HARYANA COMMUNITY FORESTRY PROJECT
FOREST DEPARTMENT
GOVERNMENT OF HARYANA

THE IMPACT OF WATER HARVESTING DAMS AND PROJECT EXPERIENCE

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EXECUTIVE SUMMARY

Water scarcity limits economic growth in many parts of India and Haryana is no exception. In general, 65% of Haryana is arid and semiarid and droughts are a very frequent feature. Most of the natural forests of the state are located in the Shivalik region where, due to excessive human and livestock pressure, the hills have been denuded of forest cover and major part of precious rainwater is lost as run-off. The Haryana Community Forestry Project (HCFP), therefore, focused rainwater harvesting by adopting a participatory watershed management approach. Since 2000-01, till 2006-07, 19 earthfill dams were constructed in selected micro-watersheds of Panchkula and Yamunanagar districts.

These dams have a total catchment area of 1342 hectares and a combined water storage capacity of 328.63 hectare metres. The dams vary in height from 9 to 16 metres and top length varies from 70 to 210 metres. It has been possible to provide the facility of irrigation to 1069 hectares rainfed farmlands with gravity. The total cost of dam construction, spillways, and pipelines and soil conservation works in selected watersheds comes to Rs. 487.87 lakh, out of which 82.5% money was spent on labour. The famous watershed development project at Sukhomajri in Haryana Shivaliks demonstrated the need of effective community participation to ensure sustainability of project interventions. Special efforts made to ensure sustainability are:

- Preparation of a reference field manual on the entire technology of dam construction.
- Collection of baseline information on land and livestock status and assets available, so as to study the impacts of project interventions. This also included vegetation surveys before and after the project in catchment areas of water harvesting dams.
- Detailed dialogue with the communities, assessing their needs and perceptions, level of commitment and formation of Village Resource Management Committees. All the community was actively involved in planning, execution and management of water harvesting dams (WHDs) and irrigation system.
- An element of cost sharing was also introduced, in which each village community contributed Rs. 30,000 as social fund before the start of work. They all did the excavation and layout of water conveyance system.
- The village communities agreed to refrain from grazing and excessive fuel wood extraction from forest catchments yielding run-off to the reservoirs.

The impact assessment studies were initiated in all the project villages, which brought about the following facts:

- In case of seven sites, 100% of run-off water was harvested, at four sites 78 to 91% and at six 58 to 70% was harvested at an average cost of Rs. 48,660/ha against usual cost of canal irrigation above Rs. 1.20 lakh/ha. The cost of harvested water varied from Rs. 7.4 to Rs. 31.8/m^3 and cost of earth fill varied from Rs. 40 to Rs. 52/ m^3.
- Studies in a pilot village of Bharauli indicated that the yield of wheat increased from 18.35 to 30.8q/ha. The area under vegetable crops increased manifold and as a

result net return from 84.5 ha. command area increased from Rs. 235,935 to 973,764 in a short span of two years and to Rs. 1,291,113 in the third year and summer forage crops were included after dam construction. Even in the not so fortunate village of Ibrahimpur, the net returns increased from a mere Rs. 4,138 to Rs. 62,520 from 47.4 ha command area. In yet another village, Mirpur, the value of all crops increased by 2.7 times in the second year of irrigation as compared to pre-irrigation baseline. Wheat remained the main crop with double the yield. Profitable crops like onion and onion seed replaced oil seed and pulse crops. The crop value increased from Rs. 7,000 to Rs. 260,000 and fodder production increased six times.

- As the fodder supplies improved, the number of buffaloes increased, resulting in 41.9% increase in milk sold/day in the village. In another typical village, Kaimbwala, the number of buffaloes increased from 97 to 134 and cows from 18 to 43. The total milk production by 16 families went up from 146 to 287 litres/day. The daily income from sale of milk has increased from Rs. 57 to Rs. 175/day.
- Breakeven analysis indicated that the cost of dam construction was recovered in a period of 3.5 years from additional crop and milk production.
- A study was commissioned to assess the benefits of dam construction to landless in these villages. It was clearly brought out that landless got more employment not only in dam construction, but opportunities of earning daily wages as farm labour increased manifold. Farm women are increasingly employed in vegetable and paddy crop production. On an average, a landless family now earns wages worth Rs. 8,480 per year from farm operation. All landless keep livestock and fodder availability from local sources has improved, which has resulted in more milk production. The increased employment opportunities have resulted in better housing quality, access to water and electricity, debt servicing and starting of several other income generating activities.

Large number of perceptible changes in dam villages were recorded through another study.

- Distress sale of land has gone and hitherto uncultivated lands have been levelled and brought under cultivation. The price of land has gone up 5 to 6 times. FYM and fertilizer use has increased. The land rent has gone up four times.
- The number of tractors, trolleys, land levellers, disc ploughs, harrows, diesel engines, chaff cutters, spray pumps, grain storage bins have increased manifold. Rubberised pipes are being used for irrigation instead of unlined Kachha channels.
- Migration with livestock and open grazing in forest has considerably reduced. The number of women going to forest for grass cutting and fuel wood collection has come down.
- School attendance, particularly of female child, has improved, expenditure on social functions, education, health care, housing, have all gone up. The number of motorcycles, scooters, TV sets, mobile phones, electrical appliances and furniture has gone up.

The management of dams and irrigation systems by the village community remained the primary concern of the project for ensuring sustainable development. How the empowered communities manage the system and solve day-to-day problems of resource sharing/democratic water distribution remained an active area of concern. The highlights of irrigation system management are:

- All the dam villages have duly elected and registered VRMCs
- The VRMCs elect an executive body to manage the affairs with due representation of women and scheduled castes/tribes.
- The reservoirs are regularly auctioned by an open bid system to a local contractor and the reserve rates are being raised year after year. A set of rules and regulations has been framed for the contract.
- Water is given on a pre-decided rate of Rs. 10 to Rs. 25/hour to individual stakeholders.
- The VRMCs undertake all repair maintenance costs from the social fund.
- The distribution of water is regulated as per availability and crop needs.
- The introduction of paddy and a tendency to use more water for paddy at the cost of Rabi crops is becoming a cause of concern
- Siltation of water storage reservoirs and lack of appropriate mechanism for desiltation remains an issue, which needs to be resolved.

Several institutional, technical, managerial and economic issues involved in dam and irrigation system management are highlighted in the report.

1. INTRODUCTION

Water is a major problem in the overall economic development of Shivaliks. These hills receive a mean annual rainfall of 1200 mm, of which about 80% is received in three monsoon months. People in the Shivaliks are engaged in rearing livestock, with resultant grazing pressure on these hilly watersheds. Rain fed farming with crop failures is very common. The focus in this area, therefore, lies in the construction of water harvesting dams (WHD) and the protection of the concerned catchments with active collaboration of village institutions. Several projects including the WHD project at village Sukhomajri have demonstrated the technical feasibility, economic viability and social acceptability of harvesting surplus monsoon rainwater and its efficient use during the post-monsoon dry period for flood moderation and drought. It is felt that the only way to turn the physical features of the land and improve the socio-economic condition of the people in the Shivalik region is by harvesting surplus rainwater and its efficient use during the post-monsoon dry period. Improving water infrastructure is the logical entry point for bringing about change – both in transforming the means of livelihood from cattle rearing to cultivation and reducing the daily ordeal of women.

In general, 65% of Haryana is arid and semi-arid and droughts are a recurring feature. Water resource management is, therefore, of primary importance for agriculture and socio-economic development of the State. The state of Haryana has only 6.6% of its geographical area under tree cover and over a third of the same is degraded. The state forest policy envisages increasing the tree cover to 20% by the year 2010. Haryana New Forest policy aims at 20% by the year 2010. The Haryana Community Forestry Project (HCFP) supported by the European Commission, having 9 years of operational period (November 1998–June 2008), assumes high relevance to achieve this policy objective of improving forest cover by adopting participatory approaches of development. The HCFP targets disadvantaged groups who are primary users of biomass, particularly women, landless, small and marginal farmers and users of common property resources, by promoting farm forestry and afforestation of common lands and degraded sandy areas**.**

In the typical semi-arid, sub-tropical monsoon type of climate, the Shivaliks of Haryana receive mean annual rainfall of 1200 mm of which about 80% is received in three monsoon months (Fig.1). Several projects including Sukhomajri demonstrated the technical feasibility, economic viability and social acceptability of harvesting surplus monsoon rainwater and its efficient use during post-monsoon moisture stress period for drought proofing, flood moderation and linking economic interest of communities in forest protection. The focus of the HCFP in the Shivaliks, where people are engaged in rearing livestock putting grazing pressure on hilly watersheds and rainfed farming with common crop failures, therefore, lies in the construction of water harvesting earthendams (WHD) and the protection of the associated catchment areas with active collaboration of Village Resources Management Committees (VRMC). The HCFP constructed 19 WHDs in the Shivaliks region during 2001-06 out of which 10 are in Panchkula district and 9 in Yamuna Nagar district (Table 1.1).

