

Assessment of Land Use & Land Cover Changes

Impact of Common Land Development



PREPARED BY
Foundation for Ecological Security

SOUTH ASIA
Pro Poor Livestock Policy Programme
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Assessment of Land Use and Land Cover Changes: Impact of Common Land Development

Annexure to Document 21

**“Common Land Development and Poor Livestock Keepers:
Experiences from Common Land Development in the States of
Rajasthan and Madhya Pradesh in India”**

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1. INTRODUCTION

Imageries of Remote Sensing (RS) satellites provide data on the temporal and spatial status of natural resources. Repetitive coverage helps in understanding various changing physical processes in a particular area as also in monitoring closely, the changes taking place across different areas. The availability of data at different spatial resolutions (as coarse as 1 km or as fine as 1 m) provides the means of observing the land simultaneously at micro as well as macro levels.

FES uses satellite imageries to assess the quantitative changes that have taken place in its project areas due to the interventions of the communities in the protection and conservation of their natural resources. A similar exercise was undertaken in 2003 using the satellite imageries of the project locations of both - before (1996/98) and after (2002) the project intervention period. The same analysis has been extended in this study using imageries of the year 2006. The results, though not 100% accurate, are fairly reliable.

2. METHODOLOGY

The study has used visual interpretation and digital image processing techniques in order to extract resource-related information either independently or in combination with other relevant data. The use of a combination of both digital plus visual analysis techniques (Hybrid) made it possible to extract the best of the two. Geographic Information System (GIS) techniques have been further utilized for the integration of RS data with other spatial and non-spatial data. The preliminary maps prepared by using these hybrid techniques (digital plus visual) were then checked on the ground for their accuracy through GPS surveys. Accordingly, mid-course corrections were incorporated into the maps and the final interpretation was carried out directly onto the digitally enhanced image. The image interpretation key for different land use/land cover categories has been provided in the annexure.

The study has referred to satellite imageries (IRS LISS 3 + PAN) of Thoria watershed for the month of December in the years 1993, 2002 and 2006 and of Ladwan watershed in the years of 1996, 2002 and 2006 so as to assess the changes in the status of land use/cover that have taken place in these areas over time. To complement this change detection analysis, a vegetation study enumerating the various plant species and a quantification of biomass was carried out simultaneously within the same areas. The satellite images have been compared with those of a control site selected from an

adjacent area which has characteristics similar to the study areas but which has not experienced any community protection. This comparison renders the changes taking place in the protected areas more easily perceptible.

The study carried out in both the project sites of FES indicates a significant improvement in the status of vegetative cover in the areas being protected by the local communities over the past 10 to 13 years. A control site in each study location has been included in the study in order to compare the changes that have taken place in the protected areas. Given below are certain definitions that will make context of the usage of these terms clearer and precise.

FORESTS AND AGRICULTURAL LAND: CLASSES AND CLASSIFICATION

1. Dry Deciduous Open Forest

These are patches having healthy tree cover but with tree density ranging between 10 to 40% canopy area. The trees are spread evenly across the area and are largely characterized by thorny trees of maximum height 10 metres. Small dense patches less than the minimum mapable units are also to be seen in certain parts. These patches appear in the satellite imagery in the colour range of dark to light pink and have a smooth to rough texture. They can occur within or outside the protected forest areas.

2. Riverine Dense Forest

This is a distinct belt of vegetation that is formed along the principal rivers and streams. Due to favourable conditions of growth, the height and girth of trees in this category are found to be at their best. These form regular shapes along the streams and appear clearly in the satellite imagery as dark red to bright red in smooth texture. The density of tree canopy is more than 40%.

3. Riverine Open Forest

This is a distinct belt of vegetation formed along the principal rivers and streams. Due to favourable conditions of growth, the trees show a very good height and girth but are very sparsely distributed along the course of the water-body. These form regular shapes along the streams and are clearly identified in the satellite imagery as having a smooth texture and appearing in the range of pink to light pink and sometimes bluish green (depending upon the content of soil moisture). The density of the tree canopy is less than 40%.

4. Dry Deciduous Mixed Degraded Forest

As the name specifies, this is a deciduous forest with low thorny trees and xerophytes predominating its composition. The height of the trees is usually less than 10 metres (Champion and Seth, 1968, pp 45) and the canopy is largely broken or sparse. The vegetation is very sparsely distributed over the area. The ground status of this vegetation category as observed through the study was not healthy. This appears in the satellite imagery in the range of brownish red to brown. This type of forest can occur within or outside the protected areas.

5. Scrubland

All lands with poor tree growth, comprised mainly of small or stunted trees, having canopy density less than 10% are classified as scrubland (FSI report 1999). These areas are characterized by very scattered trees with very small canopy area. They appear in the range of brown to light brown in the satellite imagery. These can occur within or outside the protected areas.

6. Agriculture single cropped

These are agricultural lands where a single crop is harvested during the *Kharif* season.. These can be easily identified in the satellite imageries for the months of November and December.. Due to the soil moisture content, they appear in the range of greenish blue to blackish green on the satellite data. They follow a very regular shape.

7. Agriculture double cropped

These are the agricultural lands where cropping is undertaken during both the *Kharif* as well as the *Rabi* seasons. They are easily identified in the satellite imageries of the months of November and December, as the standing crop is clearly visible. Hence they appear on the satellite area as red to bright red with very regular shapes.

8. Water bodies

All the rivers and streams are classified water bodies. They appear on the satellite data as dark blue with specific shapes.

9. Wastelands

These are areas where soil is totally exposed and are characterized by the presence or the complete absence of scattered shrubs. These lands can be reclaimed in most

situations. These lands are usually accessed as local grazing lands in the post-monsoon season. In the satellite data, they are distinguishable as ranging between light blue to white.

3. STUDY AREA

3.1 Thoria Watershed

The Thoria Watershed in the Ajmer district of Rajasthan covers an area of about 4500 ha. The project interventions of FES for Common Land Development in this region began in 1996 in the village of Thoria under the IWDP (Integrated Watershed Development Programme) and were later extended to all other villages in the watershed area through the implementation of various land and water conservation activities. The average annual rainfall of this area is 600 mm. The geology of the area, with good unconfined aquifer, is favourable for recharge.

