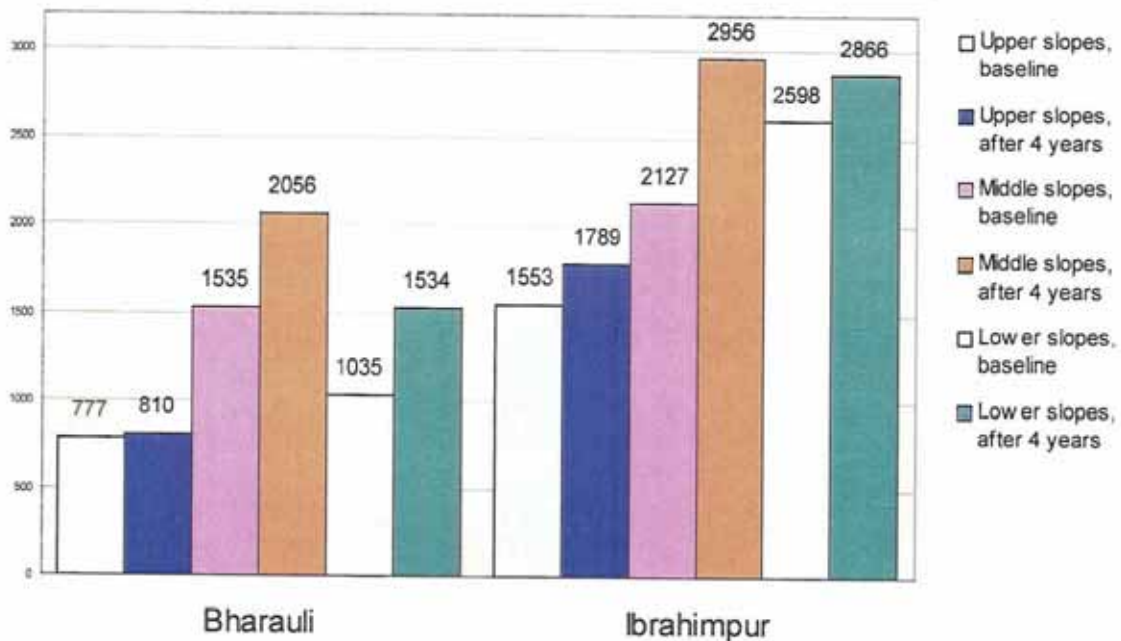


Vegetation Study in Forest Catchments of Water Harvesting Dams at Bharauli and Ibrahimpur

Increase in tree cover in catchment areas of two water harvesting dams (Density per hectare)



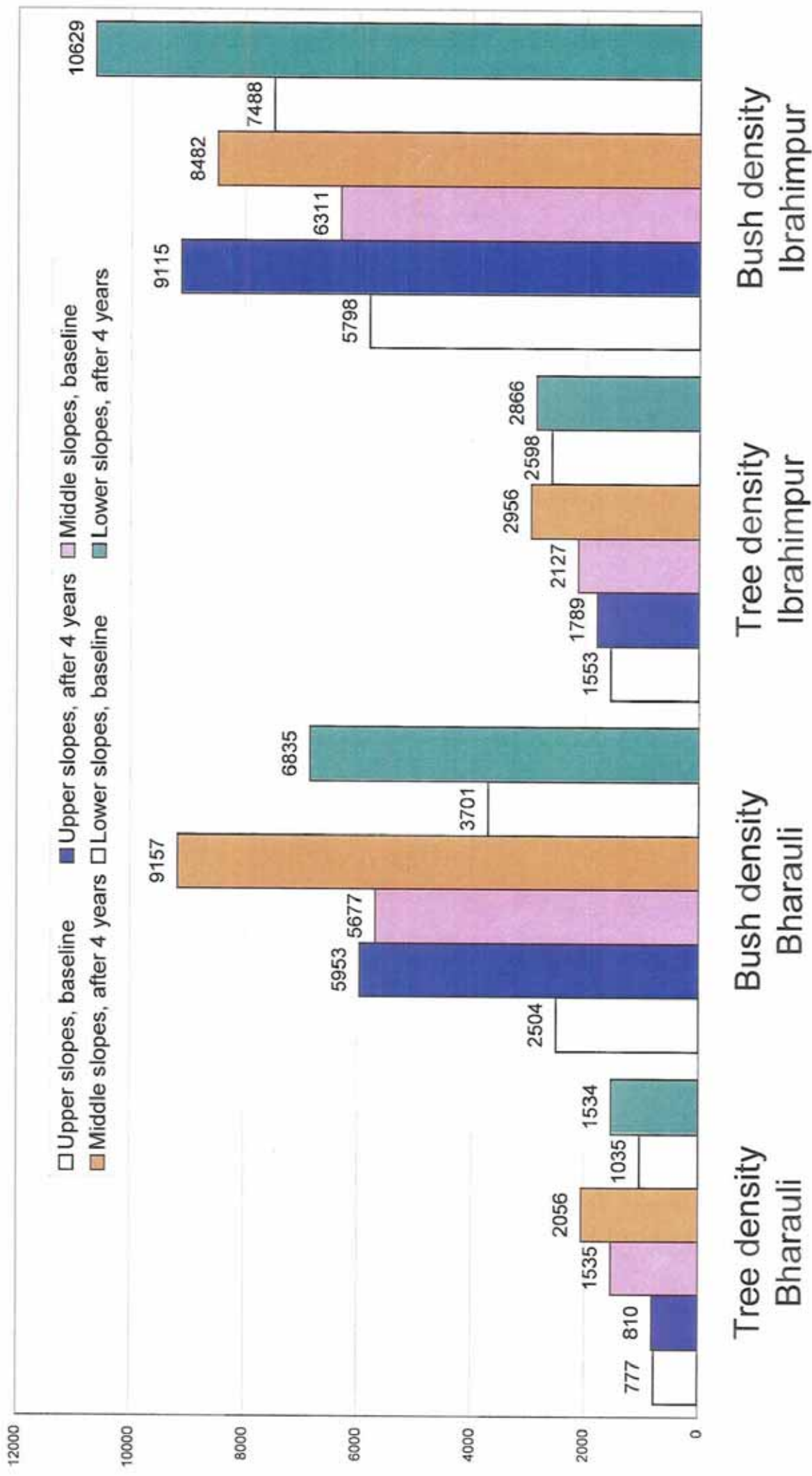
Submitted To

Project Director
Haryana community forestry Project
Department Of Forest Haryana

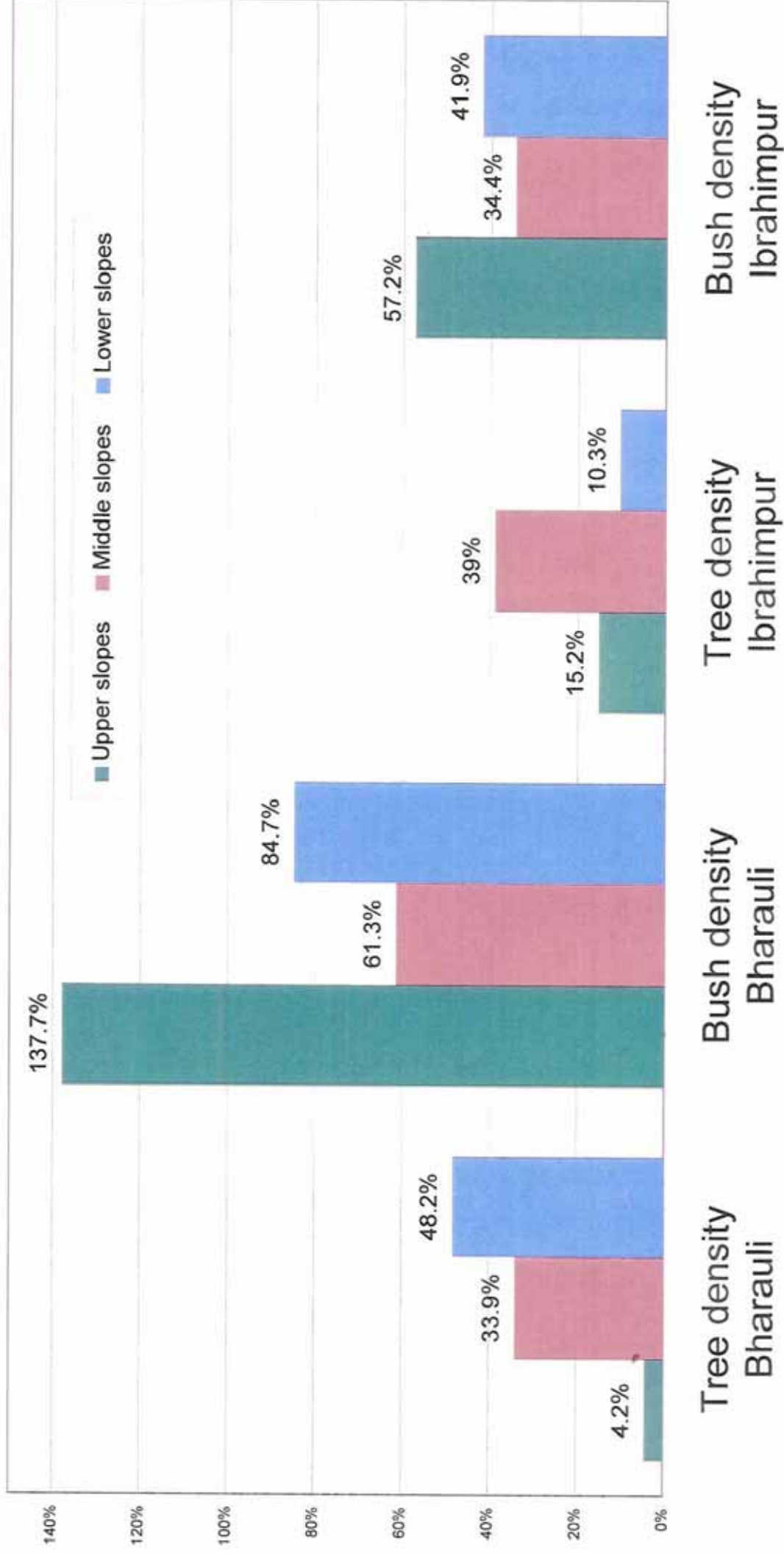
Submitted By:

Society for Promotion and Conservation of
Environment Chandigarh
Mar. 2006

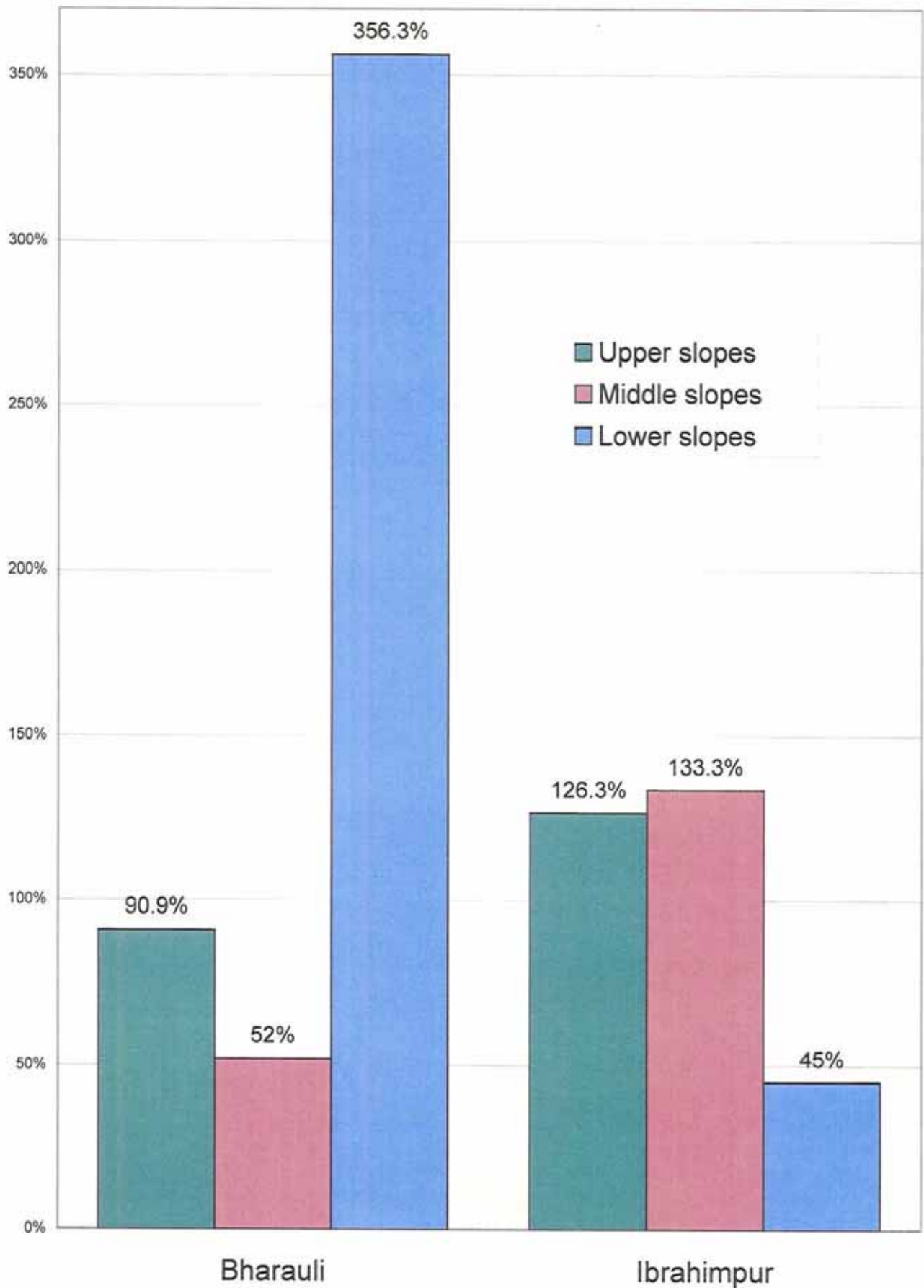
Increase in vegetation cover in catchment areas of two water harvesting dams (Density per hectare)