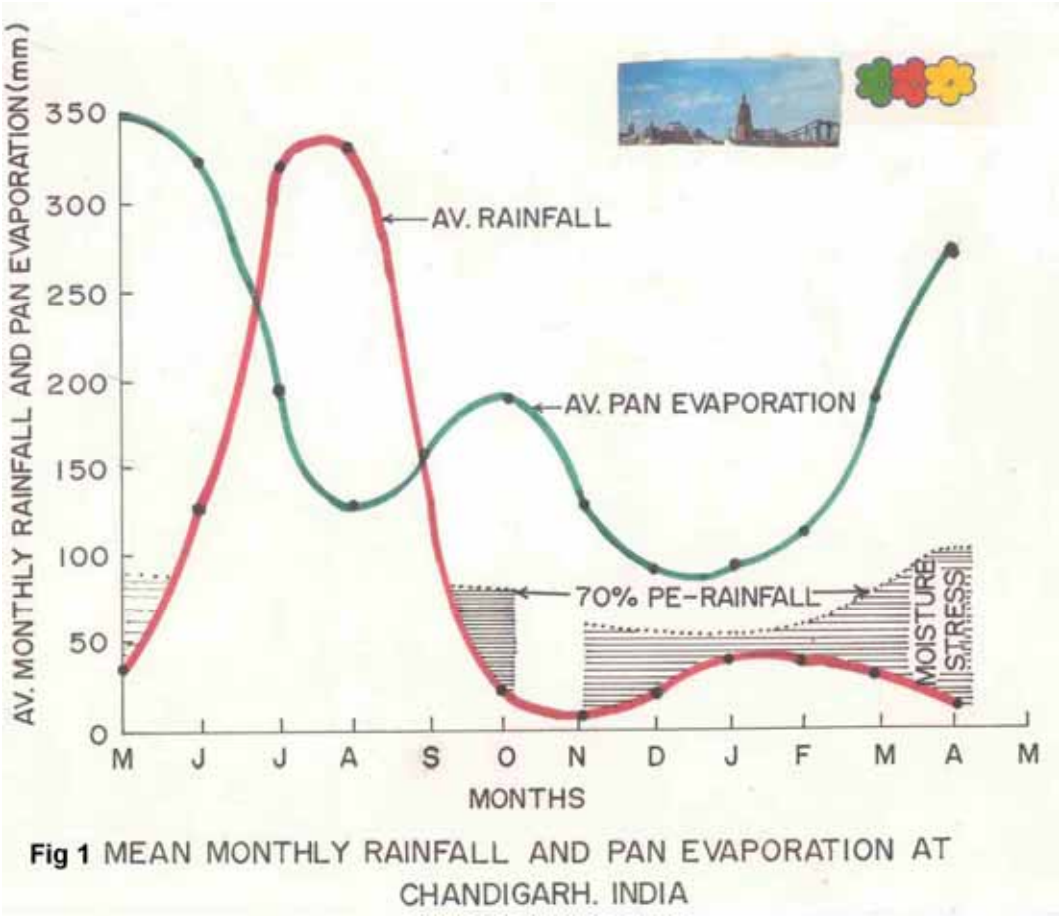


Fig 1 MEAN MONTHLY RAINFALL AND PAN EVAPORATION AT CHANDIGARH. INDIA

TABLE 1.1 Details of 18 Water Harvesting Dams Constructed by HCFP

Year	No of Dams	Project Villages	
		Ambala Division	Kurukshetra Division
2001-2002	2	Bharauli	Ibrahimpur
2002-2003	3	Kaimbwala Mirpur I	Bhagwanpur
2003-2004	7	Turon I Dhandion Banswala Mandappa	Kansli Thaska Kathgarh
2004-05	5	Mawas Rana/Mirpur II Bhediwala/Turon II	Nanheri Nawagaon
2005-06	2		Paniwala Rampur Gainda
Total	19	10	9

1.1 EVALUATION STUDY

It was envisaged in the project documents that the performance of the first two dams would be evaluated by an expert team of an external agency and on the basis of such an evaluation further work on the remaining WHDs would be taken up. This evaluation of two WHDs constructed during 2001-02 at Bharauli and Ibrahimpur was carried out by the scientists of the Punjab Agricultural University,

Ludhiana based at its Regional Research Station for Kandi Area Ballowal Sankhri district, Nawanshehr. The salient details of these two dams are given in Table 1.2.

TABLE 1.2: Salient details of Water Harvesting Dams constructed during 2001-02 at Bharauli and Ibrahimpur

Sr.	Particulars	Unit	Water Harvesting Dam	
			Bharauli	**Ibrahimpur**
1	Catchment area	(ha)	90	30
2	Submergence area	(ha)	5.13	5.49
3	Total dam height	(m)	14	9
	Free board	(m)	2	1.5
	Net height	(m)	12	7.5
4	Dead storage height	(m)	4.5	3
5	Total storage capacity	(ha.m)	24.7	13.25
	Dead storage capacity	(ha.m)	2.25	1.38
	Live storage	(ha.m)	22.45	11.87
6	Top width of dam	(m)	5	4
7	Length of dam at top	(m)	120	129
8	Side slopes U/S	-	3:1	3:1
	D/S	-	2.5:1	2.5:1
9	Annual rainfall	(mm)	1200	1200
10	Gross command area	(ha)	150	80
	Net command	(ha)	93.5	52.6
	No. of beneficiary families	CC No	86	59
11	Length of conveyance pipeline	RCC 150 mm	1500	904
		80 mm	500	500
12	Dia of pipeline	Cm	15	15
13	Total earth work	Cu.m	49160	12651
14	Cost of earth work	Rs.	24,24,434	594196
a)	Cost of cement, sand, bajri, stone blast, brick, stone	Rs.	2,47,500	85170
b)	Cost of pipe outlet lead, yarn, sluic valve, tee, tail, piece distribution outlet	Rs.	1,78,775	77425
c)	Cost of conveyance pipeline	Rs.	2,40,700	114300
	Sub total	Rs.	6,66,975	276895
B)	Labour cost	Rs.	24,24,434	594196
	Total	Rs.	30,91,409	871091
	Contingency 1%	Rs.	30,914	8711
	Grand total	Rs.	31,22,323 or 31,22,000	8,79,802 Or 8,80,000

The total cost of the structure including all components was Rs.31.22 lakhs in Bharauli and Rs. 8.80 lakhs in case of Ibrahimpur.

On the basis of a score card system adopted in the study, out of total 100 marks allotted to five different components, the Bharauli WHD scored 77.44 marks and was labelled as green. The WHD Ibrahimpur scored 57.2 marks and was labelled as yellow (Table 1.3).

Table 1.3: Scores of Bharauli and Ibrahimpur WHDs in various types of evaluation

Type of Evaluation	Marks Allotted	Marks Scored		Overall Impact	
		Bharauli		Ibrahimpur	
Technical feasibility	40	31.34	Green	27.4	Green
Environmental impacts	10	7.2	Green	6.2	Green
Economic viability	10	8.2	Green	7.8	Green
Participatory process development	35	28	Green	15	Orange
Institutional linkages	5	2.7	Yellow	0.8	Purple
Total	**100**	**77.44**	**Green**	**57.2**	**Yellow**

In yet another score card system which was based on different assessment criteria of technical viability, financial efficiency and social credibility, the WHD of Bharauli and Ibrahimpur scored 64.00 and 54.3 marks our of 100 and also labelled as green and yellow respectively (Table 1.4). A comparison based purely on technical criteria was also attempted (Table 1.5). The cost per m^3 of earthwork and per m^3 of water stored was Rs. 49.32 and Rs. 46.97 and per m^3 of water stored was Rs. 13.91 and Rs. 7.41 in case of Bharauli and Ibrahimpur respectively. The submergence area formed only 4.81% of total catchment area in Bharauli but 18.3% at full lake level in case of Ibrahimpur. The wheat crop yield increased from 7.68 to 18.95 and 26.85 q/ha with one and two irrigation at Bharauli and from 9.75 to 14.30 and 17.80 q/ha, at Ibrahimpur respectively. The BC ratio was 2.11 and 1.93 and 1R 41.95 and 64.10 percent at Bharauli and Ibrahimpur projects.

Bharauli VRMC managed to collect a social fund of Rs. 55,654 against Rs. 1300 by VRMC of Ibrahimpur. The VRMC at Bharauli held large number of meetings to sort out issues, operationalised the water distribution system, auctioned the reservoir for Rs. 18,000 per year with a responsibility for maintenance and protection of the system during the contract period and hence showed a good maturity as compared to Ibrahimpur VRMC. Nature was not that favourable to Ibrahimpur as it received scanty rainfall and hence system could not become as vibrant as it normally should have been with the availability of water. Taking an overall assessment in view, the study concluded, “There was practically no major defect/discrepancy in the design, planning and construction of the water harvesting dams and their associated components”.

