in newer part of district.

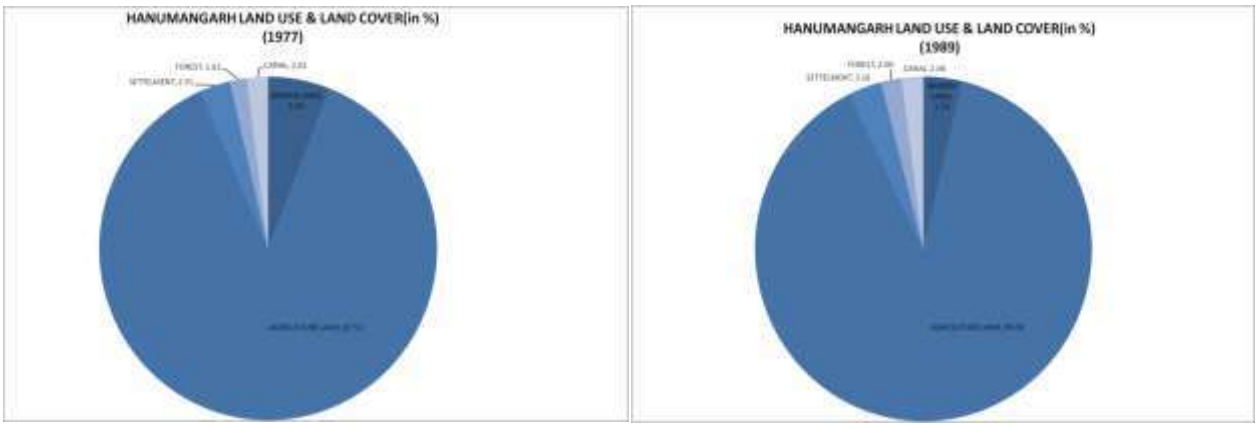

Figure no 2: *Pie diagrams of Hanumangarh district - Land use and land cover (1977 & 1989)*

Hanumangarh is starting point of Indira Gandhi canal in Rajasthan. Hanumangarh district, which is part of arid region of Rajasthan, prior to canal, was not suitable all together for the intensive cultivation, but the introduction of

canal has caused a decrease in barren land and an increase in Agricultural land and forests cover. Areas which got covered by canal in the first stage of the construction of canal have started showing waterlogging and salinity issues in last decade of last century and some increase in area under barren land on cost of agriculture land in Hanumangarh district. It is mainly contribute by unscientific and unplanned agriculture practices adopted at field level along with local litho and geological structures. But overall Hanumangarh is now converted into a green pasture by canal irrigational facilities and shows similar agriculture trends as Punjab and Haryana.

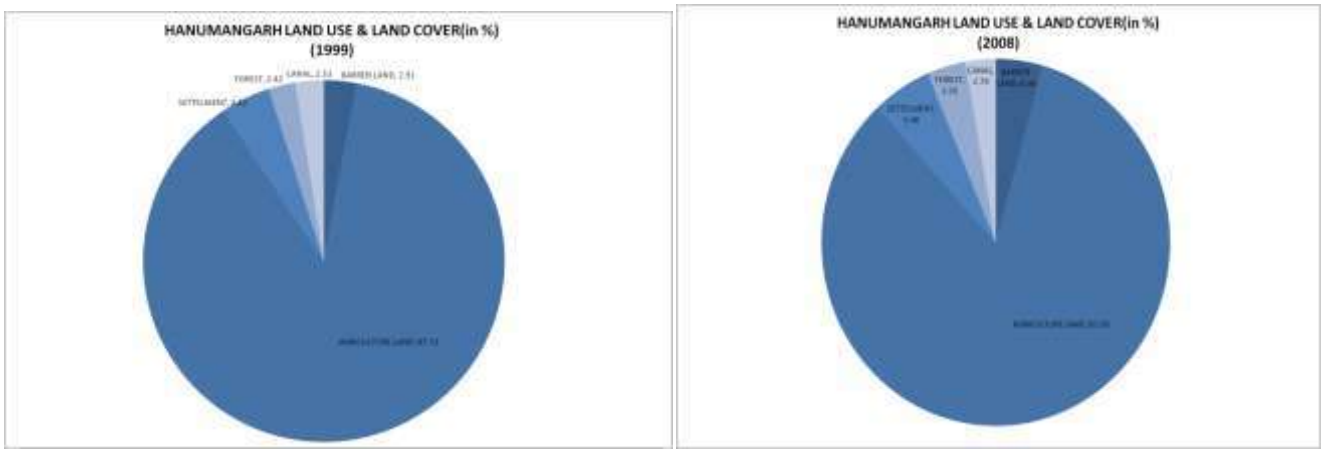

Figure no 3: *Pie diagrams of Hanumangarh district - Land use and land cover (1999 & 2008)*