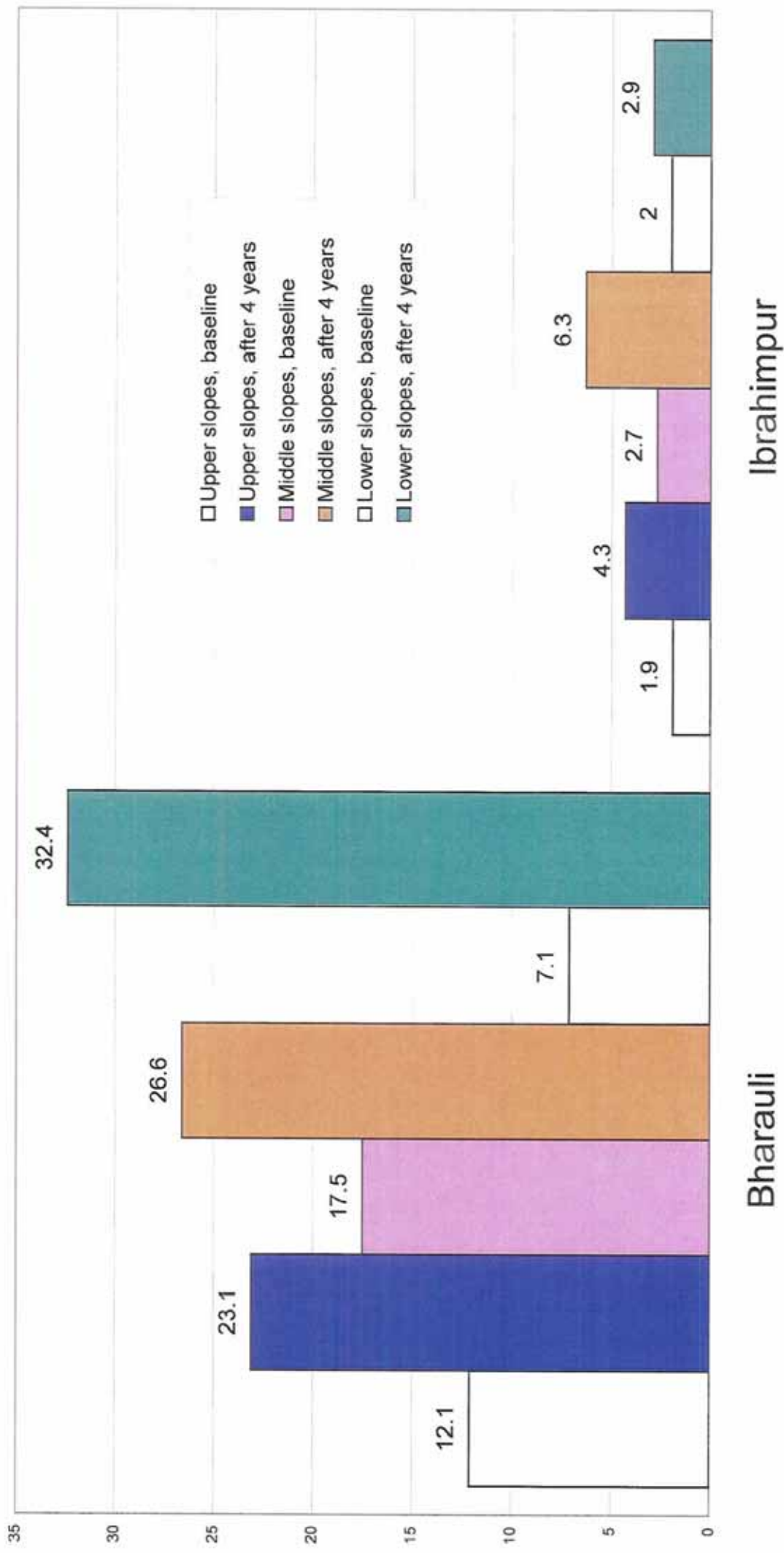
Increase in vegetation cover in catchment areas of two water harvesting dams after 4 years



Increase in grass yield in catchment areas of two water harvesting dams after 4 years



Increase in grass yield in catchment areas of two water harvesting dams (Quintals per hectare)



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ACKNOWLEDGEMENT

The vegetation studies in the catchment areas of two model water harvesting dams constructed by the Haryana Community Forestry Project (HCFP) in village Bharauli (Panchkula district) and Ibrahimpur (Yamunanagar district) were completed with the willing cooperation and active support provided by Presidents and members of VRMC Bharauli and Ibrahimpur which is greatly appreciated

We are greatly indebted to the Haryana State Govt. and its Department of Forest Panchkula for awarding this study to SPACE considering the same as a competent professional group. We fall short of words to express our gratitude to Mr. S.K. Dhar IFS, Project Director HCFP for his constructive suggestions, professional inputs and facilitating the conduct of this useful study. The coordination, willing support and guidance received from Mr. Goran Jonsson, the Technical Assistance Team Leader to the project is also thankfully acknowledged.

This society is particularly thankful to Dr. S.S. Grewal for the conduct of this study and compiling this report as team leader.

**President
Society for Promotion and Conservation of
Environment, Chandigarh.**

EXECUTIVE SUMMARY

The vegetation studies in catchment area of two model water harvesting dams constructed by the Haryana Community Forestry Project during 2001 were conducted to quantify the changes in the stock of trees, bushes and grasses caused by the improvement in moisture regime and protection by the people who were benefited by the facility of irrigation water harvested from these forest catchments. The changes in vegetation cover complex modify the hydrological behaviour of catchments feeding the reservoirs and provide indications about the silt loads, biotic pressure and hence their useful life. With such an objectivity, the base line status of vegetation was first established in October 2001 in the catchment of Bharauli. (Panchkula District) and Ibrahimpur (Yamunanagar District) Dams and the same was repeated after 4 years in October-November 2005. In all 36 and 27 sample plots of 10m x 10m size were established to represent physiography of upper, middle and lower hill slopes of 90 and 30 ha catchment of Bharauli and Ibrahimpur. The changes in the status of vegetation (stock of trees, bushes, grasses) litter accumulation; soil moisture and soil pH were studied by following standard techniques. The following significant changes were observed.

Bharauli Catchment

- *The overall tree stock density improved from 777 to 810 in upper, 1535 to 2056 in middle and from 1035 to 1534 trees / ha on lower hill slopes thus registering an increase of 4.3, 33.9 and 48.2% in a period of four years. All the tree species have gained growth in terms of increase in height and girth. The number of miscellaneous types of trees have particularly gone up.*
- *The bush stock particularly of Lantana, Karaunda, Curry Patta and miscellaneous types registered a phenomenal increase. The over all bush density increased from 2504 to 5953, 5677 to 9157 and from 3701 to 6835 bushes / ha on upper, middle and lower hill slopes thereby increasing their numerical strength by 137, 61 and 85% in four years.*
- *The number of grass clumps was drastically reduced but not the overall yield of grass. The number of clumps was reduced from 100 to 42.2 in upper, 90.6 to 34.0 in middle and from 51.9 to 23.8 / m² on lower hill slopes. The number of superior grasses like Bhabar has particularly come down.*
- *It was surprising to note that overall air dry mean grass yield increased from 12.2 to 27.4 q/ha. Such an increase was from 12.1 to 23.1 (91%), 17.5 to 26.6 (52%)*

and from 7.1 to 32.4 q/ha (356%) on upper, middle and lower hill slopes respectively. Evidently, the clump number have decreased but clump size have improved significantly. The mean clump weight has increased from 0.12 to 0.55, 0.19 to 0.78 and from 0.14 to 1.36 gms on upper, middle and lower hill slopes.

- The improvement in canopy cover was reflected in litter accumulation on forest floor. The overall leaf litter accumulation increased from 1.59 to 2.28 t/ha (43.9%) Such an increase was 17.6, 45.4 and 53.1% on upper, middle and lower hill slopes.

Ibrahimpur Catchment

- The overall tree stock density improved from 1553 to 1789, from 2127 to 2956 and from 2598 to 2866 trees/ha in upper, middle and lower hill slopes thereby registering an increase of 15.2, 38.9 and 10.4% respectively in a period of four years. There has been mortality in younger stocks of Khair, Amaltas and Tendu on upper slopes. The number of miscellaneous tree species increased significantly. The decrease in the number of mature trees provided evidence of removal of trees from the forest catchment.
- The bush stock increased from 5798 to 9115 (75% rise), from 6311 to 8482 (a rise of 34%) and from 7488 to 10629 bushes / ha (a rise of 42%) on upper, middle and lower hill slopes respectively. Lantana, Karonda and miscellaneous bush species mainly contributed to this rise.
- Like Bharauli, the number of grass clumps was reduced from 119.0 to 30.8, from 52.1 to 36.2 and from 106.5 to 34.7 / m² in upper, middle and lower hill slopes. However, the grass yield increased from 1.9 to 4.3 (126% rise), 2.7 to 6.3 (134% rise) and from 2.0 to 2.9 q/ha (45% rise) on respective slopes in a period of 4 years. The mean clump weight (biomass yield) increased from 0.16 to 1.40 on upper, 0.52 to 1.75 on middle and from 0.19 to 0.86 gms/m² on lower hill slopes.
- The leaf litter accumulation increased from 23.7 to 29.0 on upper. 18.5 to 28.3 on middle and from 29.8 to 34.8 q/ha on lower hill slopes. The incidence of forest fires was reported in the area which seems to be the reasons of low accumulation of forest litter.
- The overall improved in vegetation cover is expected to reduce runoff and soil loss to the reservoir. Extraction of mature trees from Ibrahimpur catchment needs to be checked.

1. INTRODUCTION

The Haryana Community Forestry Project funded by the European Commission is operating in selected blocks of the state. In the Haryana Shivaliks, in addition to other components, the project proposed to construct 18 water harvesting dams (WHDs) through active participation of the local communities organized as Village Resource Management Committee's (VRMCs). The VRMCs were involved in site selection, planning, execution and subsequent maintenance of assets created. The main objective was to harvest rainwater from forest watersheds by constructing small earthen dams of 8 to 16 m height, The harvested water is used for supplement irrigation in rainfed command area to improve productivity of grain and forage crops and reduce the risk of crop failures. The equitable distribution of water helps in alleviating poverty and in the process tie up the interest of local communities with forest protection. The detail of 17 WHDs constructed so far by the HCFP is as under.

Table 1.1 Water harvesting dams constructed in Panchkula and Yamunanagar districts by HCFP in different years.