3.2 Ladwan Watershed

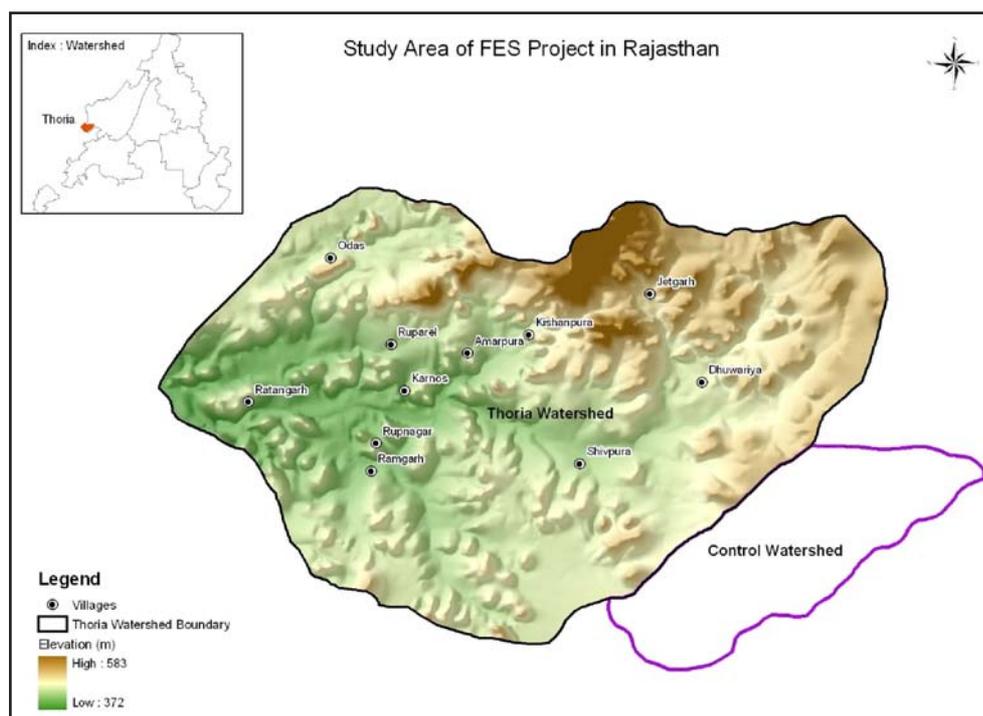
The Ladwan Watershed in Shajapur district of Madhya Pradesh covers a total area of about 3000 hectares. The area is inhabited predominantly by pastoral communities. It has an annual average rainfall of 900 mm. The geology of the area is primarily dominated by basalt and thus the availability of groundwater is very poor except in the fractured and weathered zones.

4. RESULTS

4.1 Thoria/Lilri Watershed in Bhilwara Project of FES in Rajasthan

4.1.1 Thoria Watershed

The analysis reveals positive changes in almost all classes of vegetation as well as in agricultural productivity since the inception of the project. This could be attributed to the success of the local communities in conserving and managing their common lands. The rainfall of the area in 1993, 2002 and 2006 is recorded as 292 mm, 51 mm and 650 mm respectively, with the year 2002 presenting itself as the fourth consecutive drought year. The details of the analysis are given below:



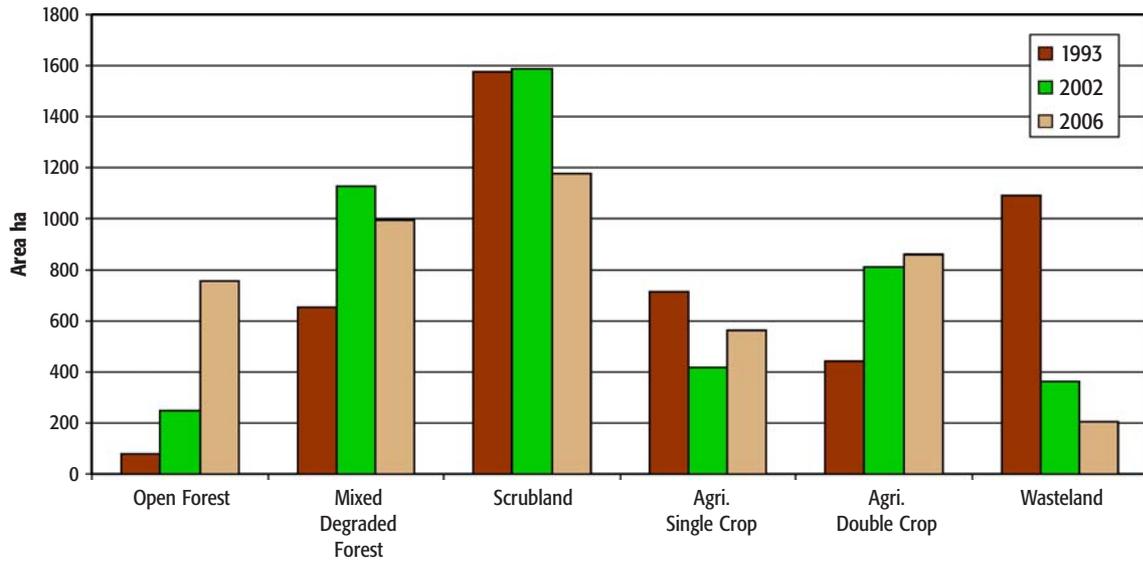
The open forest category with canopy cover in the range of 10% to 40% has increased from 80 hectares in 1993 to 756 hectares in 2006 - an increase of almost ten fold. The increase of open forest in the year 2002 is less in comparison to that in 2006 due to low rainfall in that particular year.

The mixed degraded forest category has also improved by almost 52%. The increase in this category was 73% in 2002. However, by the year 2006, this category was promoted to the open forest category. Similarly, with the scrubland also being promoted to the mixed degraded and open forest by that year, there is a decrease in this category of about 25%.