5. TAHSILS LEVEL ANALYSIS OF LAND USE LAND COVER CHANGE IN HANUMANGARH DISTRICT

Prior to 1995, Hanumangarh district was part of Ganganagar district. Than after Ganganagar bifurcated into 16 tahsils comprising into two districts namely Ganganagar and Hanumangarh. For comparison purposes in land use and land cover, there is only five tahsils in Hanumangarh district considered. These tahsils are namely Bhadra, Hanumangarh, Nohar, Sangaria and Tibbi, which existing prior to 1995. Pilibanga tahsil carved out from Anupgarh tahsil of Ganganagar district and Rawatsar tahsil separated from Nohar tahsil of Hanumangarh district. For uniformity in comparison across time, tahsils have been merged within their mother tahsils.

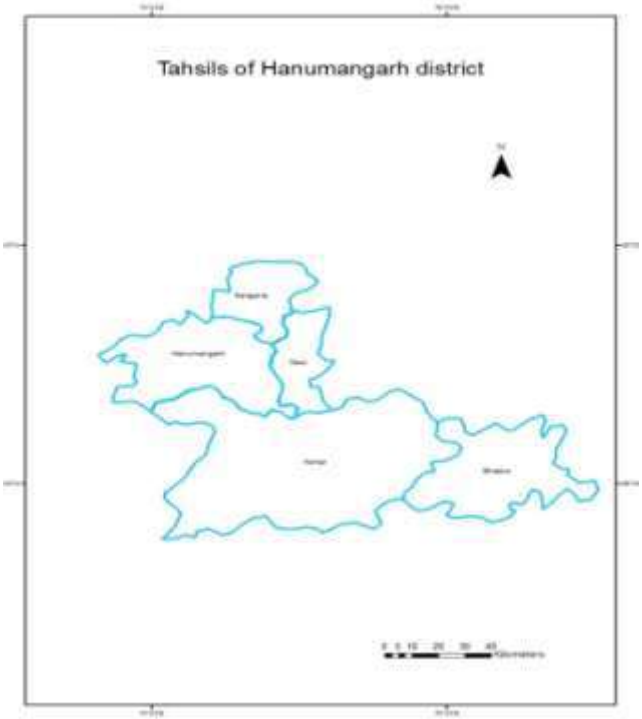

Figure no 4: *Tahsils of Hanumangarh district*

Land Use Land Cover change at tahsils level can be seen in table number 2. To depict the clear pattern of land use land cover change four time periods have been taken for tahsils of Hanumangarh district, which are; 1979-80 to 1981-82, 1985-86 to 1987-88, 1995-96 to 1997-98 and 2003-04 to 2005-06.

Change in land use land cover during 1979-82 to 1985-88: In Hanumangarh district there is increase in the forest area over these time period. Highest changes occur in Bhadra tahsil followed by Nohar and Hanumangarh. While other tahsils show increase in forest cover is very low compare to above three tahsil. Land put to non agricultural uses is show increase in all tahsil in Hanumangarh district. Impact of Indira Gandhi canal in Hanumangarh district is clearly visible in term of decrease in area of barren and wasteland over these time periods in these tahsils. Maximum changes occur in the region of the Hanumangarh and Nohar tahsils. Permanent pasture in Hanumangarh district is also very low; all 5 tahsils show no changes or negative changes in this category over these years. Area under miscellaneous tree, crops & groves shows prominent increase in Sangaria tahsil. Negative trends occur in the Tibbi while other tahsil show average positive changes during time period.

Culturable wasteland show negative changes in the three tahsils, except two tahsils namely Bhadra & Sangaria, show positive changes. It means during this time period there is increase in the area of culturable wasteland. There negative changes in all of the tahsil in between 30 to 50%. Current fallow land show declination trend in these time periods in Hanumangarh district. This is clearly showed for less than one year fallow land area decrease over time period. Other than current fallow land also shows negative changes in all tahsils, this is clearly show there is visible impact of the Indira Gandhi canal in this region. There increase in area of net sown area in all tahsil over the time period. Highest changes occur in the Nohar followed by Bhadra tahsil of Hanumangarh district.