TABLE 1.4 Critical evaluation of Water Harvesting Dams at Bharauli (Bh) and Ibrahimpur (Ib)

Assessment Criteria	Criteria Description	Bh	Ib	Score out of 10 in each	
				Bh	Ib
Technical Viability	* m^3 of water stored/m^3 of earth work	4.57	9.38	4.2	8.7
	* Water available (cm)/ha of command	24	22.6	7.0	6.5
	* Submergence areas as % of total catchment	5.7	18.3	9.5	4.7
	Sub total			**20.7**	**19.9**
Financial efficiency	* Cost Rs/m^3 of water stored	13.91	7.41	5.0	9.5
	* Cost Rs/m^3 of earth work	49.32	46.97	5.2	5.7
	* Cost Rs/ha of command	33390	16726	4.5	8.3
	* Expenditure Rs/beneficiary family	36302	14912	3.7	8.1
	Sub total			**18.4**	**31.6**
Social Credibility	* Social fund generated by VRMC	55654	1300	8.4	1.0
	* Interaction and meetings of VRMC	19	3	8.5	1.0
	* Functional vibrancy and institutional maturity	Good	Poor	8.0	0.8
	Sub total			24.9	2.8
	Total score out of 100			**64 Green**	**54.3 Yellow**

The study further suggested that:

- The project must pay proper attention to reducing silt loads to the reservoirs by vegetative and mechanical measures. The cost of such measures to be included in the project estimates.
- Timely survey, planning, execution and completion of dam and conveyance system be ensured. The staff must be trained in all these aspects taking manual as the base.
- Ensure active involvement of communities from day one till final withdrawal.
- Introduce an element of some cost sharing which may go to enrich the social fund. This fund should be used for future maintenance.
- The revegetation of borrow areas should be included in the project estimates.
- The communities would need follow-up by extension services as they change from subsistence level to intensive agriculture supported by credit facilities.
- Finally, the HCFP may build up further on the lessons learnt from the construction of these two water-harvesting dams.

TABLE 1.5: Comparison of water Harvesting dams on the basis of technical data

Sr. No.	Technical Criteria	Bharauli	Ibrahimpur
a)	Cost per m^3 of earth work 2424434/49160	49.32	46.97
b)	Cost per m^3 of water stored 3122000/224500	13.91	7.41
c)	M3 of water stored/m^3 of earth work	4.57	9.38
d)	Cost per hectare of command 3122000/93.5 (232 acres/130.5 acre)	33390	16726
e)	Cost per hectare of catchment and command 3122000/(93.5+90)	17014	10998
f)	Expenditure per beneficiary household 3122000/86 87980/59	36302	14912
g)	Average water depth at full lake level Total storage/submerge area = 24.7 ha.m/5.13 ha	4.81	2.41
h)*	Submergence area as % of total catchments area 5.13/90x100 AND 5.49/30x100	5.7	18.3
i)	Rental value of stored water at local rate (Rs.)	18000	5000
j)	Catchments: Command ratio 90.0 93.5	1:1.03	1:1.7
k)	Water availability per ha of command at full lake level (cm) 22.45/93.5	24.0	22.6
l)	Material cost %	7.9	9.7
	Pipe outlet %	5.7	8.8
	Conveyance pipeline %	7.7	13.0
	Labour cost %	77.7	67.5
	Contingency %	1.0	1.0
	Total %	100.0	100.0

*Bunga 8.7% and Sukhomajri 16.3%

Giving due weightage to all natural and human factors, the study clearly brought out that both the Water Harvesting Dams are technically sound, eco-friendly, economically viable with good rate of returns and socially acceptable and compatible with the well being of the rural society. These initiatives are duly tailored to the dire needs of the poor rural communities and would lead to economic development, local governance and efficient management of natural resources for their common welfare. On the strength of positive results, the evaluation study recommended the construction of large number of such water-harvesting dams wherever site conditions permit.

2. TECHNICAL DETAILS OF WATER HARVESTING DAMS

2.1 Design Details

The design details of all the 19 WHD's constructed by HCFP between 2001-02 to 2006-07 are summarised in (Table 2.1). The catchment area vary from a low of 23 hectare in Banswala to 230 ha in Rampur Gainda. The height of the dams very from 9 to 15 metres, submergence area from 1.36 (Thaska) to 8.43 hectare (Rampur Gainda), and storage capacity from 5.10 (Thaska) to 44.7 hectare metre in Rampur Gainda. The cost of dams including pipelines vary from Rs. 8.8 lakh in Ibrahimpur to Rs.57.10 lakh in Rampur Gainda. Other design details are also provided for ready refrence in this table.

2.2 Depth v/s storage curves

Depending upon the site conditions, earthen dams store variable amount of water at various heights. When slope is less in the proposed reservoir/submergence areas and bowl is wide and open, the storage capacity is more. But when slope is more and submergence area is in the form of a narrow gorge, the storage capacity at the same height is relatively less. Height v/s storage curves are drawn to find out storage capacity at different heights. Such curves are used to find out the amount of available water in the reservoir for irrigation at different times of the crop growing season. The number of hours the system can provide irrigation water from the left over storage is then worked out. Keeping the technical requirement of such curves in view, the depth v/s storage curves were drawn first for Bharauli (Fig.2.1) and then for other dam project.

Fig.2.1

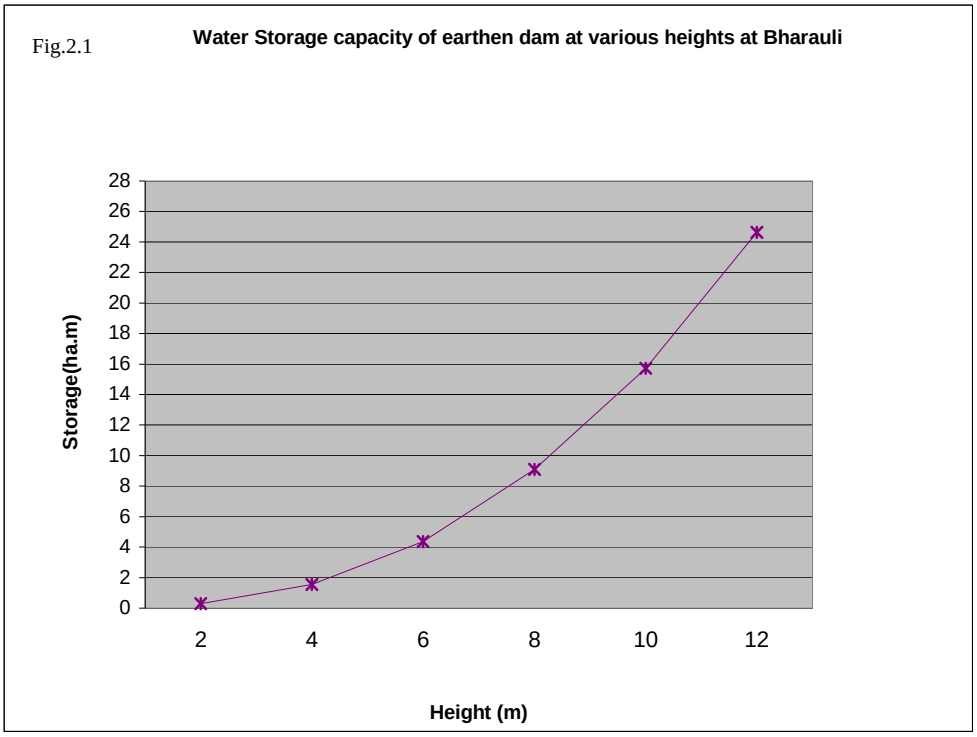
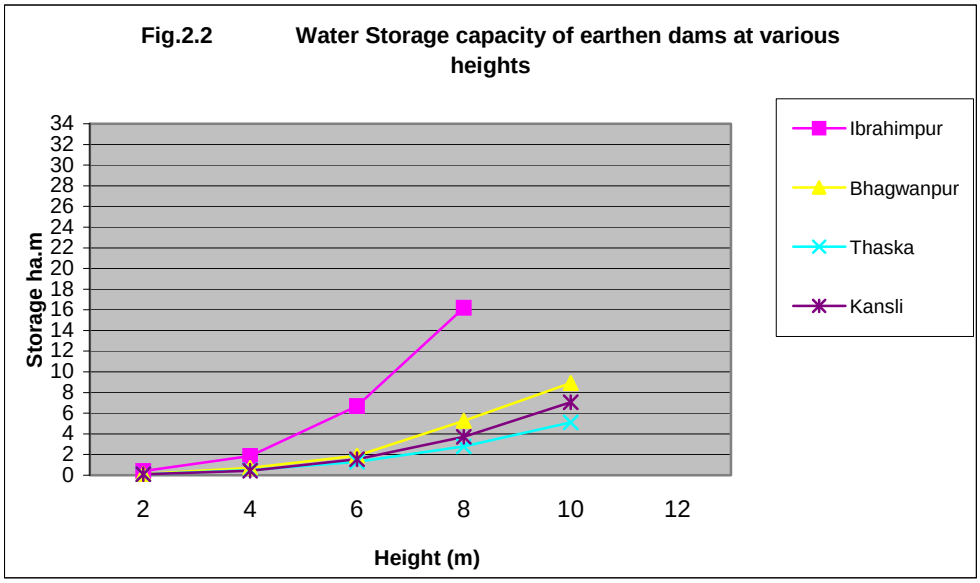
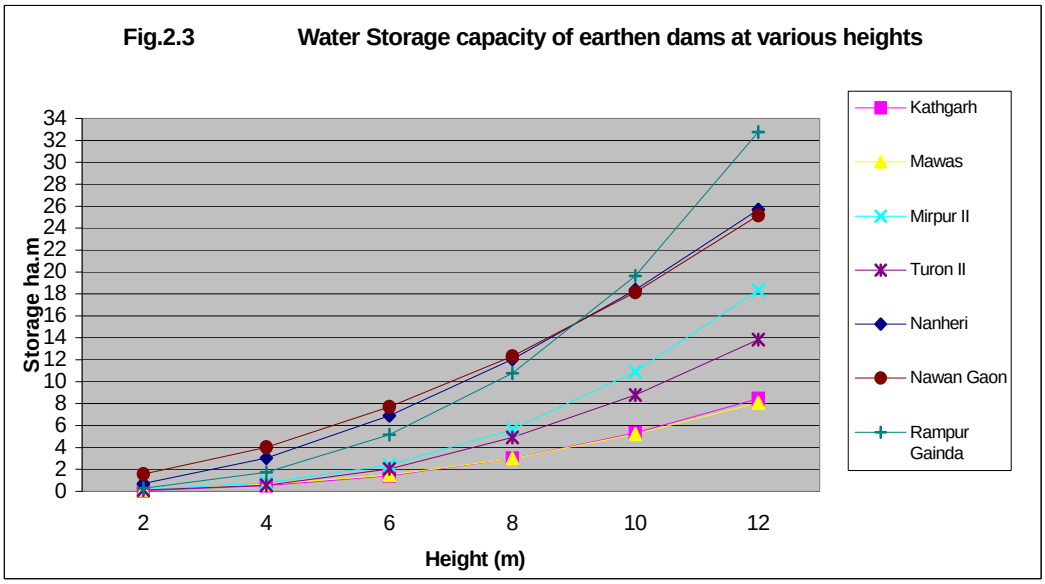