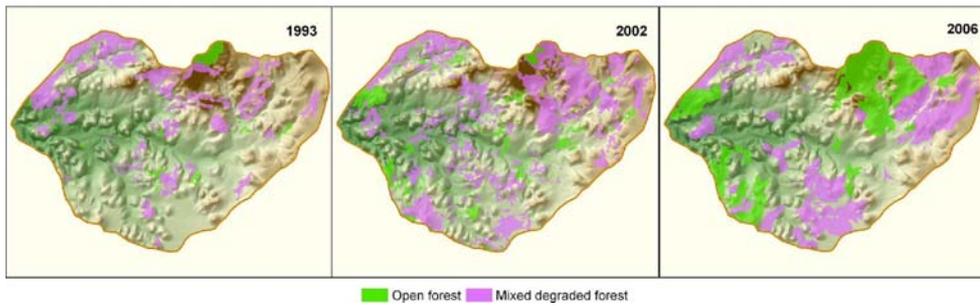
Table 1: Land use/cover change of Thoria Watershed in the period from 1993 to 2006

Land use/cover Category	Area in Ha			Change from 1993 to 2002	Change from 1993 to 2006	Percentage change from 1993 to 2002	Percentage change from 1993 to 2006
	1993	2002	2006				
Open Forest	80	246	756	166	676	208	845
Mixed Degraded Forest	654	1129	995	475	341	73	52
Scrubland	1578	1586	1177	8	-401	1	-25
Agri. Single Crop	717	418	563	-299	-154	-42	-21
Agri. Double Crop	443	815	859	372	416	84	94
Wasteland	1089	362	206	-727	-883	-67	-81
Total	4561	4561	4561				

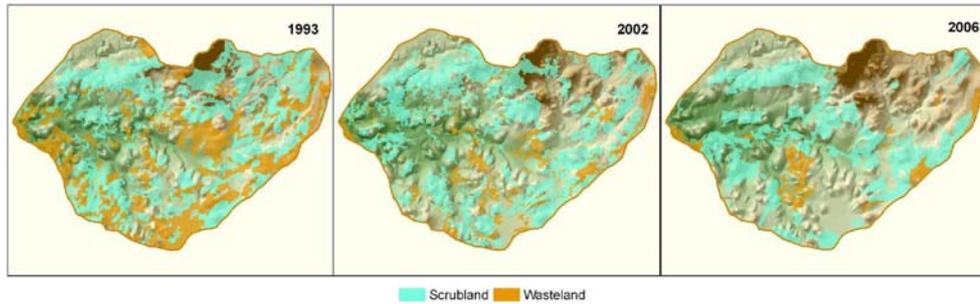
Change in Landuse/Cover of Thoria Watershed from 1993 to 2006



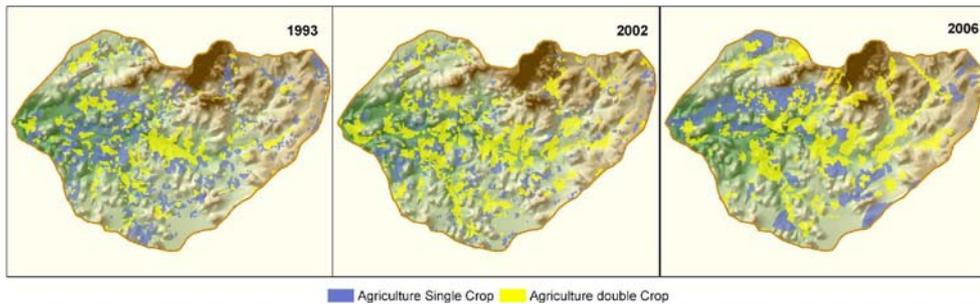
Change Detection Study of Thoria Watershed in FES Project Area of Bhilwara, Rajasthan



Change in Landuse/cover of Thoria Watershed



Change in Crop Intensity



In terms of agricultural productivity, the double crop (*Rabi*) has increased by 94% due to the assured availability of water as compared to the pre-project intervention period. Since the satellite imageries are those of the month of December, they indicate only the *Rabi* crop.

The area under wasteland reduced by a significant 81% in 2006 as compared to the year 1993. However, this decrease was limited to 67% in 2002, which could be attributed to the dry conditions induced by drought.

Though conservation measures by the local communities are found to be more intensive within the common lands, there are many such activities that been taken up in the outside of these lands as well. About 100 check dams have been constructed on drains across the watershed to check soil erosion, to recharge the aquifer by storing water and also to provide drinking water to livestock. Saplings of various tree and fodder species have also been distributed through various nurseries, all of which have together contributed to a significant improvement in the biomass, biodiversity and water resources in the area.

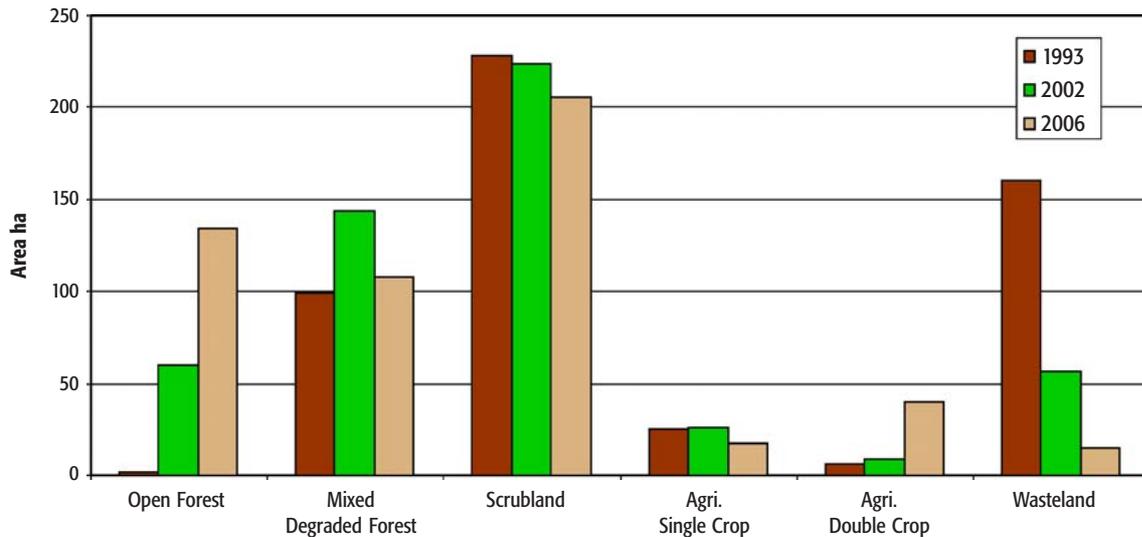
4.1.2 Result of the Analysis of Community Protected Areas in Thoria Watershed

About 500 hectares of land falling in the Thoria watershed had been leased to five Tree Growers Cooperative Societies (TGCS) in the year 1998. The local communities have taken up various measures for the protection and management of these lands since then. The following analysis shows the results of the change in land use/cover over the last ten years.