Change in land use land cover during 1985-88 to 1995-98: Forest area continuously increase over time period. In this time period there is increase in area in all tahsil. Maximum changes in occur in Tibbi and Bhadra tahsils, while Sangaria tahsil has no changes in forest canopy in these time periods. Land put use for non agricultural land area show increase over time period except for Tibbi tahsil, where negative changes occurred. Barren & wasteland show highest increase in Nohar tahsil, while remaining tahsils have very little variation in this category. Area under permanent pasture and other reduced over the time periods in all tahsils of Hanumangarh district, while in category of miscellaneous tree and other show both decrease and increase in area over the time period, but in absolute term it is very low changes in these areas.

Culturable wasteland shows reduction in tahsils of Bhadra, Hanumangarh and Sangaria, while in Nohar and Tibbi tahsils show increment in the area under this category, contributed by canal irrigational problems of water logging and salinity. Current fallow land shows reduction in Nohar and Sangaria tahsils over the time periods, while Bhadra, Hanumangarh and Tibbi tahsils show increase in this category. While other than current fallow land show increase in almost tahsils. Net sown area during this time periods have very less increase and even it show negative trends over these years in Hanumangarh district, mainly contributed by problems associated by land degradation and other processes in Indira Gandhi canal command area, which made agriculture land unsuitable for agriculture practices over these years.

Table number 2: Tahsil wise land use land cover change in Hanumangarh District (area in %)

	Bhadra Tahsil		Hanumangarh Tahsil		Nohar Tahsil		Sangaria Tahsil		Tibbi Tahsil	
Category/ Year	1979-82	2003-06	1979-82	2003-06	1979-82	2003-06	1979-82	2003-06	1979-82	2003-06
Forests	0.01	1.51	1.85	2.38	0.02	1.97	0.00	0.15	0.03	0.29
Land put to non-agricultural uses	4.54	4.71	9.13	9.31	4.36	4.55	7.56	7.78	8.38	8.99
Barren and wasteland	0.00	0.11	0.14	0.00	0.15	0.13	0.00	0.00	0.00	0.20
Area under permanent pasture and grazing lands	1.59	0.46	0.05	0.05	2.44	0.70	0.00	0.00	0.00	0.00
Area under miscellaneous tree crops and groves	0.00	0.00	0.01	0.00	0.65	0.00	0.02	0.00	0.04	0.03
Culturable waste land	0.11	0.01	0.29	0.01	2.49	0.49	0.02	0.00	0.23	0.35
Current fallow	11.43	7.53	9.85	4.52	14.42	11.63	5.37	4.87	6.41	3.50
Fallow other than current fallow	0.43	1.20	0.95	1.55	3.68	4.07	0.17	0.06	0.65	1.84
Net sown area	81.90	84.48	77.72	82.17	71.78	76.46	86.87	87.13	84.25	84.81

Source: Computed from Rajasthan Agriculture Statistics at a Glance (1970 to 2009), Commissionerate of Agriculture, Rajasthan, Jaipur

Change in land use land cover during 1995-98 to 2003-06: In forest area, maximum area increased in Bhadra & Nohar, while other tahsil shows very less and no changes over the time period. Land use put for non agricultural purpose show increase in area over time periods in these tahsils, but in Tibbi tahsil, there were slight negative changes in this category. Barren & wasteland reduced in Nohar, while it is slightly increase in Tibbi tahsil. Remaining three tahsils have no considerable changes over these time period. Area under permanent pasture and others show reduction in Bhadra and Nohar tahsils of Hanumangarh district & Suratgarh, while it is increased only in Hanumangarh tahsil. Area under miscellaneous tree, crops & groves shows a reduction pattern in all tahsils.

Culturable wasteland increased in area during these time periods in three tahsils, namely Hanumangarh, Sangaria and Tibbi, while reduction in area mainly in the Bhadra and Nohar tahsils. Current fallow & other than current fallow land show increase in area over time period. There all tahsil show positive increase in area of these 2 categories. Nohar shows the maximum changes over the time period. Then in net sown area shows an adverse impact over the time period. There is all tahsils in Hanumangarh district shows negative changes over the time period; it means decrease in absolute area in net sown area. It is mainly contributed by various land degradation aspect, which affected the net sown areas in these tahsils. Tibbi show minimum reduction in area over the time periods.