TABLE 2.1 Salient details of Water Harvesting Dams constructed by HCFP during 2001-2007

Particulars	Unit	Bharauli	Ibrahimpur	Mirpur	Bhagwanpur	Kaimbwala	Turon	Dhandion	Bans wala	Thaska	Kathgarh	Kansli	Mandappa	Mirpur II	Turon II	Rampur Gainda	Mawas	Nanheri	Nawagaon	Paniwala
Year of construction		2001-02	2001-02	02-03	02-03	02-03	03-04	03-04	03-04	03-04	03-04	03-04	03-04	04-05	04-05	06-07	04-05	04-05	04-05	06-07
Catchment area	(ha)	90	30	70	26	50	65.00	30.75	23.00	25.00	40.00	32.00	145.0	54	46	230	32	145	124	84
Submergence	(ha)	5.13	5.49	-	-	-	2.69	1.84	1.80	1.36	1.74	2.01	3.0	4.10	2.84	8.43	1.57	4.75	4.15	
area	-	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.25	0.35	0.30	0.30	0.30	0.30	0.3	
Run-off coefficient	(mm)	1200	1200	1000	1000	1000	1200	1200	1200	1200	1200	1200	1000	1000	1000	1000	1000	1000	1000	
Rainfall	(ha m)	24.70	13.25	21.70	9.10	13.209	15.53	9.86	9.79	5.10	8.44	7.071	15.61	19.54	13.83	44.7	8.11	29.97	29.08	22.95
Storage capacity	(ha m)	2.25	1.38	1.88	0.71	0.88	1.03	0.75	1.03	0.49	0.54	0.44	1.21	1.96	0.58	1.74	0.81	3.02	4.04	
Dead storage	(ha m)	22.45	11.87	19.82	8.39	12.41	14.50	9.11	8.76	4.61	7.90	6.63	14.40	17.58	13.25	38.98	7.30	26.95	25.04	
Net storage																				
Total height	(m)	14	9	14.5	12	14.5	14.7	14	14	12	14	12	15	14	14	15	14	15	15	
Free board	(m)	2	1.5	2.5	2.5	2.5	2	2	2.5	2	2	2	2	2	2	2	2	2	2	
Net height	(m)	12	7.5	12	9.5	12	12.7	12	11.5	10	12	10	13	12	12	13	12	13	13	
Top width	(m)	5	4	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
Total top length	(m)	120	129	85	14	110	117	96	77	70	85	94	79	95	110	181	100	210	200	
Total earth work	(m^3)	49160	12651	29440	30310	36075	45363	27064	21601	19859	30704	25194	27265	35058	52436	78889	44614	107202	12191	
Cost of labour	(Lakh	24.24	5.94	18.27	12.45	15.25	21.04	13.38	10.04	9.64	13.53	11.84	14.15	15.38	23.02	39.32	20.78	44.30	48.79	
Material	Rs.)	6.98	2.86											7.24	7.47	7.78	5.03	5.20	5.81	
Length of pipe outlet	(m)			90	75	90	95	85	85	84	85	75	80	85	95	100	75	90	75	
Dia of pipe outlet	(cm)			20	15	20	20	20	20	20	20	20	20	15	15	20	15	20	20	
Length of U/G pipeline	(m)	1500 500	904 500	1500	200	500	1000 G1	500 PVC	900+ 200 PVC +GI 10+10	200 G1	250+ 350 G1+ PVC	800+200 PVC +GI	PVC 920 GI 385 1305	PVC 1500 GI 600 2100	PVC 1500 GI 700 2200	PVC 900 GI 450 1350	PVC 500 GI 500 1000	PVC 1000	PVC 850 GI 150 1000	
Dia of U/G pipeline	(cm)	15 8	15 8	15	15	15	10	15		10	10+10	10+10	10 cm	10 cm	10 cm	10 cm	8 cm	10 cm	10 cm	
Spillway Width	(m)			5.0	4.0	5.0	3.0	2.5	3.0	3.0	3.0	3.0	8.0	3.0	3.0	5.0	2.5	6.0	5.0	
Height	(m)			1.2-1.5	1.2-1.5	1.2-1.5	1.0	1.0	1-1.2	1.2-1	1.0	1.2-1.0	1.1-1.2	1.2	1.2	1.2	1.2	1.3	1.3	
Length	(m)	-	-	58	58	58	60	50	60	75	40	35	54	75	67	80	47	54	64	
Command area	(ha)	93.5	52.6	60	20	35	50	45	31	40	42	43	70	60	32	165	36	67	90	37.65
Total cost	(Lakh Rs.)	31.22	8.80	25.55	16.46	21.10	28.62	18.06 17.10	15.43	13.86 12.18	17.51	14.23	27.27	25.58	30.97	57.10	25.81	49.50	54.60	33.17
Cost/m^3 of earthwork	(Lakh Rs.)	49.32	46.97	44.34	51.11	47.97	48.71	49.45	46.50	40.77	46.37	46.99	51.90	43.87	43.90	49.84	46.58	41.32	40.02	
Cost/m^3 of water storage	(Lakh Rs.)	13.91	7.41	10.89	16.11	17.93	18.43	17.34	15.76	23.88	20.76	20.12	18.94	13.09	22.39	11.76	31.82	16.51	18.78	
Silt detention structures	Number	Crate - 3 Mas - 1 Coffer - 1	-	Three + one coffer	One	-	Two exist, two new	-	One	One exists	One struc-ture exists	One structure provided	One raised, one new	Coffer 1 Str. 3	Three exist	One	-	-	-	
Run-off water harvested	%	78	100	100	100	100	68	91	100	58	60	63	48	100	100	59	84	69	78	
m^3 of water/m^3 of earth	Ratio	5.02	10.47	8.32	3.00	4.85	3.42	3.64	4.53	2.57	2.75	2.81	5.73	5.57	2.64	5.16	1.82	2.78	2.39	

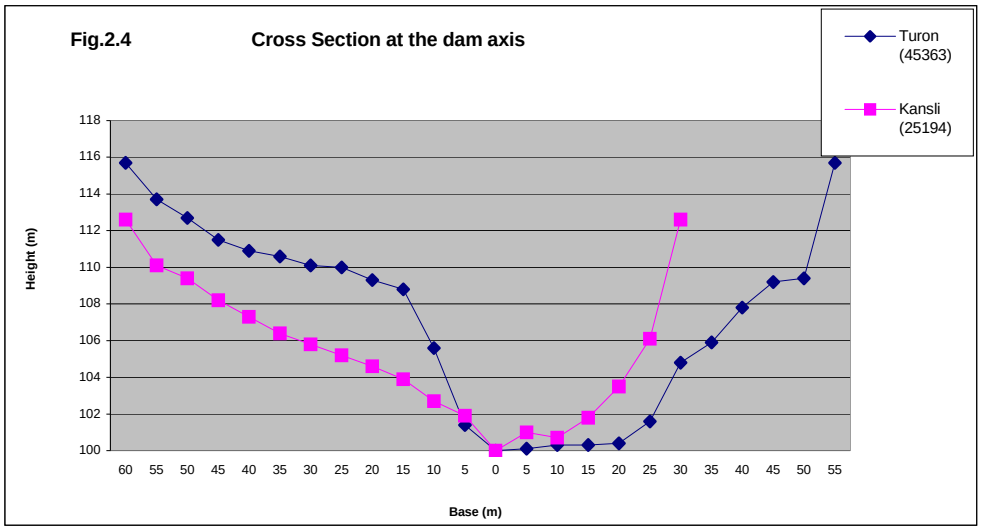
Comparing the height v/s storage capacity curves of Ibrahimpur, Bhagwanpur, Thaska and Kansli, it is noted that Ibrahimpur reservoir store much more water than the other three at 8 metre dam height (Fig.2.2). At 10 metre height, Bhagwanpur reservoir store more water which is followed by Kansli and Thaska. Out of seven dams having 12 metre of storage depth of water, Mirpur II stores maximum water at full lake level and Mawas reservoir stores the least amount of water (Fig2.3). The reservoirs of Nanheri and Nawangaon stores almost same amount of water at each height but store less water than Mirpur II though the cost of dams is much higher than Mirpur II. This is because of excellent bowl quality of Mirpur II reservoir.