Table 2: Land use/cover Change of PA Area in Thoria Watershed from 1993 to 2006

Land use/cover Category	Area in Ha			Change from 1993 to 2002	Change from 1993 to 2006	Percentage change from 1993 to 2002	Percentage change from 1993 to 2006
	1993	2002	2006				
Open Forest	2	60	134	58	132	2900	6600
Mixed Degraded Forest	99	144	108	45	9	45	9
Scrubland	228	224	206	-4	-22	-2	-10
Agri. Single Crop	25	26	17	1	-8	4	-32
Agri. Double Crop	6	9	40	3	34	50	567
Wasteland	160	57	15	-103	-145	-64	-91
Total	520	520	520				

Change in Landuse/Cover of PA Area in Thoria Watershed from 1993 to 2006



The open forest category, which was 2 hectares in 1993, has increased by 60 hectares in 2002 and by 134 hectares in 2006. The increase is largely due to the promotion of the categories of mixed degraded forest and scrublands to that of open forest. Therefore, we see a reduction of scrublands by 22%, which could also have been added to the category of mixed degraded forest.

Similarly, the mixed degraded forest has increased by 45 hectares in 2002 and by 9 hectares by 2006. This class of vegetation has also been promoted to open forest.

While the change in agricultural single crop is marginal, it is found to be manifold in the case of the double crop (*Rabi*). However, the agricultural lands for which this phenomenon has been reported are not a part of the common lands that have been leased. They feature in this analysis as they were encompassed by the watershed boundary, and lie either in the valleys of the Commons, or adjacent to common land boundaries under private ownership.

The category of wasteland has been converted to vegetative cover and has reduced from 160 hectares in 1993 to 15 hectares in 2006.

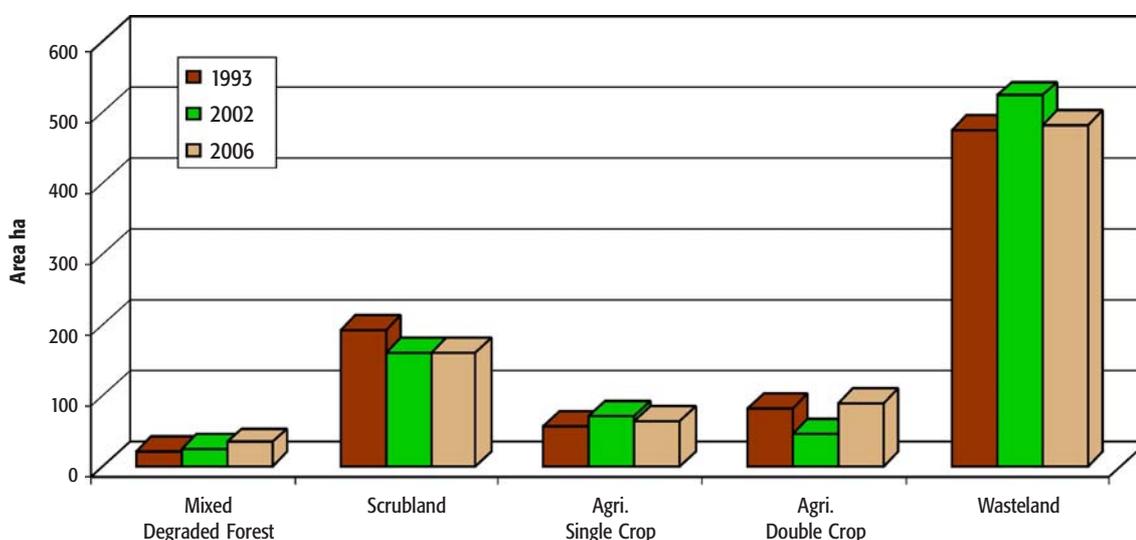
4.1.3 Result of the analysis of control watershed adjacent to Thoria Watershed

The change detection analysis was carried out for an adjacent watershed which has an area of about 800 hectares and has characteristics similar to those of the Thoria watershed before the interventions by the communities for its management and protection began. The result of the interpretation of land use/cover from 1993 to 2006 reads as follows:

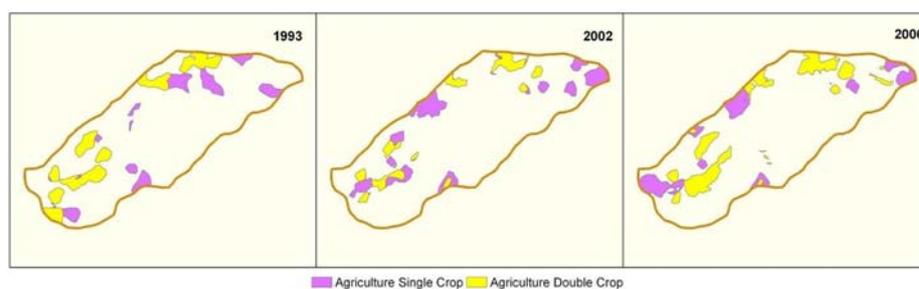
Table 3: Change in Land use/cover of Control Watershed adjacent to Thoria watershed from 1993 to 2006