Year of construction	No. of dams	Project villages	
		Panchkula District	Yamunanagar District
2001-02	2	Bharauli	Ibrahimpur
2002-03	3	Kaimwala Mirpur I	Bhagwanpur
2003-04	7	Turon I Dhandion Mandappa	Kansli Thaska Kathgarh
2004-05	5	Mawas Mirpur II Turon II	Nanheri Nawangaon

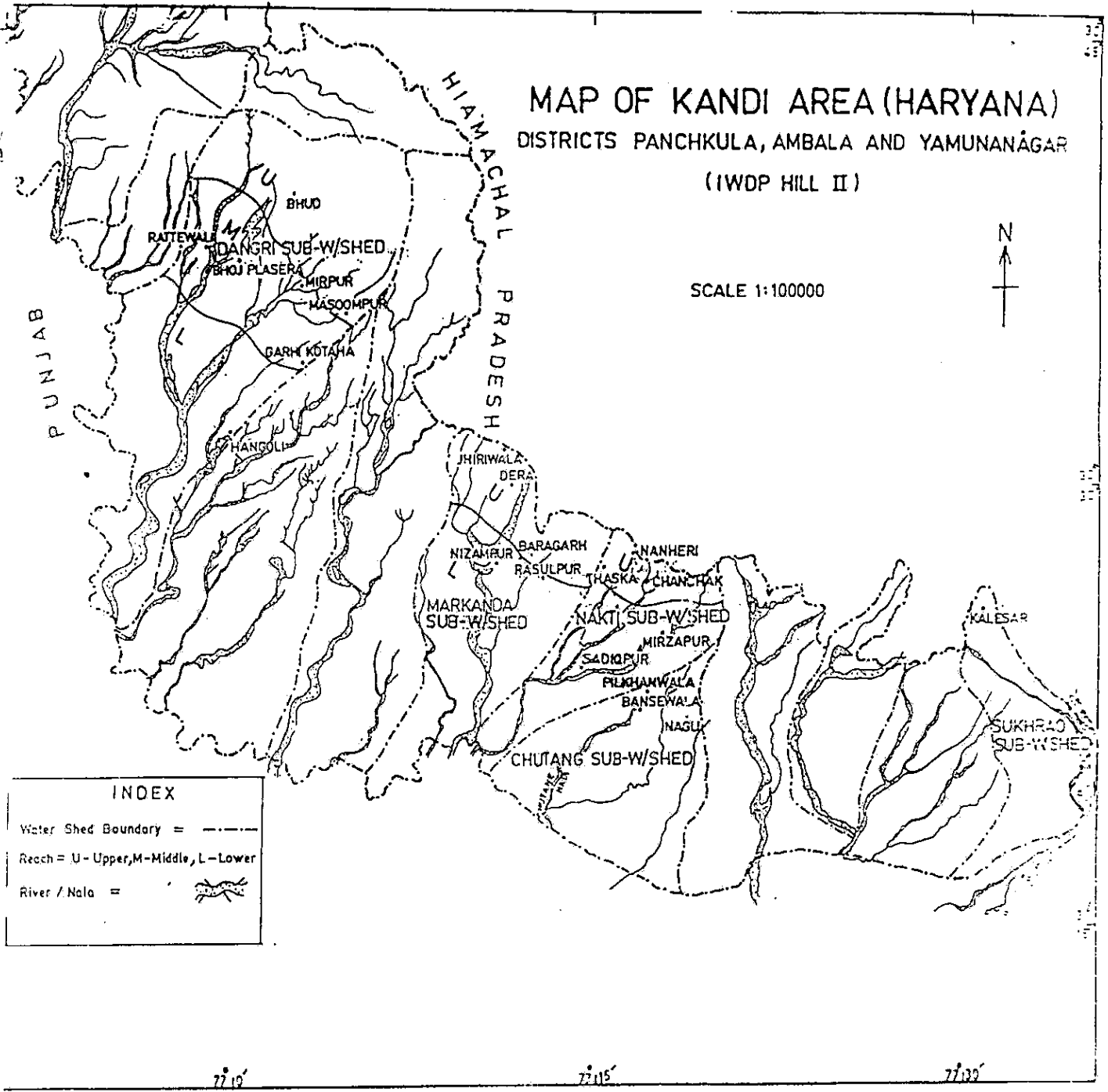
As per the requirement of the HCFP, the first two dams were supposed to be evaluated by an independent agency and on that basis the remaining dams were to be constructed. This evaluation of the first two WHDs constructed during 2001-2002 at village Bharauli and Ibrahimpur was carried out by the scientist of the Zonal Research Station for Kandi Area Ballawal Saunkhri of the Punjab Agricultural University, Ludhiana. This evaluation revealed that these two WHDs are technically sound and economically viable with good rate of economic returns. The study pointed out that these water harvesting projects are tailored to the dire needs of the people and would promote participatory management of natural resources in the Shivalik region. On such recommendations, the work on the remaining 15 WHDs was initiated by the HCFP.

The project management also decided to evaluate all the 18 dam projects by its internal monitoring system for their both long and short term benefits covering hydrological changes, flow of economic dividends, social and environmental impacts. Such an impact assessment, however, required the establishment of base lines of information on the pre-project status of catchment and command areas including the productivity of crops and live stock and social status of beneficiaries. A study for establishing, such base lines was therefore, carried out by the Chandigarh based Society for Promotion and Conservation of Environment (SPACE).

The survey of the hilly forest catchments of the pilot projects namely Bharauli and Ibrahimpur was carried out in October and November 2001 and report presented to the Project Director HCFP in January 2002. In the 90-hectare forest catchment area of Bharauli, 36 sample plots were established on upper, middle and lower hill slopes. In case of 30-hectare forest catchment area of Ibrahimpur, 27 sample plots were laid. The detailed base line data on tree, bush and grass composition, grass yield, litter accumulation, soil moisture and soil pH was compiled. The changes in the vegetation cover complex of these two pilot projects over a period of 4 years were again recorded from the same sample plots in October – November 2005. The report at hand presents the results of the catchment studies repeated in 2005 and illustrate the details of changes observed in this period.. The practical significance of these changes for the future management of water harvesting dam projects are also highlighted.

MAP OF KANDI AREA (HARYANA)
 DISTRICTS PANCHKULA, AMBALA AND YAMUNANAGAR
 (IWDP HILL II)

SCALE 1:100000



INDEX

- Water Shed Boundary = - - - - -
- Reoch = U - Upper, M - Middle, L - Lower
- River / Nala =

2. METHODOLOGY

As per the terms of reference of the proposed catchment studies in village Bharauli and Ibrahimpur, the same sample plots earlier laid in October–November 2001 for baseline survey were taken for observations. Out of 36 plots of 10m x 10m size randomly selected for Bharauli catchment, 16 plots were located on upper slopes, 14 on middle and remaining 6 plots on the lower slopes. The number of sample plots were decided according to the area of the catchment represented by these three physiographic positions, Similarly in case of Ibrahimpur forest catchment, 11 samples plots were laid on upper, 7 on middle and 9 on lower slopes.

A proforma was designed in consultation with the project authorities to collect information on salient features of each sample plot including aspect, slope, soil, grazing pressure, wild life, erosion status and plant damage etc Annexure-I. The enumeration of tree stock in terms of distribution of various species in girth and height classes and bushes in various height classes was carried out. The number of grass clumps of various species and litter accumulation was recorded from 1m x 1m plots laid at cross section of diagonals of the plots. The soil moisture samples from two soil depths 0-15 cm and 15-30 cm were taken and soil moisture determined gravimetrically as per standard method, Soil pH as determined using pH meter in 1:2 soil water suspension.

In case of grass samples, fresh weight was recorded at site and then air dry weight was recorded till constant weight at room temperature. The same manpower was used in the study which was used earlier for base line studies so that the sample plots could be located exactly at the same place. A map of the catchment with location of sample plots is provided for reference. The base line information is now presented in annexures for comparison. Any additional observation made during the traverse of the catchment area is included in the appropriate sections of the report. Detailed discussions were held with the VRMC members and villagers to, validate and verify the facts noted during the study.

BHARALI CATCHMENT

3.0 VEGETATION STATUS OF BHARAU LI CATCHMENT

3.1 General Description

The main drainage line locally called "Sherwali khol" starts from very close to village Sherwala located on Raipur Rani- Morni pacca road and then flows in southward direction towards village Bharauli (Fig. 2). Several secondary lines both from eastern and western side drains into the main drainage system. Some 5 to 6 hectare area was covered by very steep, bare cliffs which was represented by plot number 4 and 5. Most of the plots are located on aspects of North-East (10), North-West (8), South-West (6), and South-East (5).

The land is located on very steep to steep slopes particularly on upper areas and only seven plots are located on moderate slopes. About 33% of plots represent rocky or shallow rocky area with low soil depth. In rest of the area, the soil stratum is moderately deep to deep. Most of the area is gullied with several soil erosion. Khair was planted in pits before the first survey when base line was carried out. Most of the grasses, bushes and tree species have natural origin.

3.2 Tree Stock Density

3.2.1 Upper Hill Slopes

- In case of upper hill slopes, the overall tree stock density improved barely from 767 to 810 trees / ha thus registering a gain of only 5.6% in a period of 4 years.
- While the overall not seven number of trees was 343, 282, 93 and 49 in 0-15, 15-30, 30-60 and more than 60 cm girth classes in 2001 which changed to 350, 199, 180 and 81 trees in respective girth classes in 2005. This indicated considerable increase in girth as number of trees in 30-60 cm and >60 cm girth classes have almost doubled during this period. A similar trend was noted in height class distribution.
- The number of natural khair and miscellaneous tree species increased from 206 to 244 and from 131 to 312 / ha. The number of Papri trees decreased from 156 to just 19, and planted Khair trees decreased from 212 to 156/ha.