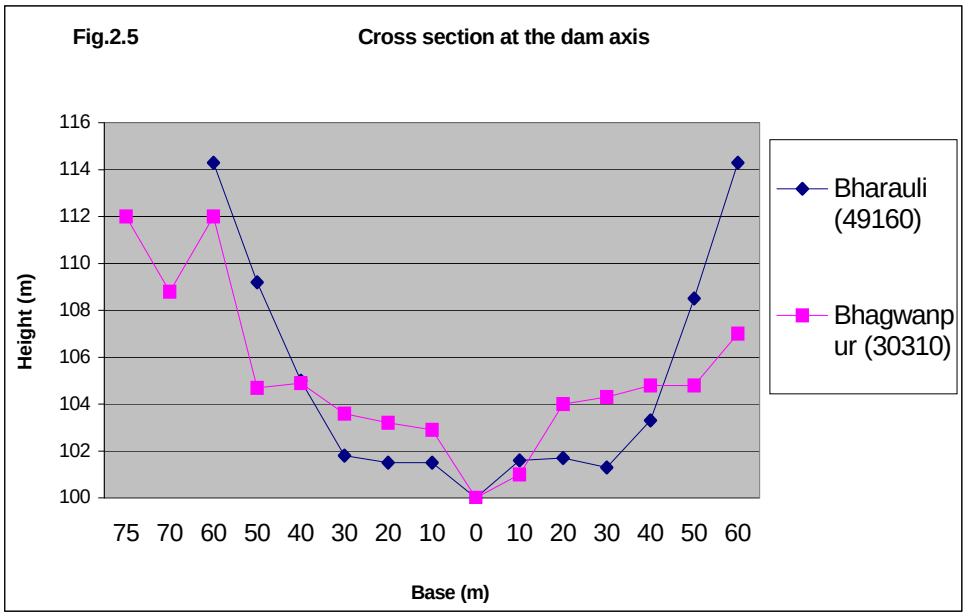


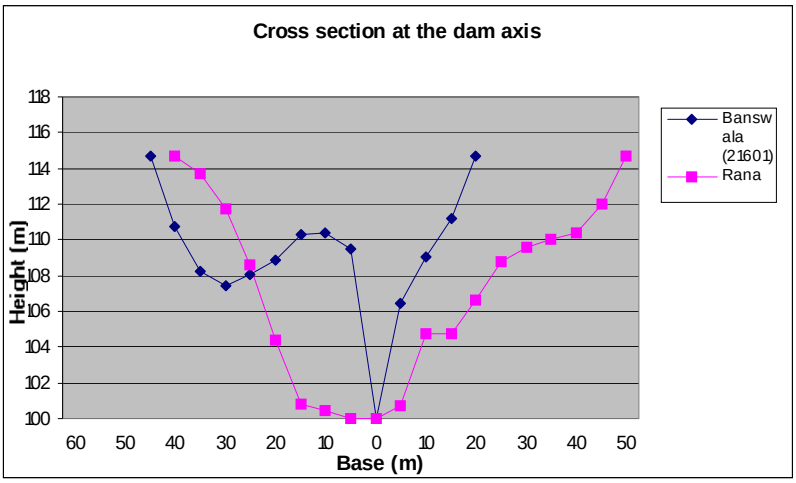


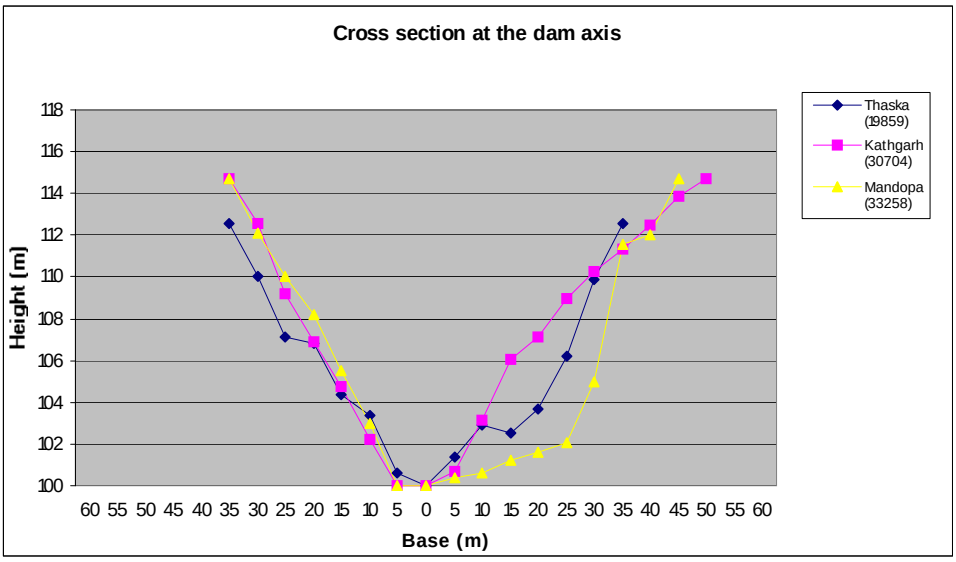
2.3 Cross-Sections at the Dam Axis

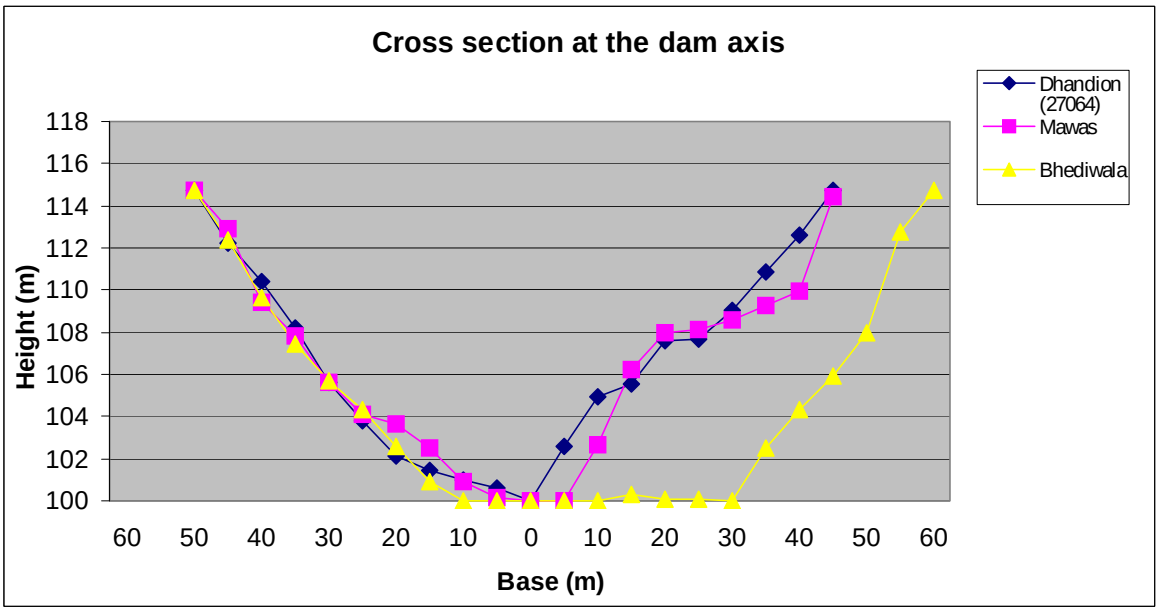
The width of the Nala at the site selected for dam construction and shape of side slopes determine the cost of earthen dam. The cross-section at the proposed dam axis is drawn by taking elevation levels at 5/10 metre interval from the centre of Nala to both sides. Taking zero at the centre, levels converted to height are drawn for both the sides and the plot is drawn to show the shape of Nala at the dam axis. This cross-section becomes the basis for calculating earth work in dam construction. The shape of the cross-section provides a good indication about the site quality and shape of the earth-fill. The shape of cross-section of Banswala was narrow v shape with almost 10 metre deep gorge(Fig.2.4). But the cross-section at Mirpur II (Rana) was typical U shaped axis with 20 metre wide base and uniformly rising banks (Fig2.5). These shapes are very important for a designer. The cross-sections for number of dam axis were drawn for the sake of comparison (Fig) and are self explanatory.