Land use/cover Category	Area in Ha			Change from 1993 to 2002	Change from 1993 to 2006	Percentage change from 1993 to 2002	Percentage change from 1993 to 2006
	1993	2002	2006				
Mixed Degraded Forest	21	24	34	3	13	14	62
Scrubland	192	161	160	-31	-32	-16	-17
Agri. Single Crop	57	72	63	15	6	26	11
Agri. Double Crop	83	47	88	-36	5	-43	6
Wasteland	475	524	483	49	8	10	2
Total	828	828	828				

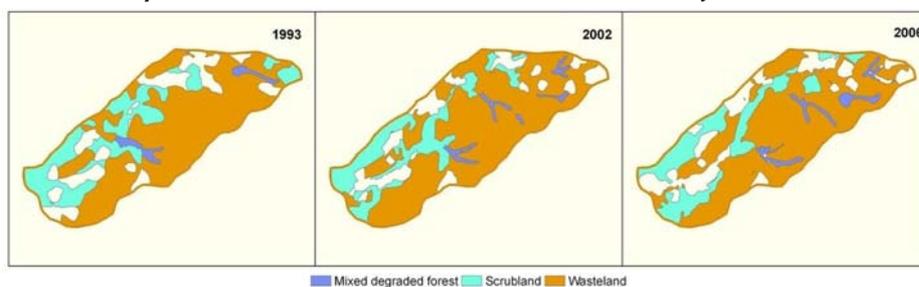
Change in Landuse/Cover of Control Watershed of Thoria



Change in Crop Intensity in Control Watershed of Thoria



Change Detection Study of Control Watershed for Thoria Watershed in FES Project Area of Bhilwara, Rajasthan



The category of open forest is not to be found across this watershed. However, it has been noticed that the mixed degraded forest has increased by 13 hectares in 2006 from about 21 hectares in 1993.

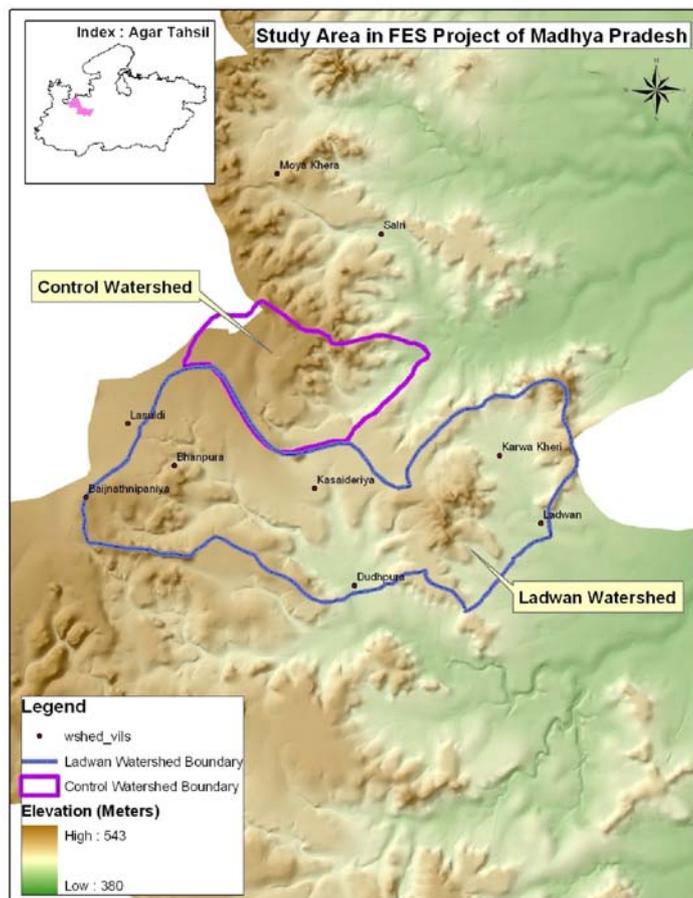
There is no significant change in agricultural area. The double crop has come down in 2002, it being a drought year. The *Rabi* area in 2006 has decreased by 6%. The status of wastelands has remained the same in 2006 as in 1993.

This analysis shows that the change in vegetative cover as well as agriculture is negligible in this area in the period from 1993 to 2006, except in the category of mixed degraded forest. In the absence of community protection, there has been no reduction since the year 1993 in the category wastelands either. This is in sharp contrast to the results displayed by areas under community protection, where the change is significant and measurable.

4.2 Ladwan Watershed in Agar Project of FES in Madhya Pradesh

4.2.1 Ladwan Watershed

Ladwan watershed covers an area of about 3000 hectares. It falls in the catchments of the Lakunder River, a tributary of the River Kali Sindh. The landscape is typically grassland with undulating terrain. The status of land use/cover for this watershed has been interpreted using the satellite imageries for the month of December for the years of 1996, 2002 and 2006. The rainfall of the area in 1996, 2002 and 2006 is recorded as 1150 mm, 732 mm and 1500 mm respectively. The year 2002 was the fourth consecutive drought year.