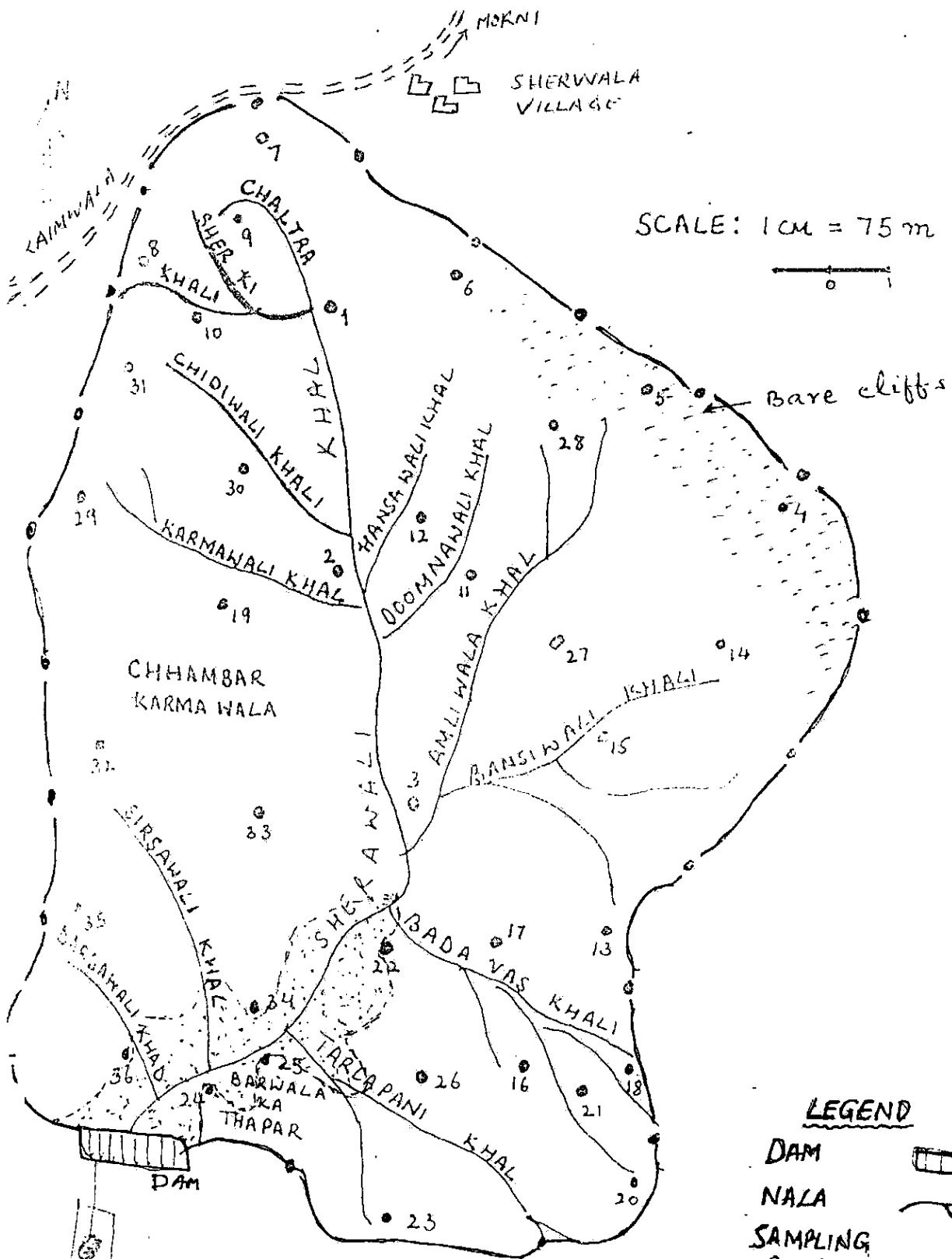


TABLE 30

DESCRIPTION OF SAMPLE PLOTS IN THE CATCHMENT OF BHARALI

Village - Bharali

PLOT NO.	ASPECT	SLOPE	SOIL DEPTH	EROSION STATUS		GRAZING INDICATORS		WILD ANIMAL	PLANT DAMAGE	VEGETATION CONDITION		TREATMENT PLOTS
				Severe erosion	Gullied	Yes	No			Partial	No	
BU-1	N	Very Steep	Rocky	Severe erosion	Gullied	No	No	No	-	Moderate	Mixed	No
BU-4	N	Very Steep	Rocky	Gullied		No	No	No	-	Sparse	-	-
BU-5	NW	V. Steep	Rocky			No	No	No	No	Thick	Natural	No
BU-6	NW	Steep	Rocky	Gullied		No	No	No	Partial	Sparse	Natural	No
BU-7	NE	V. Steep	Shallow Rocky	Gullied		No	No	No	Partial	Moderate	Natural	No
BU-8	SE	Steep	Mod. Deep rocks	Gullied		No	No	No	No	Thick	Natural	No
BU-13	N	V. Steep	Deep	Slip Erosion		No	No	No	Partial	Sparse	Natural	No
BU-14	SE	M. Steep	Mod. Deep	Mild Erosion		No	No	No	No	Moderate	Natural	No
BU-18	SE	V. Steep	Landslide	Slip Erosion		No	No	No	No	Moderate	Natural	No
BU-20	NW	V. Steep	Deep	Landslide		No	No	No	No	Sparse	Natural	No
BU-23	NW	Steep	Rocky	Gullied		No	No	No	Partial	Moderate	Natural	No
BU-28	NE	Steep	Deep	Landslide		No	No	No	Partial	Absent	Natural	No
BU-29	NW	Slight	Rocky	Mild Erosion		Yes	No	No	No	Thick	Natural	No
BU-31	NE	Steep	Rocky	Gullied		No	No	No	No	Moderate	Natural	No
BU-32	NE	Steep	Rocky	Gullied		No	No	No	No	Thick	Natural	No
BU-35	NW	V. Steep	Deep Stones	Gullied		No	No	No	Partial	Moderate	Natural	No
BM-2	N	V. Steep	Mod. Deep	Gullied		No	No	No	Partial	Thick	Mixed	Yes
BM-9	E	V. Steep	Mod. Deep	Gullied		Yes	No	No	Partial	Moderate	Mixed	Yes
BM-10	SW	V. Steep	Mod. Deep	Gullied		No	No	No	Partial	Moderate	Mixed	Yes
BM-11	SW	V. Steep	Deep Eouiders	Slip Erosion		No	No	No	Partial	Moderate	Mixed	Yes
BM-12	E	V. Steep	Deep	Slip Erosion		No	No	No	Partial	Thick	Mixed	Yes
BM-15	NE	Moderate	Mod. Deep	No Erosion		No	No	No	Partial	Thick	Mixed	Yes
BM-16	SW	Moderate	Landslide	Slip Erosion		No	No	No	Partial	Moderate	Mixed	Yes
BM-17	NW	Steep	Deep	Gullied		No	No	No	No	Thick	Natural	No
BM-19	NE	V. Steep	Deep	Landslide		No	No	No	No	Moderate	Natural	No
BM-21	SE	V. Steep	Deep	Landslide		No	No	No	No	Moderate	Natural	No
BM-24	W	V. Steep	Deep	Landslide		No	No	Yes	Partial	Moderate	Natural	No
BM-27	NE	Moderate	Rocky	Gullied		No	No	Yes	No	Moderate	Mixed	Yes
BM-30	NE	Moderate	Rocky	Rill Erosion		No	No	No	No	Moderate	Natural	No
BM-33	SW	Steep	Rocky	Gullied		No	No	No	No	Thick	Natural	No
BL-3	NE	Moderate	Deep	Rill Erosion		No	No	No	Partial	Thick	Mixed	Yes
BL-22	SE	Slight	Deep	Sheet Erosion		No	No	No	No	Moderate	Natural	No
BL-25	SW	Slight	Deep	Rill Erosion		No	No	No	No	Moderate	Natural	No
BL-26	SW	Moderate	Mod Deep	Sheet & Rill Erosion		No	No	No	Partial	Moderate	Natural	No
BL-34	NE	Slight	Deep	Sheet & Rill Erosion		No	No	No	Partial	Moderate	Natural	No
BL-36	NW	Moderate	Deep	Rill Erosion		No	No	No	No	Moderate	Mixed	Yes

- The stock to Neero trees marginally improved from 37 to 49 and that of Amaltas from 25 to 30 trees / ha in this period.
- While a high rate of mortality was noted in planted Khair but, a lions share of natural Papri trees have also vanished.
- There was no major forest fire in the last 4 years in this area. This elimination of young seedlings of Khair and Papri is due to bush evasion.

3.2.2. Middle Hill Slopes

- The tree stocks were maximum in middle of hill slopes. The overall stock density improved from 1535 to 2056 trees / ha between 2001 and 2005 thus recording an increase of 33.9 percent over the base level in this period.
- The overall number was 1000,263,179 and 93 trees / ha in 2001 which increased to 1186, 485, 221 and 164 trees / ha in 2005 in girth classes of 0-15, 15-30, 30-60 and > 60 cm respectively. There was consistent rise in number of trees in each height and girth class. The increase in number of trees in 0-15 cm class shows addition of new recruits through natural regeneration. The overall growth pattern has been clearly indicated by increasing number of trees in higher height and girth classes.
- Both planted and natural Khair and miscellaneous tree species have dominated the mid-hill slopes. There were no trees of Amaltas and Neero before the project and now 7 trees of Neero and 14 trees / ha of Amaltas have been added. Here again Papri trees have decreased from 21 to 14 trees / ha due to similar reasons.
- The number of Khair trees both natural and planted in >60 cm girth class were only 43/ ha in the year 2001 which increased to 100 trees / ha in 2005. Similarly, the number of miscellaneous tree species in this class also registered an increase from 93 to 164 trees / ha. This trend of tree species gradually Jumping from lower to higher girth and height classes indicate increase in forest trees cover and enrichment of tree stock.

- The mortality of planted Khair seedlings noted on higher hill slopes (as their number in 0-15 cm girth class decreased from 206 to 75/ha) was not observed on mid-hill slopes.

3.2.3 Lower Hill Slopes

- Though the site conditions for growth of trees are better on lower hill slopes but effective area under trees is reduced because of the presence of larger gullies in this physiographic zone. The overall tree stock density on lower hill slopes has increased from 1035 to 1534 trees / ha between 2001 and 2005, thus registering an increase of 48.2% this period against 5.6% increase on upper and 33.9% on mid-hill slopes. Better moisture regime in the peripheral areas of the reservoir which falls in lower hill slopes appears responsible for better tree growth.
- The overall tree number was 634,34,350 and 17 trees / ha before the project in 2001 which increased to 667, 483, 317 and 67 trees / ha in 0-15, 15-30, 30-60 and >60 cm girth classes respectively. A sizeable number of trees have been added to 15-30 cm girth class in last 4 years indicating faster growth of younger stock.
- The number of planted khair trees have increased from 267 to 516 trees / ha indicating better survival and growth performance of planted seedlings in lower hill slopes where moisture conditions are much better than upper hill slopes where Khair mortality was noted.
- The number of miscellaneous tree species have also recorded 47% increase in 4 years where large number of trees like Neem and Kikar, have shown their presence.
- Amaltas was conspicuous by its absence and papri trees have not been added.

Table 3.1 Tree stock distribution (Na/ha) before and after the project in girth and height classes in sample plots on three hill slopes at Bharauli.

A- Upper Slopes (Mean of 16 plots)

Name of tree species	Before /After	Girth class distribution (cm)					Height class distribution (m)				
		0-15	15-30	30-60	>60	Total	0-2	2-4	4-6	>6	Total
Khair Natural	Before	19	94	62	31	206	13	94	68	31	206
	After	19	50	131	44	244	19	38	106	81	244
Khair Planted	Before	206	-	6	-	212	206	-	6	-	212
	After	75	81	-	-	156	75	81	-	-	156
Neero	Before	19	6	-	12	37	12	12	-	13	37
	After	6	19	12	12	49	6	19	12	12	49
Amaltas	Before	6	19	-	-	25	6	6	-	13	25
	After	-	12	12	6	30	-	-	12	18	30
Papri	Before	37	119	-	-	156	156	-	-	-	156
	After	19	-	-	-	19	19			-	19
Others	Before	56	44	25	6	131	69	37	12	13	131
	After	231	37	25	19	312	225	37	37	13	312
G. Total	Before	343	282	93	49	767	462	149	86	70	767
	After	350	199	180	81	810	344	175	167	124	810

B- Middle Slopes (Mean of 14 plots of 10 m x 10 m size)

Name free species	Number Before / After	Girth class distribution					Height class distribution (m)				
		0-15	15-30	30-60	>60	Total	0-2	2-4	4-6	>6	Total
Khair Natural	Before	200	21	143	43	407	128	79	86	114	407
	After	136	93	150	86	465	122	100	57	186	465
Khair Planted	Before	600	57	-	-	657	628	-	-	29	657
	After	793	100	7	14	914	664	150	71	29	914
Neero	Before	-	-	-	-	-	-	-	-	-	-
	After	-	7	-	-	7	-	7	-	-	7
Amaltas	Before	-	-	-	-	-	-	-	-	-	-
	After	-	14	-	-	14	-	14	-	-	14
Papri	Before	7	14	-	-	21	7	14	-	-	21
	After	-	14	-	-	14	-	14	-	-	14
Others	Before	193	171	36	50	450	214	129	28	79	450
	After	257	257	64	64	642	278	214	43	107	642
Total	Before	1000	263	179	93	1535	977	222	114	222	1535
	After	1186	485	221	164	2056	1064	499	171	322	2056

C- Lower Slopes (MEAN OF 6 PLOTS OF 10 X 10)

Name of tree species	Number Before / After	Girth class distribution (cm)					Height class distribution (m)				
		0-15	15-30	30-60	>60	Total	0-2	2-4	4-6	76	Total
Khair Natural	Before	200	-	250	-	450	200	50	50	150	450
	After	133	117	217	50	517	100	150	67	200	517
Khair Planted	Before	267	-	-	-	267	267	-	-	-	267
	After	383	133	-	-	516	383	133	-	-	516
Neero	Before	67	17	33	-	117	17	50	50	-	117
	After	17	83	50	-	150	17	67	66	-	150
Amaltas	Before			-	-		-	-	-	-	-
	After	-	-	-	-	-	-	-	-	-	-
Papri	Before	33	-	-	-	33	17	16	-	-	33
	After	17	17			34	-	34	-	-	34
Others	Before	67	17	67	17	168	67	17	67	17	168
	After	117	133	50	17	317	100	100	100	17	317
G. Total	Before	634	34	350	17	1035	568	133	167	167	1035
	After	667	483	317	67	1534	600	484	233	217	1534

3.3 Bush Stock Density

- There has been tremendous increase in bush stock during the last four 4 years. The bush density increased from 2504 to 5953 on upper, 5677 to 9157 on middle and 3701 to 6835 bushes / ha on lower hills slopes, thus recording a rise of 137, 61 and 85 percent over the base number of bushes. While there was no increase in Kuri and marginal or no increase in Basuti but spectacular rise in Lantana, Karaunda, Curry Patta and miscellaneous bush species was noted, on all the three hill slopes.
- The upper slopes have been invaded by Lantana and miscellaneous bush species as their number has increased from 1256 to 2674 and from 280 to 1419 /ha respectively. The overall number of bush species in upper slopes registered an increase from 762 to 2762 / ha in 0-1 m height class, 1568 to 2861 / ha in 1-2 m height class and from 174 to 330 / ha in >2 m height class.
- The mid-hill slopes have been most dominated by bush species and to this significant addition have been made by miscellaneous species (695 to 2011 /ha) and Curry Patta (393 to 996 / ha),
- Lantana and Karaunda have also registered an increase of 42 and 20% respectively.
- The lower hill slopes have been invaded by miscellaneous bush species as their number registered a quantum jump from merely 50 to 1434 / ha. While the number of Karaunda has just doubled, the bush species like Curry Patta, Basuti and Lantana have also increased by 25 to 50 percent.
- The sharp increase in miscellaneous bush species indicate the increased richness in bio-diversity. A general rise in height of bush species indicate better moisture conditions and nutrient cycling.
- The thick canopy of bushes is sure to reduce run off and soil loss to the reservoir down below. It would also adversely affect the regeneration of natural tree species. Bushes would, however, positively contribute to litter accumulation and reduce soil erosion.