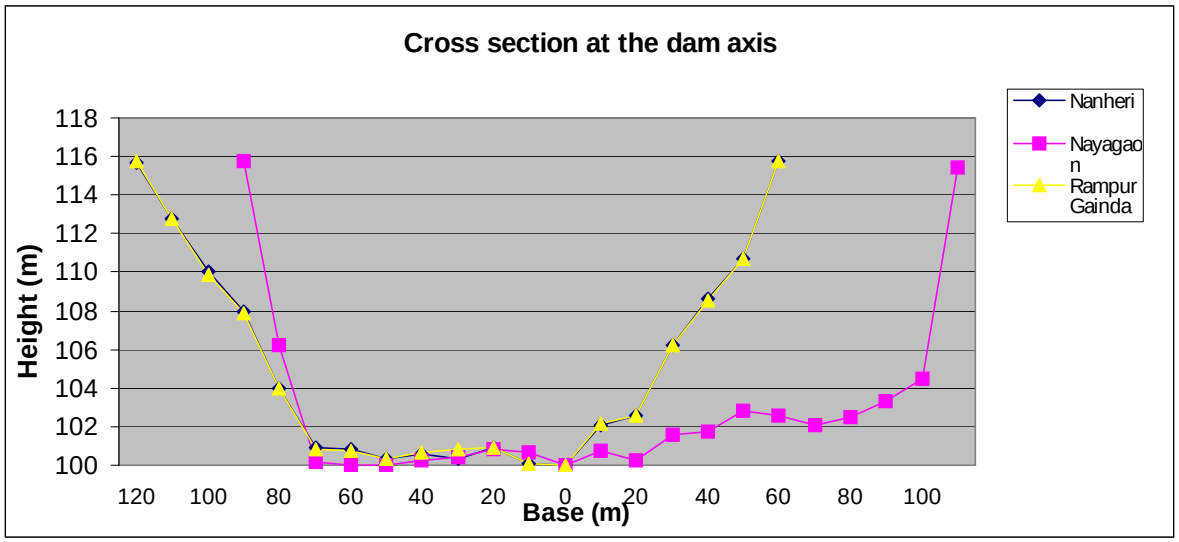





Cross section at the dam axis
Height (m)
118
116
114
112
110
108
106
104
102
100
60 50 40 30 20 10 0 10 20 30 40 50
Base (m)
Banswala (21601)
Rana


Cross section at the dam axis
Height (m)
118
116
114
112
110
108
106
104
102
100
60 55 50 45 40 35 30 25 20 15 10 5 0 5 10 15 20 25 30 35 40 45 50 55 60
Base (m)
Thaska (19859)
Kathgarh (30704)
Mandopa (33258)





2.4 ASSESSMENT OF HYDROLOGICAL BEHAVIOUR

The hydrological behaviour of watersheds is strongly influenced by the amount, distribution and intensity of rainfall in addition to soil, slope, vegetation cover and several other watershed characteristics. In case of reservoirs in Yamunanagar, the rainfall of Kalesar and Yamunanagar were considered being the nearest stations available. The first two water harvesting dams at Bharauli and Ibrahimpur were constructed between Nov. 2001 and April 2002 and hence stored monsoon run-off of 2002-03 and 2003-04, which in case of Bharauli was 944 and 1167 mm against 40 years mean of 896 mm. Both of these were reasonably good

monsoon rainfall seasons for Bharauli. No rainfall records for Ibrahimpur are available but general indication is that 2002-03 was very poor and 2003-04 was just an average monsoon rainfall season.

The remaining three WHDs at Kaimbwala, Mirpur and Bhagwanpur were constructed between October 2002 and March 2003. These three WHDs stored the monsoon rainfall of 2003. Mirpur and Kaimbwala are located within a 5-km fee-line distance from each other. The rainfall records of the Central Soil and Water Conservation Research and Training Centre, Chandigarh (CS&WCR&TI) as recorded at Mansa Devi Farm could be considered for their hydrological behaviour.

The monsoon rainfall of 1167 mm during 2003 filled the reservoirs completely and there was spillover in September 2003 in case of Bharauli and Mirpur. However, the reservoir at Kaimbwala was not filled up to the top and there was no run-off. Relatively, fewer run-offs and slightly more seepage were observed in Kaimbwala reservoir. In case of Ibrahimpur, the reservoir was not completely filled and there was no run off. In case of Bhagwanpur the reservoir was filled up to the top but in the absence of rainfall data, no precise estimation could be made about the hydrological behaviour.

There are no rainfall recorders installed in the project area. In case of reservoirs located near Raipur Rani, the rainfall records of Chandigarh were considered. The yearly rainfall for 2001-2002, 2002-03 and 40 years mean were 1189, 1179 and 1115 millimetres.

The monsoon rainfall of 944 mm received during 2002 completely filled the Bharauli reservoir and there was spill over. The seepage rates are very, very low due to impervious strata and run-off is high due to steep slopes, heavy soil and poor vegetation cover at least in upper reaches of catchment. Rain, water was released from the pipe-outlet during the heavy rains. In case of Ibrahimpur, the monsoon rainfall was quite low and reservoir was just half filled.

Monsoon period is most crucial for water harvesting dams and behaviour of monsoon rains greatly influence storage of water and the need of water for irrigation. For example, the arrival of monsoon was delayed during whole of July 2004 and practically there was no rainfall during July 2004 except few isolated showers. As a result, severe drought conditions prevailed in whole of the northern India. The sowing of rainfed kharif crops was not possible. Where farmers did sowing on receiving isolated showers had to bear the loss of crop failures. Since widespread

rains were absent, the planting of nursery raised plants was delayed and not even 10% nursery stocks were lifted during whole of July 2004.

After dry and desiccating July, the month of August 2004 started with a heavy rainfall in its first week. This rainfall was widespread and occurred continuously for 3 days. Incidentally, the intensity of rainfall was very high and in 24 hrs of August 2 and 3, 2004 more than 300 mm rainfall was received in a pocket covering Chandigarh, Panchkula, Kalka, Morni hills falling in the catchment areas of Ghaggar river. This rainfall caused flash floods and tributaries of Ghaggar caused extensive damage to infrastructure and property. The flooding by Ghaggar damaged the bridges & bridge on Ghaggar linking Panchkula and Nada Sahib had to be closed for traffic. The performance of WHDs during monsoon in general and during this heavy storm was particularly of hydrological importance.

Four cofferdams were constructed during 2003-04 to create silt storage basins in the catchment areas. One cofferdam each was made at Bharauli and Mirpur in the upper reaches of drainage lines. In addition, two cofferdams one each at Bunga and Gobindpur were constructed under the "desiltation and rehabilitation of silted up reservoirs" programme. The heavy rainfall storm which occurred on Aug. 2 and 3, 2004 breached the cofferdam at Bunga and Bharauli. The inspections of breached cofferdams were made on 5-8-04 and following observations were made.

- The reservoir behind the cofferdam was filled up to the capacity and spillway operated for 12 hours after the cessation of rainfall.
- The pipe outlet laid at 1 metre height from ground level operated throughout since start of heavy rain.
- The breach occurred almost 36 hours after cessation of rainfall when spillway was carrying low discharge.
- The breach occurred along the pipeline axis because one joint out of three within the dam body had opened up.
- The leak from opened joint appeared responsible for breach. Probably, the hydraulic pressure in the pipeline caused vibrations, which facilitated the opening of a weakly, laid joint.
- The breach occurred when rainfall had already stopped 36 hrs. earlier and flood flows had already passed on the spillway. This is the reason that size of the breach was small i.e. about 2.5 metre at the base and 4.5 metre at the top. The top breach width increased due to mudslides.
- Compaction of the earth fill was inadequate or the fill material was light in texture

As the breach occurred in the coffer dam water rushed to main reservoir which was almost full by that time. This caused abrupt rise in water level of the main reservoir. The spillway was not able to handle the excessive spillover. So sand filled bags were placed on main dam side to save the embankment.

The VDC lowered the spillway level by removing 3 layers of bricks and this helped in the quicker disposal of floodwater. The spillway construction was not complete and construction was not as per approved plans. The head over crest was provided 1 metre in approved plans where as at site it was just 40 cm. The forest guard did not receive the approved drawings. The lessons learnt from this experience are:

- PVC pipe should not be used as pipe-outlet.
- Anti-seep collars should be provided.
- Relatively heavy soil should be used in case of core and earth fill should also be of heavy soil.
- The silted up soil could be used as fill material on top of main dam as it forms the free board potion of the dam body. But in case of cofferdam, the deposited soil quite often is almost sand and liable to the formation of rills on the top and side slopes.
- Proper compaction of such fill material is not possible. As such heavy soil should be added in 6" layers and compacted.