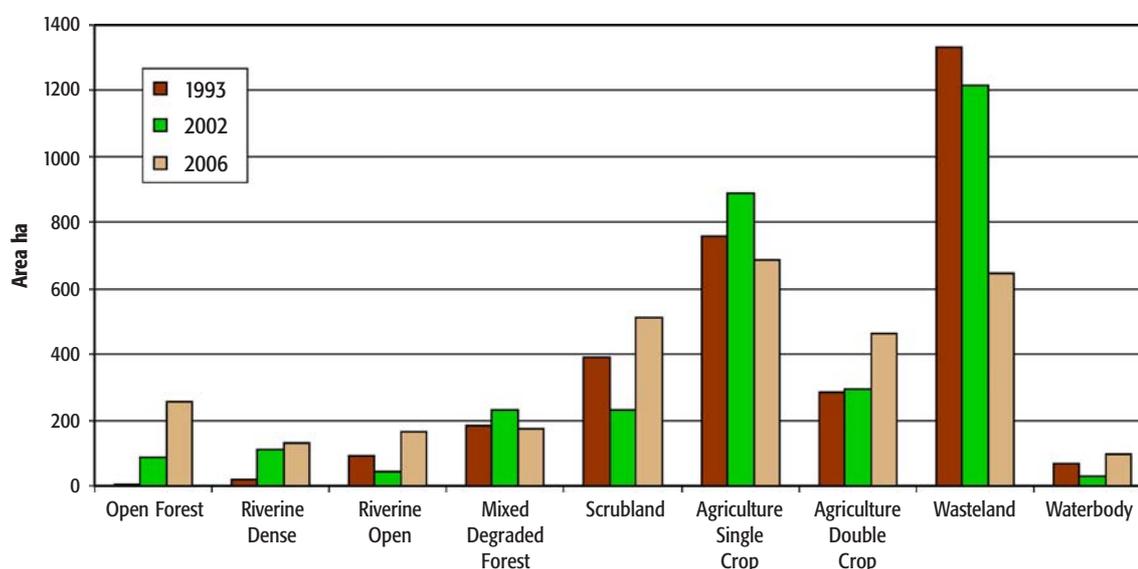


There are two categories of land use/cover, namely the riverine dense and riverine open forest, that have been added to the classification as they form a predominant class in this region. These lands being primarily pastoral or grasslands, there exists no dense forest in the region. The details of the analysis are given below.

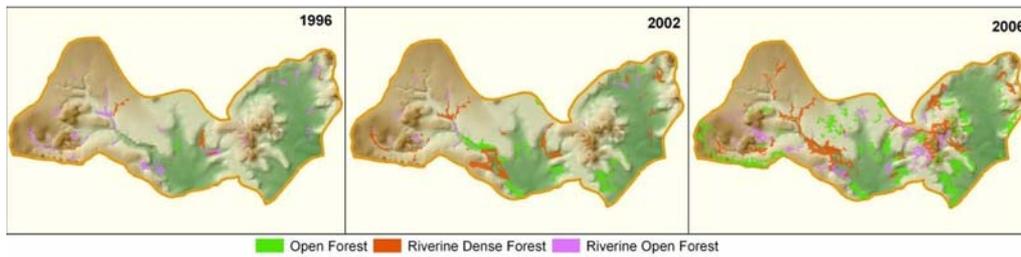
Table 4: Change in Land use/cover of Ladwan Watershed from 1996 to 2006

Land use/cover Category	Area in hectares			Change in Area from 1996 to 2002	Change in Area from 1996 to 2006	Percentage change from 1996 to 2002	Percentage change from 1996 to 2006
	1996	2002	2006				
Open forest	4	85	248	81	244	2025	6100
Riverine Dense	22	110	183	88	161	400	732
Riverine Open	85	26	95	-59	10	-69	12
Mixed degraded forest	191	312	179	121	-12	63	-6
Scrubland	402	339	668	-63	266	-16	66
Agri. single crop	742	854	596	112	-146	15	-20
Agri.double crop	295	266	488	-29	193	-10	65
Wasteland	1326	1114	585	-212	-741	-16	-56
Waterbody	72	33	97	-39	25	-54	35
Settlement	13	13	13	0	0	0	0
Total	3152	3152	3152				

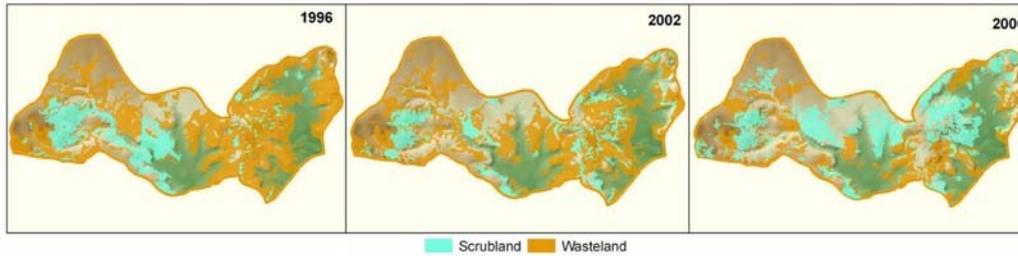
Landuse/Cover Change Analysis of Ladwan Watershed from 1996 to 2006



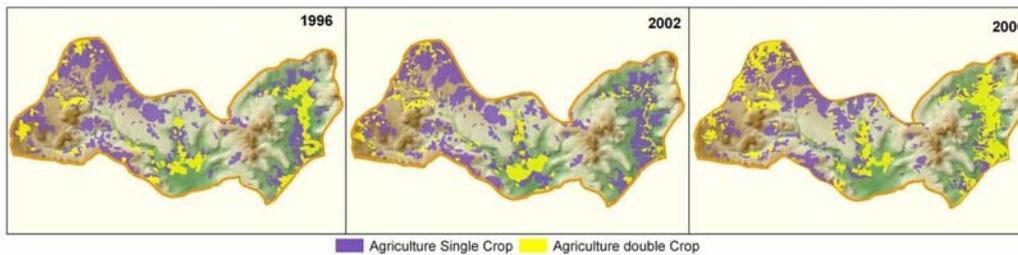
Change in Landuse/cover of Ladwan Watershed in FES Project Area of Shajapur district, Madhya Pradesh



Change in Scrubland and Wasteland



Change in Agriculture Intensity



Open forest has increased from four hectares in 1996 to 85 in 2002 and 248 in 2006. Riverine dense forest has increased from 22 hectares in 1996 to 183 hectares in 2006. The riverine open forest has not shown any significant change since 1996. The categories of riverine dense as well as riverine open forest appear along the river valleys or drainage networks.

Mixed degraded forest has decreased by 12 hectares, i.e. by about 6% in the ten-year period from 1996 to 2006. This class is more in 2002 and much of it was converted to open forest in 2006.

Agricultural single crop has come down whereas double crop (*Rabi*) has increased significantly (65%) in the years from 1996 to 2006. The double crop has come down in the year 2002 due to the consecutive drought years. However, the double crop areas has been found to have gone up in the agricultural areas lying below the water harvesting structures constructed by the communities even under the drought conditions of 2002.. Wastelands have reduced from 1996 to 2006 by 56%.