Table 3.2 Shrub density in forest catchment area of Bharauli reservoir by height classes (m) before and after dam construction on three slopes positions (no/ha)

Name of shrub species	Number before and after	Upper slopes (Mean of 16 plots)				Middle slopes (Mean of 14 Plots)				Lower slopes (Mean of 6 plots)			
		0-1	1-2	>2	Total	0-1	1-2	>2	Total	0-1	1-2	>2	Total
Lantana	Before	294	962	-	1256	567	2596	64	3227	-	2551	-	2551
	After	406	2156	112	2674	1252	2724	594	4570	633	1417	1567	3617
Basuti	Before	-	75	150	225	302	9	-	311	483	-	-	483
	After	131	87	150	368	228	91	-	319	467	133	-	600
Karaunda	Before	81	194	6	281	786	64	201	1051	300	117	-	417
	After	631	256	31	918	859	384	18	1261	500	367	17	884
Kuri	Before	-	319	-	319	-	-	-	-	-	-	-	-
	After	-	250	-	250	-	-	-	-	-	-	-	-
Curry Patta	Before	131	6	6	143	27	128	238	393	-	200	-	200
	After	250	62	12	324	457	484	55	996	33	267	-	300
Others	Before	256	12	12	280	110	457	128	695	-	50	-	50
	After	1344	50	25	1419	1408	603	-	2011	1234	183	17	1434
Total	Before	762	1568	174	2504	1792	3254	631	5677	783	2918	-	3701
	After	2762	2861	330	5953	4204	4286	667	9157	2867	2367	1601	6835

3.4 Grass Stock and Yield

Grasses became the major casualty in the process of forest catchment rehabilitation through control of biotic interference imposed by social fencing. In the upper hill slopes, the number of grass clumps were reduced from 100 to 42.2 / m². Bhabar grass which was earlier available in all the 16 plots on upper hill slopes was now available on 8 plots and its mean clump number was reduced from 16.1 to 3.4 / m² in the last 4 years. While the highest number of clumps / plot was 120 earlier, it was reduced to just 10 in 2005. Grasses like Khabbal and Dabb have practically disappeared. The numerical strength of Sarala and Dholu have come down from 12.3 to 9.5 and from 54.9 to 15.0 clumps / m².(Table)

Table 3.4 Number of grass clumps on three hill slopes before and after the project 4 years.

Hill Slopes	Period	Number Of Grass Clumps / m ² area						
		Bhabar	Dabb	Dholu	Sarala	Khabal	Others	Total
Upper slopes (Mean of 16 plots)	Before	16.1	0.5	54.9	12.3	0.9	15.3	100
	After	3.4	0.1	15.0	9.5	-	14.2	42.2
Middle slopes (Mean of 14 plots)	Before	32.1	3.9	39.0	4.9	0.8	9.9	90.6
	After	5.9	0.4	10.9	3.0	0.5	13.3	34.0
Lower slopes (Mean of 6 plots)	Before	8.3	-	20.5	6.7	0.3	16.1	51.9
	After	4.5	-	9.5	5.3	0.8	3.7	23.8

Similar is the case of mid-hill slopes, the mean number of grass clump has come down from 90.6 to 34.0 /m². Dholu was the most predominant grass followed by Bhabar but now their number has come down from 39.0 to 10.9 and from 32.1 to 5.9 clumps / m² respectively. The number of miscellaneous grass species of non-descript nature have gone up from 9.9 to 13.3 clumps / m² but important grasses like Khabal, Dholu, Sarala are getting shaded out due to powerful bushes like Lantana and Karonda. Bhabar grass was present

in all the plots located on mid-hill slopes but its number has dwindled very badly.

In case of lower hill slopes too, the total number of grass clumps was reduced from 51.9 to 23.8 m². Though Dholu, Sarala and Bhojar have shown their presence but their number has significantly come down.

The Local communities heavily depend on forests for forage grasses but invasion of abnoxious weeds like Lantana have reduced the availability of such grasses. This is true for areas even outside the project catchments. Even if grass is present in some areas, the extraction has become a problem as all footpaths have been covered by thorny Lantana bushes. The survey team had to clear lot of Lantana to make passage for sample plots. Women folk, which used to collect grasses have lost their bottle against Lantana and do not venture to enter such Lantana infested areas.

It is surprising to note that though number of grass clumps have decreased drastically, the mean air-dry grass yield has gone up from 122 to 274 gms / m² between 2001 and 2005 (Table)

Table 3.5 Mean air-dry grass biomass in sample plots of Bharauli forest catchment before and after the project on three hill slopes.

Period	Mean air dry grass yield (gms/m ²) on three hill slopes			
	Upper slopes	Middle slopes	Lower slopes	Mean
Before	121	175	71	122
After	231	266	324	274
% Increase	91	52	356	125

The mean grass yield has increased on all the hill slopes but lower hill slopes registered a quantum jump mainly because of better moisture regime in the peripheral area of the reservoir. It was noted that grasses and bushes in this area have made a vegetative barrier which is holding back the soil being eroded from upper and middle slopes. The deposition of eroded soil is

also promoting vegetation growth. These areas were under great grazing pressure before the dam construction. Lesser number of clumps per unit area but better grass yield indicate that clump size has improved due to better moisture regime and soil deposition. This may itself be the reason of reduction in number of clumps / m². The grass weight per clump has increased from 0.12 to 0.55, from 0.19 to 0.78 and from 0.14 to 1.76 gms in upper, middle and lower hill slopes.

The air dry grass yield of 122 gms / m² is equivalent to 1.22 t/ha which has gone up to 2.74 t/ha. This is by far not a big deal but still such a gain over an 85 ha of catchment (90 ha- 5 ha of water body) would be 129 tonnes which at a very nominal rate of Rs. 500 / t would be worth Rs. 64500 /.

3.5 Litter Accumulation

The accumulation of leaf and branch litter on forest floor is directly related to the extent of canopy cover and provides a very good index of soil amelioration. It is satisfying to note that overall mean air-dry litter biomass accumulation on soil surface increased from 1.59 to 2.28 t/ha thereby registering a gain of 43.9 percent (table)

Table3.6 Mean air-dry litter accumulation in three hill slopes in forest catchment of Bharauli before and after the project.

Period	Mean air dry litter biomass (t/ha) on three slopes			
	Upper slopes	Middle slopes	Lower slopes	Mean
Before	0.98	1.18	2.61	1.59
After	1.15	1.71	3.99	2.28
% Increase	17.6	45.4	53.1	43.9

The upper, middle and lower hill slopes registered an increase of 17.6, 45.4 and 53.1% over the base levels in a span of 4 years. The accumulation of litter on soil surface not only check soil erosion by reducing the direct impact of rain drops (dissipation of kinetic energy of rain drops) but also arrest over-flowing sediment in suspended form, reduce nutrient loss and promote biological activity.

The overall quantity of leaf litter is quite small. One reason is that some plots are located on bare hill slopes where there is no increment. Some plots have gained even upto 5 t/ha. Once the process of accumulation starts, it gains momentum provided external influences like forest fires remain under control.

3.6: Soil Moisture and Soil pH

The soil moisture in 0-15 and 15-30 cm layers was almost near wilting point when base line was carried out in October 2001. The range was 2.7 to 6.3 percent. Though no rain was received between monsoon end and end of October 2005 when again soil samples were taken for moisture measurement. The soil moisture both at in 0-15 and 15-30 cm soil depth was near field capacity (optimum range) and varied from 7.8 to 8.5 percent (table). It appears that bushes are providing shade and leaf letter is acting as mulch which combined together are promoting moisture retention.

Table 3.7: Change in soil properties on three hill slopes of Bharauli catchment.

Property	Period	Soil depth 0-15 cm			Soil depth 15-30 cm		
		Upper slope	Middle slope	Lower slope	Upper slope	Middle slope	Lower slope
Soil moisture	Before	3.2	3.2	2.7	5.2	6.3	4.3
	After	7.1	8.8	7.8	8.0	9.7	8.7
Soil pH	Before	6.8	6.6	6.6	7.6	7.3	7.2
	After	8.1	8.2	7.8	8.5	8.3	8.1

There are signs of rise in soil pH in both the depth and on all three slopes. The soil pH levels recorded in October 2005 are in the expected range. More detailed investigations are required to find out the precise reasons for the rise in soil pH.

Table : Soil moisture, pH, leaf litter and air dry grass biomass in different sample plots of Bharauli catchment.

Stratum	0-15			05-30			Leaf litter biomass gm/m ²	Air dry grass biomass gms/m ²
	Soil moisture %	Texture	pH	Soil moisture %	Texture	pH		
BU 1	0.1	SL	8.2	10.8	SL	8.6	180	230
BU 4	7.5	CL	8.5	9.6	L	8.6	160	130
BU 5	7.0	SL	7.7	7.2	L	7.9	150	190
BU 6	5.9	LS	7.7	6.1	L	7.6	190	110
BU 7	8.4	LS	8.2	9.3	L	8.4	115	190
BU 8	4.7	S	8.9	6.9	SL	9.0	100	170
BU 13	6.2	SL	7.7	9.2	LS	7.8	75	50
BU 14	8.6	LS	8.2	8.2	SIL	8.1	60	355
BU 18	8.3	SL	8.2	8.7	LS	8.4	150	490
BU 20	5.5	SL	8.1	6.4	SL	8.0	100	295
BU 23	4.2	SIL	7.8	4.9	LS	7.7	170	270
BU 28	6.9	SL	8.6	6.4	LS	8.7	110	450
BU 29	7.1	LS	8.1	5.9	SL	8.3	70	250
BU 31	7.6	SL	8.0	8.6	SIL	9.3	100	365
BU 32	7.1	SL	8.1	7.7	L	8.5	30	180
BU 35	10.0	SL	8.9	12.0	SL	8.8	100	500
Mean	7.1		8.1	8.0		8.5	115	231
BM 2	7.1	SL	8.1	6.5	LS	8.1	315	185
BM 9	13.8	LS	8.6	13.1	LS	8.7	660	140
BM 10	7.3	CL	7.7	7.8	CL	7.7	120	220

BM 11	6.0	SL	8.2	9.8	SL	8.6	30	320
BM 12	11.1	SIL	8.3	11.6	LS	8.4	180	110
BM 15	12.5	SL	8.1	15.0	SL	8.4	70	550
BM 16	7.7	LS	8.2	8.4	LS	8.5	120	210
BM 17	5.9	LS	8.2	8.6	LS	8.4	180	390
BM 19	8.3	LS	8.0	8.3	LS	8.1	80	245
BM 21	7.1	LS	8.1	7.6	LS	8.3	245	180
BM 24	10.3	SL	7.7	9.8	SL	7.8	70	600
BM 27	6.8	SL	8.1	7.6	L	8.3	45	215
BM 30	6.9	LS	8.7	9.0	LS	9.2	105	175
BM 33	12.2	SL	8.1	12.7	LS	8.3	175	250
Mean	8.8		8.2	9.7		8.3	171	266
BL 3	8.0	SL	7.6	10.6	LS	7.8	1170	300
BL 22	9.8	S	7.8	10.1	LS	8.3	140	650
BL 25	6.9	LS	7.8	6.7	LS	8.1	240	160
BL 26	4.3	SL	7.7	6.7	LS	8.1	180	65
BL 34	10.2	SL	8.0	11.3	SL	8.2	565	545
BL 36	7.5	L	8.1	8.8	SL	8.2	140	230
Mean	7.8		7.8	8.7		8.1	399	324

IBRAHIMPUR CATCHMENT

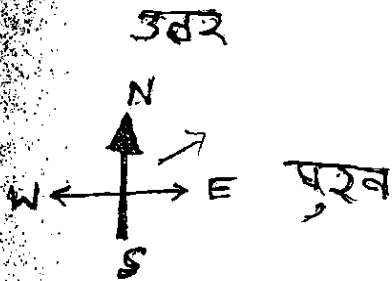
4. VEGETATION STATUS OF IBRAHIMPUR CATCHMENT.