6. CONCLUSION

The land use and land cover pattern of a region is an outcome of the natural and socio-economic factor and their utilization by man in time and space. Indira Gandhi Canal is like a great socio-economic change in Thar Desert of India. This study has focused on Hanumangarh district of Indira Gandhi Canal for studying a land use land cover change during the construction of the canal over these years. Study divides the time into four periods and has studied district level as well as tahsil level analysis of land use land cover change. This study focuses on 5 tahsils of Hanumangarh for uniformity in comparison, which are Bhadra, Hanumangarh, Nohar, Sangaria and Tibbi.

First phase of Indira Gandhi canal were commenced in Ganganagar (including Hanumangarh district) and Bikaner districts of Rajasthan. It comprises construction of 204 km long feeder canal from Harike barrage in Punjab to Masitawali (Hanumangarh) in Rajasthan, 189 km long main canal from Masitawali (Hanumangarh) in Rajasthan to Chhattargarh (Bikaner) and 3,454 km long distribution system to serve a CCA of 553 thousand hectares at 100% intensity of irrigation. The stage of the project was completed by March 1992. Irrigation under this stage started in 1961-62 in Hanumangarh district (IGNB, 2000). Hanumangarh district is very well agriculturally developed by Indira Gandhi canal system over these years. In initial years agriculture area in Hanumangarh district increased in Indira Gandhi canal command areas, but in last decade of last century there was various land degradation problems like waterlogging, salinity and other associated causes emerged in these canal command areas. After two decades of the introduction of canal irrigation, the problem of water logging and soil salinization started in the IGNP command areas. The twin problem not only adversely affected crop production in canal command but also created ecological problems (Kaswan, 2010). Canal induced land use land cover change can be seen more in between 1999 to 2008. After that meager changes could be experienced, as some negative issues started to emerge, such as water logging and salinity. These land degradation factors are manmade, because faulty and unscientific agriculture practices like, unsuitable crops in arid region grown in canal irrigated areas, water intensive crop used under irrigational facilities, higher uses of chemical fertilizers and pesticides, etc, along with natural causes of land degradation like encroachment of sand dunes from western parts of Rajasthan in agriculture fields, problems of local lithological factors, etc further deteriorated situation in canal command areas. These land degradation factors changes occurred in agriculture land in tahsils of Hanumangarh district, where Nohar, Bhadra and Tibbi tahsils shows increase in area under Barren and wasteland over these years. Forest areas increased by various afforestation drives adopted along the canal, along with various agro-forestry measures adopted at grass root level in Hanumangarh district. While permanent pastures and miscellaneous tree and others category have very low area under these tahsils of Hanumangarh district. Culturable wasteland increased in Tibbi tahsil, contributed by canal irrigated negative factors emerged in these years.

Various infrastructure facilities, which comes under land put to non-agriculture areas increased in all tahsils, especially in Hanumangarh tahsil, due to headquarter and other agglomeration effects. Current fallow land shows

reduction changes in these tahsils, this show that these lands put for agriculture practices and it is corroborated by increased area of agriculture land in term of net sown areas in these tahsils over these time periods. Except Nohar tahsil, all four remaining tahsils have fourth fifth area under agriculture practices, which shows a higher proportion of net sown area in arid part of Rajasthan. This shows clear cut impact of Indira Gandhi canal in arid part of Rajasthan, where earlier time periods paucity of water made hardship not only for human being, but also for local ecology. Water stresses also reduced by Indira Gandhi canal in arid parts of Rajasthan, especially in Hanumangarh district and now it became greenery of Rajasthan. Overall the canal has caused an increase in the area under forests, settlements, and net sown area, which are productive use of land and has caused prosperity in the district. Thus this study clearly depicts the influence of Indira Gandhi Canal on the land use land cover of Hanumangarh district. But recently some negative issues such as waterlogging and salinity have started to emerge. Thereby, efforts should be taken from various agencies including governmental and nongovernmental to manage the water use from canal in these areas. Public participation, user committees, awareness, institutional monitoring and assessment can help in checking the negatives of the canal and can help in causing the positive change in socio economic life of the local people.

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