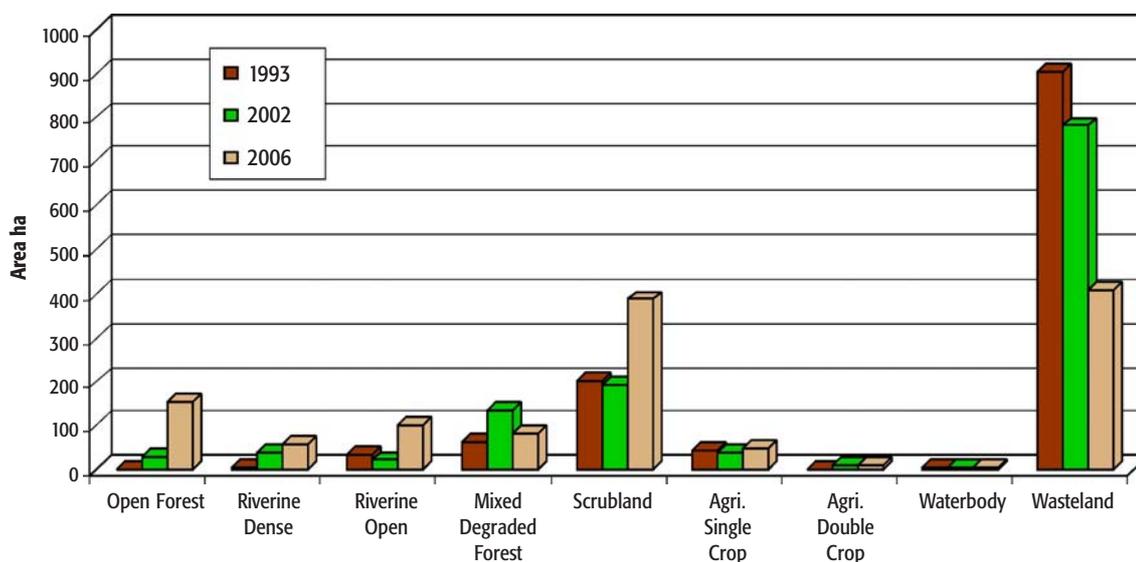
4.2.2 Result of the analysis of Community Protected Areas in Ladwan Watershed

About 1300 hectares of land falling in the Ladwan watershed was leased to Tree Growers Cooperative Societies (TGCS) in 1998. The local communities have taken up various measures for the protection and management of these lands since then. The following analysis shows the results of the change in land use/cover over the last ten years.

Table 5 : Change in Land use/cover of PA Area in Ladwan Watershed from 1996 to 2006

Land use/cover Category	Area in hectares			Change in Area from 1996 to 2002	Change in Area from 1996 to 2006	Percentage change from 1996 to 2002	Percentage change from 1996 to 2006
	1996	2002	2006				
Open Forest	0	34	160	34	160	> 100	> 100
Riverine Dense	12	42	93	30	81	250	675
Riverine Open	34	11	56	-23	22	-68	65
Mixed Degraded Forest	63	169	99	106	36	168	57
Scrubland	209	271	465	62	256	30	122
Agri.Single Crop	40	38	38	-2	-2	-5	-5
Agri.Double Crop	2	5	10	3	8	150	400
Waterbody	6	5	7	-1	1	-17	17
Wasteland	895	686	333	-209	-562	-23	-63
Total	1261	1261	1261				

Landuse/Cover Change in PA Area in Ladwan Watershed from 1996 to 2006



While the open forest category was nil in 1996, it has increased to 34 hectares in 2002 and by 160 hectares in 2006. This increase is due to the promotion of the mixed

degraded forest and scrublands to the open forest category as a result of effective community protection.

Similarly, the riverine dense category has increased from 12 hectares in 1996 to 81 hectares in 2006. The riverine open vegetation has also increased due to the promotion of scrublands to this category in the areas adjacent to river valleys. The category of Scrubland has improved by 122% since the year 1996 due to the conversion of wastelands to this category. The wastelands have reduced by 63% by the year 2006. This has contributed to the increase in other classes of vegetative covers.

Another significant change to be seen is that in the agricultural double crop (*Rabi*). These agricultural areas lie in the valley fills/river beds inside the common lands. The improvements in agricultural area due to the interventions on common lands outside the watershed boundary have not been included in this study.

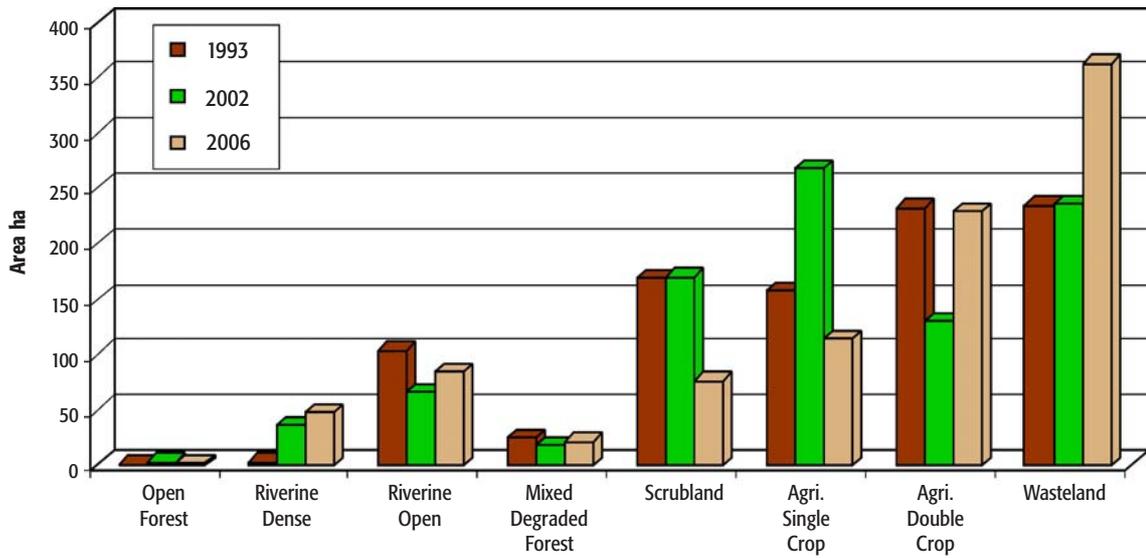
4.2.3 Result of the analysis of control watershed adjacent to Ladwan Watershed