4.1 General Description

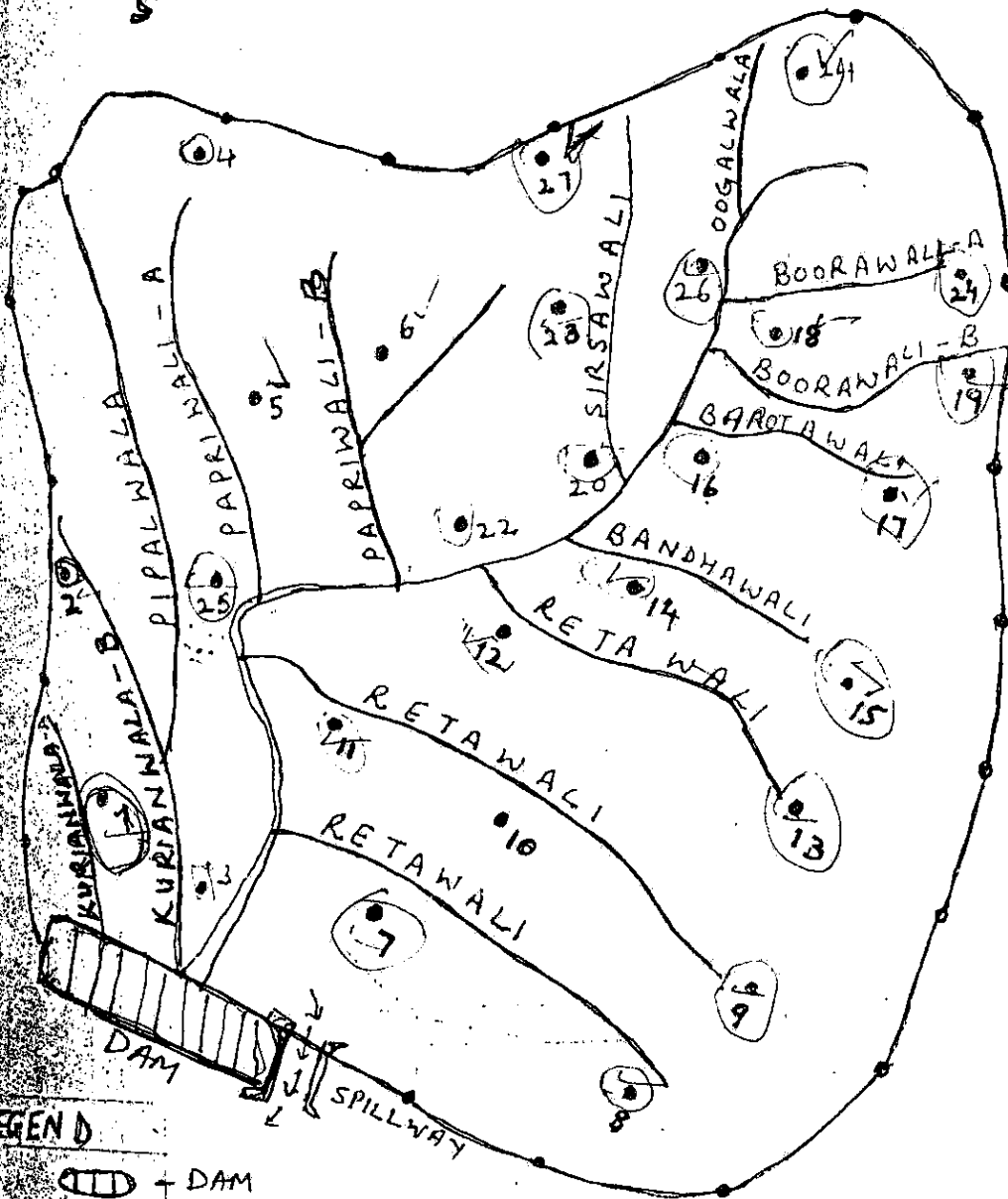
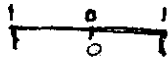
This is almost a square shaped micro-watershed covering 30 ha of forest area. The main drainage lines originate from North-Eastern corner and flows almost diagonally to the South-West end where a 9 metre high earthen dam creates a reservoir. Several secondary lines drain directly into the main from both eastern and western sides almost at regular interval. The landscape was represented by 27 plots of 10 m x 10 m size out of which 12 plots were located on western side of the main and remaining 15 plots on the eastern side. This division is almost in proportion to the area on both the sides. The topography was represented by 11 plots on the higher slopes, 7 plots on the middle and 9 on the lower slopes. Each sample plot represented on area of 1.1 ha of forest catchment. As per the orientation of the micro-watershed, 7 plots have been located on East facing aspect, 7 on West facing, 6 on North-West, 3 each on North-East and South-West and the last one faces South-East.

The slopes are steep to very steep in upper areas, moderate to steep in middle and moderate at the base, The soil depth is generally moderately deep to deep in middle and lower slopes but rocky and shallow rocky/stony in few plots on higher slopes. Soil erosion was severe in gullied area in middle and higher slopes but rill erosion was common on lower flatter slopes. Except some upper areas, indications of grazing was common and plant damage in the form of nibbling, lopping, branch cutting and digging of stumps was observed. This area was planted to Khair at the time of base line survey but planting was only in patches. The overall vegetation cover was moderate to thick with dominance of bushes. Some area was once planted to Eucalyptus in the flatter bed and the same was harvested before 2001 but some re-sprouting was there and the same continued till the final survey. The signs of cutting of trees were also noted. Grazing was common near the reservoir area as livestock is taken to watering from this and nearby villages also.

Catchment area of Village Ibrahimpur



SCALE: 1cm = 37.5 m.



LEGEND

- DAM
- NALA
- SAMPLE PLOT

Village -Ibrahimpur

Description of sample plots in catchment area

Stratum	Aspect	Slope	Soil Depth	Erosion Status	Grazing Indicator	Wild Animals	Plant Damage	Vegetarian Growth	Origin of tree vegetation	Treatment Pits
IU-2	NE	Steep	Rocky	Severe Erosion & gullied	No	No	Partial	Moderate	Mixed	Yes
IU-4	E	Steep	Rocky & Shallow	Gullied	Yes	Yes	Partial	Sparse	Mixed	Yes
IU-8	NW	Steep	Mod. Deep	Gullied	Yes	No	Partial	Moderate	Mixed	Yes
IU-9	NW	Steep	Mod. Deep	Gullied	No	No	Partial	Thick	Mixed	Yes
IU-13	NW	V. Steep	Deep	Gullied	No	No	No	Thick	Mixed	Yes
IU-15	W	V. Steep	Deep	Gullied	No	No	No	Thick	Natural	Yes
IU-17	W	Steep	Shallow Stony	Gullied	No	No	Partial	Moderate	Mixed	Yes
IU-19	NE	Steep	Deep with boulders	Gullied	Yes	No	No	Moderate	Mixed	Yes
IU-21	E	Steep	Deep	Gullied	No	No	Partial	Thick	Mixed	Yes
IU-24	W	V. Steep	Mod. Deep	Gullied	Yes	No	Partial	Thick	Mixed	Yes
IU-27	SW	V. Steep	Mod. Deep	Gullied	Yes	No	Partial	Moderate	Mixed	Yes
IM-1	NE	Moderate	Mod. Deep rocky	Gullied	Yes	No	Partial	Moderate	Natural	No
IM-5	W	V. Steep	Deep	Severe Erosion & gullied	Yes	Yes	No	Sparse	Natural	No
IM-6	W	Steep	Deep	Gullied	Yes	No	Partial	Moderate	Mixed	Yes
IM-7	W	Moderate	Mod. Deep	Mild Erosion	No	No	Partial	Thick	Mixed	Yes
IM-10	NW	Moderate	Mod. Deep	Rill Erosion	Yes	No	Partial	Thick	Mixed	Yes
IM-23	W	Steep	Deep	Gullied	Yes	No	Fully Damaged	Thick	Mixed	No
IM-26	E	Steep	Deep Stones	Gullied	Yes	No	No	Thick	Mixed	No
IL-3	E	Moderate	Mod. Deep	Gullied	Yes	No	Partial	Moderate	Mixed	Yes
IL-11	NW	Slight	Deep	Sheet & Rill Erosion	Yes	No	Partial	Thick	Mixed	Yes
IL-12	NW	Moderate	Mod. Deep	Gullied	Yes	Yes	Partial	Sparse	Mixed	Yes
IL-14	SW	Steep	Deep	Mild erosion	Yes	No	Partial	Thick	Natural	No
IL-16	SW	Moderate	Deep with pebbles	Rill erosion	Yes	No	Fully Damaged	Moderate	Mixed	Yes
IL-18	E	Moderate	Deep & Sandy	Rill erosion	Yes	No	Partial	Moderate	Mixed	Yes
IL-20	E	Moderate	Deep Stones	Rill erosion	Yes	No	Partial	Moderate	Natural	No
IL-22	E	Moderate	Moderately Deep	Rill erosion	Yes	No	No	Moderate	Natural	No
IL-25	SE	Steep	Mod. Deep rocky	Gullied	Yes	No	Partial	Moderate	Mixed	Yes

4.2 Tree Stock Density

4.2.1 Upper Hill Slopes

- The overall tree stock density in upper hill slopes of Ibrahimpur forest catchment improved from 1553 to 1789 trees / ha thus registering an increase of 15.2% in a period of 4 years.
- The overall number in 0-15, 15-30, 30-60 and >60 cm girth class was 1237, 199, 90 and 27 trees / ha in 2001 which changed to 1018, 645, 108 and 18 trees / ha in 2005. The number increased considerably in 15-30 and 30-60 cm girth classes and 2-4 m and 4-6 m height classes of trees in >60 cm girth class from 27 to 18 or from 54 to 27 in 76 m height class thus indicating growth increment. But decrease in number trees remains a cause of concern. This decrease is indicative of extraction of 9 mature Khair trees.
- There was mortality in younger tree stock (0-15 cm girth or 0-2 m height class) of Khair, Amaltas, and Tendu which, however, was off-set by substantial increase in younger stock of other miscellaneous tree species. The miscellaneous tree species constituted 31% of total stock earlier and this share increased to 44% in the year 2005.
- There was spectacular increase in younger stock of Tendu trees but the stock of Kandai trees, remained unchanged.
- A cause of worry in case of Ibrahimpur catchment remains that the percentage of large size trees to total stock have not changed. It was 7.5 percent in 2001 (trees in 30-60 and > 60 cm class). and 7.0 percent of total stock in 2005. Contrary to this, the percentage of total tree stock in both of these classes in case of Bharauli was 18.5 % in 2001 which increased to 32.2 % in 2005. The inescapable conclusion is that large size trees are being axed in this catchment.

4.2.2 Middle Hill Slopes

- As expected, the tree stock density in middle hill slopes was much higher as compared to upper hill slopes. The overall tree stock density improved from 2127 trees in 2001 to 2956 trees / ha in the year 2005, thereby registering an increase of 38.9 % over the original stock.
- The overall number of all tree species was 1785, 242,100 and zero in 2001 which changed to 1486, 1343, 99 and 28 trees / ha in girth classes of 0-15, 15-30, 30-60 cm and > 60 m girth classes respectively. The maximum increment was observed in 15-30 cm girth class against no change in 30-60 cm girth class. The number of trees more than 6m height even in 2005 was just 28 out of 2956 trees / ha i.e. less than 1 %. These observations confirm the removal of larger size trees.
- The young Khair seedlings have suffered a severe mortality as their number in 0-15 cm girth class have dwindled during these four years.
- There was spectacular increase in the number of miscellaneous tree species particularly the younger stock falling in 0-15 and 15-30 cm girth classes and 0-2 and 2-4 m height classes.
- The point of concern is that the younger stock of Khair is being replaced by the younger stock of miscellaneous tree species of Power economic importance. Secondly, the share of large size trees of > 60cm girth to total population is quite small which appears to be due to removal of larger size trees.

4.2.3 Lower Hill Slopes

- The overall stock density in valley areas improved from 2598 to 2866 trees / ha between 2001 and 2005 thereby registering a nominal rise of 10.4 percent.
- The overall number of trees was 1355, 1177, 44 and 42 trees / ha in 2001 which changed to 966, 1333, 500 and 67 trees / ha in 2005 in 0-15, 15-30 30-60 cm and >60 cm girth classes. A substantial increase in the number of trees was observed in 30-60 cm girth class, mainly by Eucalyptus trees stock, which added coppiced shoots after harvest made before 2001. Here

again, the number of trees in > 60 cm girth or > 6 m height class is very small and that too of Eucalyptus which shows removal of tree stock, as well.

- The stock of Khair trees was very small in this zone even earlier and this situation remained unchanged even in 2005. Though there was some gain in the stock of Amaltas but 22 matured trees / ha have disappeared in this case.
- While Tendu trees have shown growth increment, a substantial stock of 100 trees / ha of young seedlings of Kaudai have been added. Miscellaneous tree species and Tendu combined together formed the major share of the stock.
- The presence of a very small percentage of trees in harvestable girth class remain the cause of worry while a good number has been added in 30-60 cm girth class.

Table 4.1 Tree stocking before and after the project in girth and height classes in the catchment of Ibrahimpur project.

A- Upper Slopes

Name of trees species	Before / After	Girth class distribution (cm)					Height class distribution (m)				
		0-15	15-30	30-60	>60	Total	0-2	2-4	4-6	>6	Total
Khair	Before	554	9	18	9	590	554	9	-	27	590
	After	273	45	27	*	345	273	45	27	*	345
Amaltas	Before	91	-	9	-	100	73	18	-	9	100
	After	36	82	18	-	136	27	73	27	9	136
Eucalyptus	Before	-	-	-	-	-	-	-	-	-	-
	After	-	-	-	-	-	-	-	-	-	-
Tender	Before	273	27	18	9	327	146	154	27	-	327
	After	236	218	18	9	481	236	218	18	9	481
Kandi	Before	18	18	-	-	36	18	18	-	-	36
	After	-	-36	-	-	36	-	36	-	-	36
Others	Before	301	145	45	9	500	219	236	27	18	500
	After	473	264	45	9	791	554	192	36	9	791
Total	Before	1237	199	90	27	1553	1010	435	54	54	1553
	After	1018	645	108	18*	1789	1090	564	108	27*	1789

* Removal of trees of larger sizes.