3. BASELINE SURVEY

In order to asset the impact of the WHDs, an impact evaluation was proposed to be carried out for all the 18 WHDs. Such an assessment would not have been possible until and unless the base-line data about socio-economic status and present production levels are available. Hence base line survey of the project villages was carried out to establish benchmarks before the project with which future impacts of project interventions could be compared. Such a baseline data on pre-decided proforma was collected and compiled for each WHD, by a Chandigarh based NGO namely Society for Promotion And Conservation of Environment (SPACE). The base line survey included information such as village profile, socio-economic condition, land use and present production levels of each family that was going to receive benefit of irrigation water from the WHD.

VILLAGE PROFILE

The profiles of nine villages have been provided by SPACE, i.e. Kaimbwala, Mirpur and Bhagwanpur selected during 2002-03 and Banswala, Turon, Dhandion, Thaska, Kathgarh and Kansli selected during 2003-04. Such a profile of these nine villages is summarised in (Table 3.1). Some general comments on the village profile are as under:

- The villages in Yamunanagar district are of large size than villages of Panchkula district. The number of household is lowest (12) in Banswala highest (210) in Kathgarh. So is the total population of 106 and 1600 on two extremes.
- While the landless families are just few (2) in Kaimbwala and Mirpur but non-existent in Dhandion and Banswala. But their proportion is quite high in Bhagwanpur (80) and Thaska (70).
- There is a forestland in almost all villages except Turon.
- Area irrigated varies from zero in Kansli to 235 acres in Kathgarh.
- Size of holdings is quite small. Almost 30-40 % families own less than 2.5 acres of land.
- The assets owned show that most families are poor and lack basic amenities.
- There are no reliable sources of water and all the villages experience water scarcity.

Though the VDCs have been constituted under earlier projects, most of them are non-functional.

TABLE 3.1: Profile of Villages having component of Water Harvesting Dams - Base Line Data as in August 2003)

Particulars	**Kaimbwala**	**Mirpur**	**Bhagwanpur**	**Thaska**	**Turon**	**Dhandion**	**Banswala**	**Kathgarh**	**Kansli**
District	Panchkula	Panchkula	Y.Nagar	Y. Nagar	Pkl	Pkl	Panchkula	Y.Nagar	Y.Nagar
Block	Barwala	Raipur Rani	Bilaspur	Sadhaura	Morni	Morni	Morni	Bilaspur	Chhachhrauli
Nearest town	Raipur Rani	Raipur Rani	Bilaspur	Rasulpur	R.Rani	R.Rani	Raipur Rani	Bilaspur	Khizrabad
Total no. of households	25	62	130	200	80	24	12	210	100
	175	400	525	700	500	180	106	1600	600
Total population	23	60	50	130	60	24	12	130	85
Land owners	2	2	80	70	20	-	-	80	15
Landless	H.Gujjars, Brahmins	H.Gujjars, Harijans	Jats, Brahmins, H.Gujjars, Bania Gadaria, Harijan Kumhar, Jheor	H.Gujjars, M.Gujjars, Harijans, Brahmins	H.Gujjars Harijans Rajputs	Hindu Gujjars	Hindu Gujjars	H.Gujjars, Harijans, Gadaria, Balmiki, Kumhar, Lohar	Muslim Gujjars, Gadarias
Caste Distribution									
Total area of village (acre)	287	325	618	1300	101	76	162.5	1049	425
Area under forest (Acre)	50	40	200	700	-	20	80	540	20
Agricultural land (Acre)	237	285	418	600	101	56	82.5	509	405
-Irrigated land	100	15	168	120	16	10	52.5	235	-
-Unirrigated Land	120	260	135	380	70	32	20	208	375
-Land not available of cultivation	12	10	115	50	15	12	10	55	30
-Panchayat Land	5	0	-	50	-	2	-	11	-
Size of land holdings									
- <1.0 Acre	-	14 (23.3%)	-	20 (15.4%)	28 (46.7%)	9 (37.5%)	1 (8.3%)	22 (16.9%)	28 (32.9%)
- 1.1 to 2.5 Acre	9 (36%)	12 (20%)	8 (16%)	30 (23.1%)	28 (46.7%)	10 (41.7%)	3 (25%)	42 (32.3%)	10 (11.8%)
- 2.6 to 5.0 Acre	6 (24%)	16 (26.7%)	20 (40%)	60 (46.1%)	4 (6.6%)	5 (20.8%)	5 (41.7%)	42 (32.3%)	25 (29.4%)
- >5.0 Acre	10 (40%)	18 (30%)	22 (44%)	20 (15.4%)	-	-	3 (25%)	24 (18.5%)	22 (25.9%)
Electrified houses	22 (88%)	40 (66.7%)	78 (60%)	148 (74%)	-None 21 solar lamps	0 3 solar pumps	0 26 solar NW	168 (84%)	42 (42%)
Houses with assured water supply	25 (100%)	60 (100%)	52 (40%)	90 (45%)	24 (30%)	24 (30%)	12 (%)	210 (100%)	100 (100%)
Assets owned Tractors & trolleys	3	1	4	5	-	0	0	1	10
Bullock cart/Horse Rehra	4	25	30	30	-	0	0	28	8
Scooter/Motorcycle	5	2	10	50	2	0	1	16	10
Cycles	5	12	95	200	22	4	2	120	80
Car / jeep	-	-	1	-	-	0	0	-	-
Sources of waterKuhls	2 (non-perennial)	-	-	-	-	1	1	1 non-functional	-
Village ponds	1	1	1	2	3	1	1	2	1
Tubewells	-	6	2	4	-	-	-	1 non-functional	-
Earthen dams	2 (non-functional)	1(non-functional)	3 partly working	2 – working	2 -semi-functional	1	1	5 silted	-
Water table depth ft.	35	100	55	55	25	60	10 in nadi well	90	85
Tree plantation									
Poplar	-	600	-	-	-	-	-	3000	500
Eucalyptus	1500-5 acre	-	8000-20 acre	40,000 (100 acre)	-	1500	-	45000-10 acre	25000-60 acre
Khair	800-4acre	400	22000-periphery	-	-	-	-	1500-periphery	18000-periphery
VDC- Constituted/not	Constituted (Kandi)	Constituted (Kandi)	Constituted	Constituted	Constituted	Constituted	Constituted	Constituted	Constituted
Registered/ not	Registered	Registered	Registered	Registered	Registered	Registered	Registered	Registered	-
Social fund	**Rs. 30,000 in balance**	Rs. 10,000 in Balance		Rs. 1.3 Lakh In balance	Rs. 3,636	Rs. 650	Rs. 8,000	Rs. 60,000	
Meetings	No regular Meetings	No regular meetings held	No regular meetings	No regular Meetings	Occasionally	No regular Meetings	No regular meetings	No regular meetings	No meetings

4. ANALYSIS OF CROP PRODUCTION

4.1 Bharauli Project

Bharauli being the first WHD Project, it received maximum attention for various types of impact assessment studies. The baseline for crop production was taken for 2001-2002 and crop data of 2002-2003 was taken for first comparison. In the 96.46 hec. of the command area of the Bharauli reservoir, the area under wheat decreased from 61.28 to 56.32 hectare but crop yield with supplemental irrigation increased from 18.35 to 30.80 q/ha, thus raising the total grain production from 1124.49 to 1734.66 quintals and straw from 1225.60 to 1875.46 quintals (Table 4.1.1).

The gross returns increased from Rs. 892,269 to Rs. 1,374,152 and net returns from Rs. 43,245 to 204,104 between 2001-2002 and 2002-2003. The crop of Taramira which is generally sown on inferior rainfed lands gave negative returns and thus it was eliminated in the year 2002-03 since such lands were levelled, heavily manured and also received the facility of irrigation and hence put to more remunerative crops. While the area under gram remained unchanged, the area under lentil was reduced from 1.11 to 0.50 hectares. But there was a quantum jump in the yield of lentil from 1.68 to 5.50 q/ha. The crop production thus increased from 1.86 to 2.75 quintals, gross returns from Rs. 3,348 to Rs. 4,950, but the cost of cultivation being high, there were negative returns of 5713 and 750 during 2001-02 and 2002-03 respectively.