In order to render the changes in Ladwan watershed more clearly through the process of comparison, a change detection analysis was also carried out for an adjacent watershed of approx. area 1000 hectares having characteristics similar to those of the Ladwan watershed prior to the interventions by the communities. The result of the interpretation of land use/cover for the period from 1996 to 2006 reveals the following facts

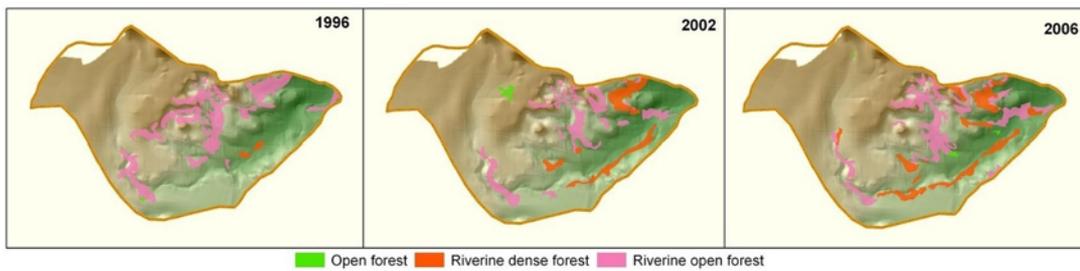
Table 6: Change in Land use/cover of Control Watershed adjacent to Ladwan Watershed from 1996 to 2006

Land use/cover Category	Area in hectares			Change in Area from 1996 to 2002	Change in Area from 1996 to 2006	Percentage change from 1996 to 2002	Percentage change from 1996 to 2006
	1996	2002	2006				
Open Forest	1	3	2	2	1	200	100
Riverine Dense	3	36	48	33	45	1100	1500
Riverine Open	104	66	84	-38	-20	-37	-19
Mixed Degraded Forest	24	18	21	-6	-3	-25	-13
Scrubland	169	170	76	1	-93	1	-55
Agri. Single Crop	158	267	114	109	-44	69	-28
Agri. Double Crop	230	130	228	-102	-3	-44	-1
Wasteland	234	236	360	-2	129	1	55
Waterbody	1	1	2	0	1	0	100
Settlement	26	23	15	-3	-1	-12	-42
Total	950	950	950				

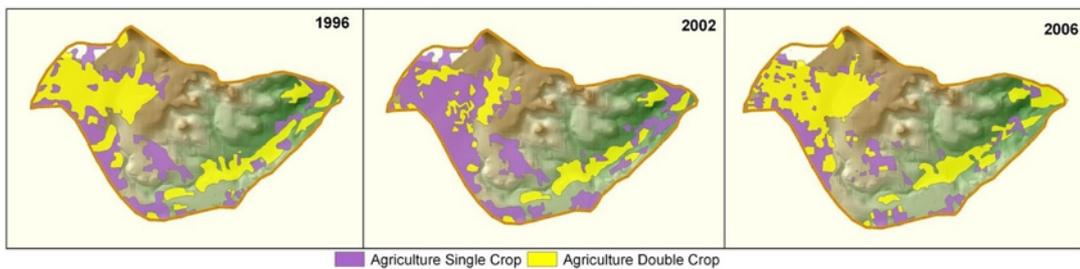
Landuse/Cover Change in Control Watershed of Ladwan Watershed from 1996 to 2006



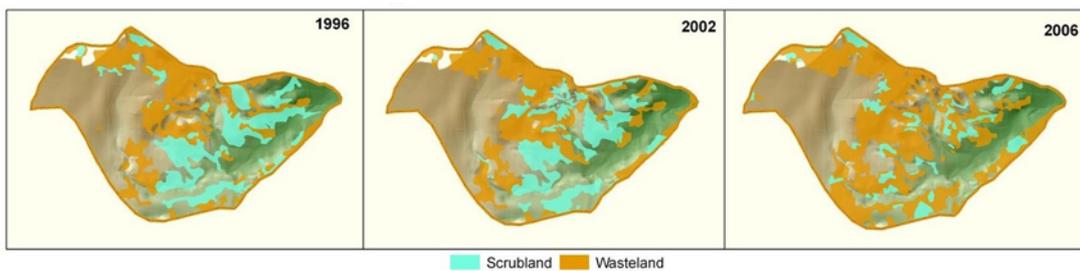
Change in Landuse/cover in Control Watershed



Change in Agriculture Intensity in Control Watershed



Change in Landuse/cover in Control Watershed



The open forest has not changed much in this watershed since the year 1996. The Riverine Dense Forest increased to 48 hectares in 2006 from a mere three hectares in 1996. Since this watershed lies between the Salri and Ladwan watershed where the local communities have been managing the common lands since the past ten years, there is a possibility that the communities of this area too would have been influenced towards the protection of the resources within the watershed. A part of the watershed is also being managed by the Forest Department under a Fodder Development Programme (FDP). The categories of Mixed Degraded Forest and Scrubland have come down by 13% and 55% respectively.

There is no apparent change in double crop area since the year 1996. However, the same has reduced significantly in 2002, which was a drought year. There is a considerable increase in Wasteland area (55%) in 2006, which is unlike the trends displayed by the protected and watershed areas.

5. CONCLUSION

The analysis of the above study has been divided into three categories.

- 1) Changes within the watershed.
- 2) Changes in the lands being leased to the community for management and conservation.
- 3) Changes in the adjacent watershed area which have characteristics comparable to those of the above mentioned study areas prior to the project interventions.

The results display vibrant changes in the protected areas in comparison to those in the non-protected ones. While the Thoria watershed shows rapid improvement in almost all categories of land use/cover, the corresponding improvements in the Ladwan watershed appear to be slower. This could be attributed to the nature of the landscape, which is primarily of the grassland type, and the high dependence of the communities on fodder.

The positive changes in both the study sites could be attributed to the protection and management of these landscapes by the local communities, through mechanisms of governance and other physical interventions.

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