B- Middle Slopes

Name of trees species	Before after	Girth class distribution (cm)						Height class distribution (m)					
		0-15	15-30	30-60	>60	Total	0-2	2-4	4-6	>6	Total		
Khair	Before	443	57	-	-	500	-	229	-	42	500		
	After	71	14	29	-	114	-	14	14	114			
Amaltas	Before	128	43	43	-	214	-	43	43	214			
	After	157	143	28	-	328	-	172	28	328			
Eucalyptus	Before	100	-	-	-	100	-	43	-	100			
	After	-	100	-	-	100	-	72	28	100			
Tendu	Before	828	43	57	-	928	-	300	57	928			
	After	786	529	14	28	1357	-	658	99	1357			
Kandai	Before	57	28	-	-	85	-	57	28	85			
	After	72	57	28	-	157	-	72	57	157			
Others	Before	229	71	-	-	300	-	114	28	300			
	After	400	500	-	-	900	-	514	-	900			
Total	Before	1785	242	100	-	2127	-	729	156	2127			
	After	1486	1343	99	28	2956	-	1400	226	2956			

C- Lower Slopes

Name of tree species	Before / After	Girth class distribution (cm)						Height class distribution (m)					
		0-15	15-30	30-60	>60	Total	0-2	2-4	4-6	>6	Total		
		44	-	-	-	44	33	11	-	-	44		
Before	11	33	-	44	11	33	-	-	44				
After	67	144	22	255	144	89	22	-	255				
Before	133	100	67	300	133	123	44	-	300				
After	311	44	-	355	267	88	-	-	355				
Before	-	133	300	500	123	88	267	-	500				
After	400	400	-	800	123	677	-	-	800				
Before	133	567	22	722	111	544	67	-	722				
After	33	22	-	55	22	33	-	-	55				
Before	134	22	-	156	123	22	11	-	156				
After	500	567	22	1089	811	278	-	-	1089				
Before	555	478	111	1144	655	378	111	-	1144				
After	1355	1177	44	2598	1400	1176	22	-	2598				
Before	966	1333	500	2866	1156	1188	500	22	2866				
After													

4.3 Bush Stock Density

- The bush stock registered a consistent rise on all the three hill slopes. Such a rise was from 5198 to 9115 bushes / ha on upper hill slopes, (75% rise), from 6311 to 8482 bushes/ ha on middle hill slopes (a rise of 34%) and from 7488 to 10629 bushes /ha on lower hill slopes (a rise of 42%).
- The comparison of Bharauli and Ibrahimpur catchment with respect to change in bush density shows that the mean stock in Bharauli rose from 3960 to 7315 bushes / ha or a rise of 73 % over the base year. In case of Ibrahimpur, the mean stock rose from 6332 to 9409 bushes / ha or a rise of 49 % in the same period.
- In case of upper slopes, Lantana, Karonda and Kuri registered an increase of 20, 1, and 43% respectively over the base numbers. However, Curry Patta and miscellaneous bush species recorded spectacular rise from 182 to 409 and from just 218 to 3153 bushes / ha.
- The rise in bush density on middle slopes was marginal in case of Karonda but 44% in case of Lantana. While Kuri got a set back and its strength decreased from 714 to 614 bushes/ha but again Curry Patta and miscellaneous bush species recorded an abrupt rise of 224 and 365%.
- The rise of 42% in bush density on lower hill slopes was mainly contributed by Lantana (29%), Karonda (41%) and miscellaneous bush species (182%), While Kuri registered a rise of 22%, the number of Curry Patta marginally decreased from 184 to 177 bushes / ha. Basuti has shown its presence only on this slope but in small numbers. The gain in height was significant in case of Lantana but not in Karonda and other bushspecie

Table 4.2: Bush Density in Forest Catchment area of Ibrahimpur by height classes before and after dam construction on three slope (na/ha)

Name of shrub species	Number before / after	Upper Slopes				MIDDLE SLOPES				LOWER SLOPES			
		0-1	1-2	>2	Total	0-1	1-2	>2	Total	0-1	1-2	> 2	Total
Lantana	Before	136	1045	727	19.8	186	1228	785	2199	422	3488	578	4488
	After	691	736	864	2291	714	1785	671	3170	1200	2866	1711	5777
Basuti	Before	-	-	-	-	-	-	-	-	-	-	-	-
	After	-	-	-	-	-	-	-	-	-44	-44	-	-
Koronda	Before	336	1745	-	2081	171	2784	-	2955	400	1200	422	2022
	After	1563	527	18	2108	999	2142	-	2141	2222	511	111	2844
Kuri	Before	-	718	91	809	43	614	57	714	-	222	78	300
	After	527	627	-	1154	257	314	43	614	122	244	-	366
Curry Patta	Before	182	-	-	182	43	43	-	86	22	-	167	189
	After	291	118	-	409	357	43	-	400	144	33	-	177
Others	Before	27	191	-	218	357	-	-	357	400	89	-	489
	After	2954	154	45	3153	1071	86	-	1157	1244	133	-	1377
Total	Before	681	3699	818	5198	800	4669	842	6311	1244	4999	1245	7488
	After	6026	2162	927	9115	3398	4370	714	8482	4976	3831	1822	10629

4.4 Grass Stock and Yield

As was observed in Bharauli forest catchment, grass became a major casualty in the Ibrahimpur catchment also. In case of upper hill slopes the number of grass clumps were reduced from 119.0 to 30.8/m² in a span of four years. (Table) Bhabar grass was the worst affected. The Bhabar grass clumps were available in 7 plots out of 11 on upper slopes earlier and now the same were seen only in 2 plots. The Bhabar grass clumps were reduced from a mean of 15.5 to 1.1 clumps / m². While the number of grass clumps of all species like Bubb, Dholu, Sarala and Khabal were reduced the number of miscellaneous grasses increased from 0.1 to 4.7 / m².

- Similar was the case in mid-hill slopes where the mean number of grass clumps was reduced from 52.1 to 36.2 / m². Dholu was the most dominant grass on these slopes but its clump numbers were reduced from 28.0 to 15.3 / m². The number of clumps of all other grasses were variably reduced except miscellaneous grasses where the number increased from zero to 9.0 clumps / m².
- In case of lower hill slopes also, the mean number of grass clumps dropped from 106.5 to 34.7 / m². While Bhabar grass was totally eliminated, the number of clumps of all other grasses came down.
- As was observed in case of Bharauli catchment, though the number of grass clumps has come down but air dry grass yield has increased from 2.2 to 4.5 q/ha. (Table).
- The mean clump weight (Biomass – number of clumps) increased from 0.16 to 1.4, from 0.52 to 1.75 and from 0.19 to 0.86 gms / m² in upper, middle and lower hill slopes
- Surprisingly, the grass yields on all the hill slopes was extremely low. This micro-watershed is still under biotic pressure of both grazing and grass extraction.

Table 4.3 Mean number of grass clumps of various species on three slopes positions of catchment area before and after dam construction (no. / m²)

Slope Position	Period	Number of grass clumps per m ²						
		Bhabasr	Dubb	Dholu	Sarala	Khabal	Others	Total
Upper slopes	Before	15.5	13.6	67.4	15.1	7.3	0.1	119.0
	After	1.1	2.8	17.0	2.5	2.7	4.7	30.8
Middle Slopes	Before	5.6	6.1	28.0	8.3	4.1	-	52.1
	After	6.4	1.4	15.3	1.1	3.0	9.0	36.2
Lower Slopes	Before	3.0	23.3	23.3	8.6	5.6	42.7	106.5
	After	-	8.3	9.1	0.6	3.3	13.4	34.7

Table 4.4 Mean air dry grass biomass on three forest hill slopes before and after the project at Ibrahimpur (q/ha)

Period	Mean dry grass biomass (q/ha)			
	Upper slope	Middle slope	Lower slope	Mean
Before	1.9	2.7	2.0	2.2
After	4.3	6.3	2.9	4.5
% age	126	133	45	105

4.5 Litter biomass accumulation

The litter accumulation is a single important indicator of the status of a forest ecosystem. Higher is the rate of accumulation faster is the rate of rehabilitation of a forest. The overall litter accumulation remain low due to forest fires, fuelwood collection and soil erosion.

Table 4.5 : Mean air dry litter biomass accumulation on forest floor and after the project on three forest hill slopes at Ibrahimpur (q/ha)

Period	Litter (q/ha) on slope position			
	Upper	Middle	Lower	Mean
Before	23.7	18.5	29.8	24.0
After	29.0	28.3	34.8	30.7
% Increase	22	53	17	28

The increase in litter accumulation was more (53%) on middle and much less (17%) on lower slopes. The occurrence of forest fire appears the main reason of low litter accumulation.

4.6 Soil Moisture and Soil pH

There has been considerable increase in soil moisture on all the three slopes of Ibrahimpur forest catchment. The soil moisture earlier was in the range of 2.6 to 5.0 percent which increased to the range of 6.4 to 8.2 percent mainly due to more shade by bushes and more litter accumulation on the soil surface which acts as organic mulch (Table).

Table 4.6 : Change in Soil properties on three with slopes of Ibrahimpur catchment.

Property	Period	Soil depth 0-15 cm			Soil depth 15-30 cm		
		Upper slope	Middle slope	Lower slope	Upper slope	Middle slope	Lower slope
Soil moisture	Before	2.9	3.8	2.6	4.3	4.8	5.0
	After	7.1	6.4	7.7	7.6	7.1	8.2
Soil pH	Before	6.6	6.6	6.4	7.6	7.4	7.4
	After	7.2	7.2	7.3	7.4	7.6	7.5

There has not been much change in soil pH mainly because the leaf litter was not get decomposed to form humus which when mixes with the soil lowers the soil pH. As such the soil pH in the forest catchment is quite normal.

Table : Soil moisture, pH, leaf litter and air dry grass biomass in different sample plots of Ibrahimpur catchment.

Stratum	0-15			05-30			Leaf litter biomass gm/m ²	Air dry grass biomass gms/m ²
	Soil moisture %	Texture	pH	Soil moisture %	Texture	pH		
IU 2	5.5	LS	6.4	5.7	LS	7.0	690	35
IU 4	6.7	LS	6.6	6.4	S	7.3	170	35
IU 8	7.4	SL	6.9	8.5	S	6.5	185	45
IU 9	7.1	LS	7.5	7.2	SL	7.5	220	25
IU 13	7.9	LS	6.7	7.8	LS	6.7	170	45
IU 15	5.9	LS	7.2	6.7	LS	7.0	290	30
IU 17	7.1	LS	6.8	7.5	L	6.9	155	50
IU 19	9.1	LS	7.1	9.6	LS	7.6	450	70
IU 21	6.2	LS	7.2	7.5	LS	7.8	270	48
IU 24	7.1	LS	7.6	8.3	LS	7.7	440	50
IU 27	7.5	LS	7.7	8.4	SL	9.5	450	40
Mean	7.1		7.2	7.6		7.4	290	43
IM 1	7.2	SL	6.7	7.0	LS	7.2	285	38
IM 5	4.5	LS	8.1	4.7	LS	7.5	100	30
IM 6	7.5	S	7.1	8.0	S	7.7	90	95
IM 7	4.6	LS	7.4	7.3	S	7.1	455	20
IM 10	7.7	LS	7.1	7.8	LS	7.4	150	40
IM 23	6.0	SL	8.3	6.7	SL	8.3	490	128
IM 26	7.4	SL	7.7	8.4	SL	8.0	410	90
Mean	6.4		7.2	7.1		7.6	283	63

IL 3	4.0	SL	7.0	5.0	SL	7.8	100	30
IL 11	7.0	S	7.5	7.9	S	7.3	620	15
IL 12	7.0	LS	7.0	8.0	LS	7.6	140	10
IL 14	5.5	LS	7.7	5.7	LS	8.0	420	30
IL 16	8.1	LS	6.6	7.5	LS	6.6	920	30
IL 18	10.4	LS	7.8	8.0	LS	7.3	120	40
IL 20	10.5	LS	7.4	12.5	LS	7.5	400	25
IL 22	10.2	LS	7.5	12.7	S	7.9	190	20
IL 25	6.2	S	7.1	6.8	LS	7.6	225	60
Mean	7.7		7.3	8.2		7.5	348	29

5. Management Issues

The repeat vegetation studies in the catchment areas of waterharvesting dams at Bharauli and Ibrahimpur have provided a clear picture of the changes which has taken place in a period of four years. The analysis of these changes brings out certain issues, which are important from management view point. Those issues are high lighted in the following section.

Bharauli Catchment

- The increase in tree stock in middle (34%) and lower slopes (48%) in a period of four years and that too in all species and in all growth classes gives a very positive sign that the objective of catchment rehabilitation is being fast achieved. The point of concern is the very slow increase the stock of upper areas where steep slopes and cliffs are more common which are prone to erosion.
- The live stock of Bharauli village does not go for grazing in catchment areas but livestock from village sherwala located just above the upper slopes from where watershed boundary starts. There were clear signs of grazing, ribbling branch cutting in plots located in this upper area. We shall have to make concerted efforts to check this grazing pressure in upper areas where soil erosion is still active.
- The bush density has increased considerably and such an increase is more in upper areas (137%) this indicating that bushes have started occupying areas which were bare earlier. The soil and moisture conditions are not ideal for tree growth but bushes have proliferated because of better tolerance and aggressive nature. In such a situation where soil erosion is a problem and trees are unable to establish, we welcome bushes to provide cover. It may take some more yards for bushes to check soil erosion from these areas. Trees would come thereafter as conditions improve.
- Though the number of grass clumps have declined but overall grass yield has increased. Obviously weaker clumps were smattered by bushes the

increase in leaf litter and decrease in soil areas is a positive signs of rehabilitation of the area.

- The water yield is likely to get reduced in the coming years. The rate of reduction in silt load was slower than expected obviously because of grazing pressure in upper areas. This area needs vegetative measures for erosion control particularly in drainage line. The dry stone check dams already there needs repair and some more are need. Incidentally stone is available in the drainage lines of upper areas.

Ibrahimpur Catchment

- The overall increase in tree stock was much lower than Bharauli in upper (15.2% increase) and lower (10.4% increase) areas but middles slopes gained by 39 percent. In the upper slopes there was mortality due to drought in last 2 years and some areas were burnt by forest fires. As a result younger stock. In the lower areas, extract of mature trees was noted which needs to be taken care of increase in
- The increase in bush stock varied between 34 and 75% where Lantana, karonda and miscellaneous bushes mainly contributed to the increase. Though the grass yield is low but it has increased significantly though number of clumps have less because of forest five. As much the problem of relation is not at all serious.
- Grazing in lower areas where livestock is allowed to go to the reservoir for during water. forest fire and extraction of mature trees are the problems which needs to be addressed

-3. see rock here '9', I find also as the non-departments of 'Shanambh' Catchment.

Stratum	No. of Khair Natural Trees per plot in girth class (cm)			No. of Khair planted trees per plot in girth class (cm)			No. of Neero trees per plot in girth class (cm)			No. of Gulhar trees per plot in girth class (cm)			No. of Papri trees per plot in girth class (cm)			No. of others trees per plot in girth class (cm)			Grand Total			
	0-2	(2-4)	(4-6)	>6	Total	0-2	(2-4)	(4-6)	>6	Total	0-2	(2-4)	(4-6)	>6	Total	0-2	(2-4)	(4-6)		>6	Total	
BU-1	1		3	1	5																2	
BU-4																						
BU-5																						
BU-6	1			1	2																	
BU-7				4	4																	
BU-8	1	1		1	3																	
BU-9				1	1																	
BU-10				1	1																	
BU-11				1	1																	
BU-12				1	1																	
BU-13				1	1																	
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BU-15				3	3																	
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BU-114				4	4																	
BU-115				4	4																	

Carabment -
Table: 3.4 Shrub density by height classes in the sample plots of Bharauli Catments

	Lantana			Basuti			Karaunda			Kuri			Curry Patta			Others			Grand Total			
	0-1	1-2	>2	Total	0-1	1-2	>2	Total	0-1	1-2	>2	Total	0-1	1-2	>2	Total	0-1	1-2		>2	Total	
BU-1	6	80	6	92	10	4	24	38	14	5	32	2	2	3	2	8						
BU-4																						
BU-5																						
BU-6		74		74	10	10		20	5		5											
BU-7	8	60		68				15	12	3	15	7	7	4	4	4						
BU-8	1	7		8				40	40		40											
BU-13	1	1		2																		
BU-14	20	30		50				6	5	11	11	2	2	2	2	2						
BU-18	6	30	2	38				15	10	25	25	4	4	6	6	6						
BU-20	3	3		6				6	6	6	6	4	4	9	1	10						
BU-23	10	45	10	65				3	10	13	13											
BU-28	1			1	1			1														
BU-29	7	9		16								5	2	1	7	6						
BU-31																						
BU-32																						
BU-35	2	6		8																		
Total	65	345	18	428	21	14	24	59	101	41	5	147	40	40	10	2	52	215	8	4	227	953
BM-2	10	10	8	28	8			8	5	2	7	6	6	1	7	40						90
BM-9	21	10		31				18	7	25	25	6	6	6	3	3						74
BM-10	6	4		10	12			12	20	8	28											52
BM-11	6			6	1			1	11	11	11											20
BM-12	10	30	10	50	4	10		14	14	5	19	8	8	4	8	4						95
BM-15	6	3	7	16				5	5	5	5	2	2	4	6	12						68
BM-16	10	45	8	63				4	7	11	11	2	2	4	6	12						146
BM-17	10	40	26	76								8	8	4	8	4						88
BM-19	10	35		45				1	3	4	4	4	4	20	24	22						98
BM-21	20	63		83				1	2	5	5	3	3	13	3	13						84
BM-24	20	30		50								4	4	4	4	4						62
BM-27	2	1	6	9								4	4	4	4	4						25
BM-30	6	20		26				11	6	17	17	3	3	20	20	20						65
BM-33	20	7		27				4	2	6	6											34
Total	137	298	65	500	25	10	10	35	94	42	2	138	50	53	6	109	154	66	220	100	220	1000
BL-3	12	30		42	8	8		16	5	10	15	14	14	14	14	14						97
BL-22		15		15				5	5	10	10											45
BL-25	4	20	58	82																		84
BL-26	10	17	13	40				3	2	1	6											46
BL-34		3	7	10				3	2	5	5	2	2	2	2	4						23
BL-36	12		16	28				14	3	17	17											95
Total	38	85	94	217	8	8	8	16	30	22	1	53	2	16	18	74	11	1	86	1	86	390

Table: 3.5 No. of clumps of various grass species in Bharauli Catchment

Stratum	Bhabbar	Dabb	Dholu	Sarala	Khabbal	Other	Total
BU-1		1	26	1		2	30
BU-4			17			40	57
BU-5							
BU-6						4	4
BU-7	5		36				41
BU-8			7				7
BU-13	10		5	9		1	25
BU-14	9		9	11		7	36
BU-18	6		14	4		4	28
BU-20	7		9	2		1	19
BU-23			24			4	32
BU-28			15			40	55
BU-29			13			20	33
BU-31	3		5			10	18
BU-32	9		20	15		50	94
BU-35	6		40	10		40	96
Total	55	1	147	52		227	575
BM-2	3		11	2		10	26
BM-9	5		20	4		12	41
BM-10	4		9	4			17
BM-11	10		17	3		50	80
BM-12	7		15			55	77
BM-15	9		10	3		5	27
BM-16	5		14	6		21	46
BM-17	13		7			2	22
BM-19	9	3	2	5	7	15	41
BM-21	2	2	4	5		2	15
BM-24	3					4	7
BM-27	1		11	4			16
BM-30	5		20	3		10	38
BM-33	7		12	3			22
Total	83	5	152	42	7	186	475
BL-3			9			9	18
BL-22	18		16				34
BL-25			10			5	15
BL-26			5			19	24
BL-34	9		2	18			29
BL-36			15	5		3	23
Total	27		57	32	5	22	143
G. Total							

Table: 4.3 Tree stocking by height classes in the sample plots in Ibrahimpuj Catchment

Stratum	No. of Khair Trees per plot in height class (m)			No. of Amaltas trees per plot in height class (m)			No. of Eucalyptus trees per plot in height class (m)			No. of Kindos trees per plot in height class (m)			No. of Kandai trees per plot in height class (m)			No. of others trees per plot in height class (m)			Grand Total
	[4-6]		>6	[4-6]		>6	[2-4]		>6	[2-4]		>6	[2-4]		>6	[2-4]		>6	
	0-2	2-4	Total	0-2	2-4	Total	0-2	2-4	Total	0-2	2-4	Total	0-2	2-4	Total	0-2	2-4	Total	
IU-2			1	2	4	1	7	17	1	1	2	4	1	1	2	1	1	2	25
IU-8			1	2	3	3	3	4	2	2	2	4				3	3	3	13
IU-13			1	1	2								1	1	2				22
IU-15			5	5	10				2	6	8					22	4	1	27
IU-13			9	5	14	1	2	7		7	8					5	3	9	23
IU-21			2	2	4					7	7					2	3	5	23
IU-24						1	1	2		7	7					6	6	6	10
IU-27			1	1	2				1	2	3					2	2	2	9
IU-4			4	4	8	2	2	4		1	1					17	17	17	24
IU-9			1	1	2					1	1					9	9	9	23
IU-17			2	2	4				4	4	4					8	8	8	19
IU-17			6	11	17				4	4	4					8	8	8	19
Total	30	5	3	38	3	8	3	15	9	26	24	2	1	53	4	61	21	4	87
IM-1			1	2	3	3	3	6	1	2	10					5	8	8	53
IM-5						1	1	2		2	2					2	2	2	5
IM-6						3	3	6		11	3					14	14	14	17
IM-7			4	4	8	2	2	4	4	4	5					9	9	9	24
IM-10			1	1	2					1	3					4	4	4	17
IM-23						1	1	2		3	3					6	6	6	15
IM-26			1	1	2					2	7					9	9	9	22
Total	5	1	1	3	9	12	2	23	2	7	38	7	4	95	2	35	27	63	207
IL-3						2	2	4		4	4					8	8	8	16
IL-11						1	1	2		4	4					8	8	8	16
IL-12						3	3	6		4	4					8	8	8	16
IL-14						2	2	4		4	4					8	8	8	16
IL-16						2	2	4		4	4					8	8	8	16
IL-18			1	2	3	1	1	2	2	2	4					6	6	6	12
IL-20						1	1	2		4	4					8	8	8	16
IL-25			1	1	2					1	1					2	2	2	5
IL-22						7	7	14		5	5					10	10	10	20
Total	1	3		4	12	11	4	27	11	8	24	2	45	10	49	6	34	103	258

Table: 4.4 Shrub density by height classes in the Ibrahimpur catchment

Stratum	Lantana			Basuti			Karaunda			Kuri			Curry Patta			Others			Grand Total
	0-1	(1-2)	>2	0-1	(1-2)	>2	0-1	(1-2)	>2	0-1	(1-2)	>2	0-1	(1-2)	>2	0-1	(1-2)	>2	
IU-2	5	15	25	45	30	10	40	3	8	11	2	7	9	5	5	110			
IU-4	4			4	30		30				5		5			3			42
IU-8	12	4		16	8		8	3	2	5			50			79			
IU-9	5			5									130			135			
IU-13	15	7		22	12		12	3		3			50			69			
IU-15	5	15	30	50	25		25	5		5			50			130			
IU-17	5	15	40	60	10	3	2	15	9	9			25			109			
IU-19	15	5		20	20		20	13	5	13	5		5			73			
IU-21	5	5		10	10	26	36	30	6	36						82			
IU-24	5	15		20	9	1	10	10		20	6		26	5		61			
IU-27					30	6	36	10	35	45			2			83			
Total	76	81	95	252	172	58	232	58	69	127	32	13	45	325	17	1003			
IM-1		50		54	24		24	1		1			20	9		108			
IM-5			4		2	20	22	4	4	8						30			
IM-6	15	25		40	10	6	16			5			5	15		76			
IM-7	10			50	12		12			3			18	4		87			
IM-10	10	3	40	53	30	10	40	3		3	3		3	20		79			
IM-23		22		25	10	50	60	3	15	18			8	2		113			
IM-26	15	25	3	40	6	40	46	10		10			5			107			
Total	50	125	47	222	70	150	220	18	22	3	43	25	28	75	6	594			
IL-3	10	20		30	20	10	30	4	3	7						85			
IL-11	5	10		60	20		20									85			
IL-12	18	12		50	16		16									85			
IL-14	16	5		63	22	4	10	35		5			50			116			
IL-16	10	40	12	62	1	3	4						10	10		114			
IL-18	15	50	6	71	26	28	52						5	5		71			
IL-20	15	36	9	60	37	3	40	5	2	7	7	3	10	2		133			
IL-22	5	55		60	40		40	5	5	5	1		1	5		121			
IL-25	14	30	20	64	18		18	2	12	14			25			111			
Total	108	154	520	358	200	46	256	11	22	33	13	3	16	112	12	957			

Table: 4.5 No. Clumps of various grass species in sample plots of Ibrahimpur catchment

Stratum	Bhabbar	Dabb	Dholu	Sarala	Khabbal	Others	Total
IU-2		17					17
IU-8			7	5		5	42
IU-13					30		30
IU-15	2	7	40				49
IU-19		2	30			15	47
IU-21		5		12		2	19
IU-24	10		10	10			30
IU-27			17			5	22
IU-4			30				30
IU-9			22				22
IU-17			30				30
Total	12	31	186	27	30	52	338
IM-1			1		6	48	55
IM-5	15		25			15	55
IM-6	10	10	15	8			43
IM-7					15		15
IM-10			26				26
IM-23	20		10				30
IM-26			30				30
Total	45	10	107	8	21	63	254
IL-3			22				22
IL-11		25	4			20	49
IL-12					30	40	70
IL-14			7			2	9
IL-16		20				16	36
IL-18			15			4	19
IL-20			10			9	19
IL-22			24				24
IL-25		30		5		30	65
Total		75	82	5	30	121	313
G. Total	57	116	375	40	81	236	905