In case of vegetable crops, the area under onion increased from 1.61 to 2.08 ha and means crop yield increased from 229.7 to 295.5 q/ha thus providing net returns of Rs. 60,569 and Rs. 97,022 during 2001-02 and 2002-03. The area under vegetable seed production was raised by the farmers, as this is a more remunerative enterprise. In case of radish seed production, the area increased from 13.08 to 15.68 ha, the yield increased from 5.33 to 7.5 q/ha and as a result, the total production rose from 69.72 to 117.6 quintals, gross returns rose from Rs. 278,880 to Rs. 470,400 and net returns from Rs. 11,721 to Rs. 69,196. The real miracle happened in case of cauliflower seed production where the area recorded almost ten times increase from 0.25 to 2.40 ha. The mean crop yield increased from 4.16 to 4.93 q/ha, but total production jumped from 1.04 to 11.83 quintals, thus raising the gross income from merely Rs. 15,600 to Rs. 177,450 and net returns rose from Rs. 7,731 in 2001-02 to Rs. 98,010 in 2002-03. Similar was the trend in carrot seed production where the area increased from 0.92 to 2.40 ha, mean crop yield increased from 4.60 to 6.04 q/ha, the gross returns thus recorded a jump from Rs. 76140 in 2001-2002 to 261,000 during 2002-03 and net returns increased from merely Rs. 58,177 to Rs. 209,100. The prices were quite favourable both in cauliflower and carrot seed and these two crops contributed significantly in raising the monetary returns from the command area. The interaction with the farmers indicated that they would continue with vegetable seed production because of the facility of assured price in a contract farming

system finalised with a Solan (HP) based firm which provides the seed material and provides buy back guarantee at a pre-decided price.

Barseem (Egyptian Clover) is another important crop of command area mainly because of the dire need of green fodder for milch cattle. It does require 5 to 6 irrigations but area is limited to 1/8th to 1/4th of an acre per farmer and 5-6 cuttings are obtained in a season. With the facility of irrigation, Barseem growth continues even up to mid May and this helps in maintaining milk production over a longer period of gestation. The Bharauli farmers raised 4.80 ha of Barseem during 2002-03 against 2.99 ha in 2001-02. While the green forage yield increased from 120 to 185 q/ha and overall production rose from 358.8 to 888 quintals. This raised the gross income from Rs. 25,116 to Rs. 62,160. As the cost of cultivation is quite high, the net returns turned out to be negative. There is a sizeable share of fallow land, which is occupied by a torrent and its area changed from 12.68 to 11.96 ha as some farmers levelled the land near its banks. The overall gross income from the command area during Rabi season increased from Rs. 1,408,549 to Rs. 2,538,284 and net income from 84.5 ha cultivated area jumped from Rs. 127,820 to Rs. 631,046.

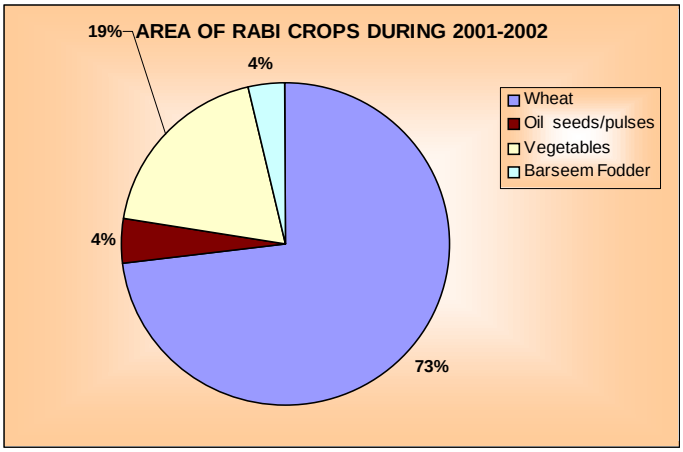
During Kharif season, growing of paddy was not a practice with these farmers due to non-availability of assured irrigation water. Since there was surplus water in the reservoir during rainy season and this had to be frequently discharged either through the pipe-outlet or spillway and it was a loss of precious water and also a loss of revenue to the VRMC as water has a price tag. This situation prompted the farmers to raise paddy rather than let the surplus water go as wasteful run-off. Thus 16 hectares of command area in kharif was put to paddy which at a yield level of 60 q/ha, generated gross returns of Rs. 576,000 and net returns of Rs. 134,000. Maize crop as such is not that much remunerative but meets the major domestic requirement for human consumption from grains and dry forage for livestock, which is mixed with green Barseem. The net returns from maize increased from Rs. 18,367 to Rs. 64,413. The forage crops like Sorghum, Bajra and Guar covered 17.5 ha in 2002-03 against 21.6 ha in 2001-02. The overall net returns rose from Rs. 89,748 to Rs. 109,287. The overall Kharif crops contributed Rs. 941,090 and Rs. 1,794,700 as gross returns and Rs. 108,115 and Rs. 307,700 as net returns. The third crop of summer fodder was raised on 2.85 ha area for the first time in 2002-03 and this provided net returns of Rs. 35,018. The grand total of all crops generated gross income of Rs. 2,349,639 and Rs. 4,389,377 and net returns of Rs. 235,935 and Rs. 973,764 during 2001-02 and 2002-03. The net income from crop production thus increased from Rs. 2,792 to Rs. 11,524 /ha or a rise of 4.1 times. Summary of crop production in Bharauli is given in Table 4.1.2.

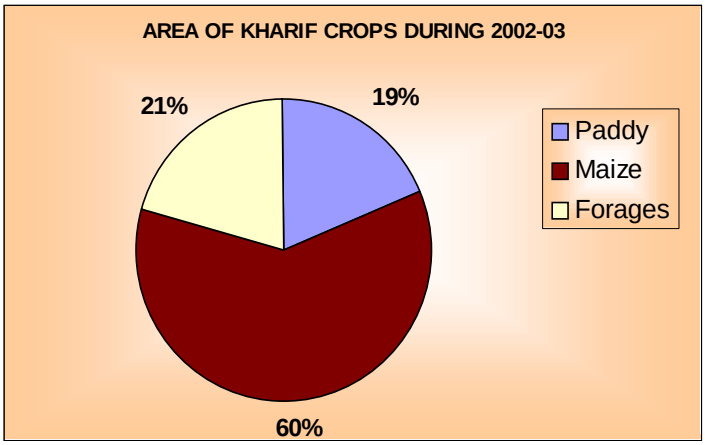
TABLE 4.1.1: Area, Yield, Production, Gross and Net returns from different crops in command area of Water Harvesting Dam at Bharauli during 2001-02 and 2002-03

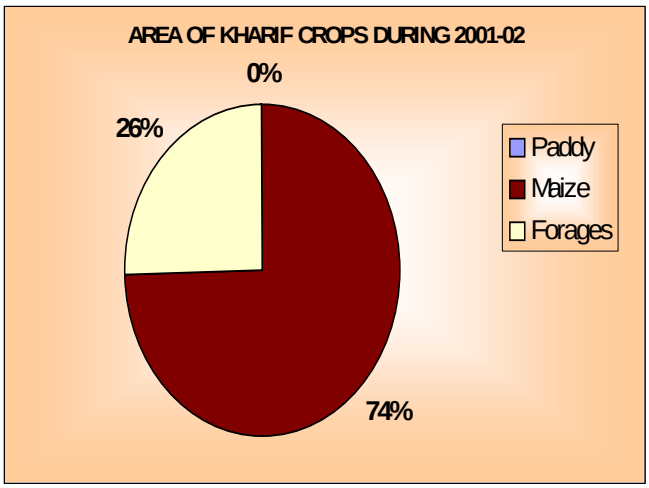
Crops	Area (ha)		% Area Under Crop		Mean Crop Yield (q/ha)		Total Production (q)		Rate (Rs./ha)	Gross Income		Cost of Cultivation Rs./ha		Total Cost of Cultivation (Rs.)		Net Returns (Rs.)	
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03		2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
Wheat	61.28	56.32	63.9	58.31	18.35	30.8	G-1124.5 S-1225.6	G-1734.66 S-1875.46	630 150	G-708429 S-183840 892269	G-1092833 S- 281319 1374152	15075	20775	849024	1170048	43245	204104
Taramira	2.24	-	2.32	-	0.8	-	1.79	-	1600	2864	-	8163	-	18285	-	-15421	-
Gram	0.3	0.32	0.31	0.33	7.33	8.25	2.2	2.64	1550	3410	4092	8288	11400	2486	3648	924	444
Lentil	1.11	0.5	1.15	0.52	1.68	5.5	1.86	2.75	1800	3348	4950	8163	11400	9061	5700	-5713	-750
Onion	1.61	2.08	1.67	2.16	229.7	295.5	369.74	613.6	300	110922	184080	31275	41855	50353	87058	60569	97022
Radish (s)	13.08	15.68	13.56	16.26	5.33	7.5	69.72	117.6	4000	278880	470400	20425	25587	267159	401204	11721	69196
Cauliflower (s)	0.25	2.4	0.26	2.49	4.16	4.93	1.04	11.83	15000	15600	177450	31475	33100	7869	79440	7731	98010
Carrot (s)	0.92	2.4	0.95	2.49	4.6	6.04	4.23	14.5	18000	76140	261000	19525	21625	17963	51900	58177	209100
Barseem (f)	2.99	4.8	3.1	5.00	120	185	358.8	888	70	25116	62160	19575	22550	58529	108240	-33413	-46080
Fallow (Torrent)	12.68	11.96	13.14	12.44	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	**96.46**	**96.46**	**100**	**100**	**-**	**-**	**-**	**-**	**-**	**1408549**	**2538284**	**-**	**-**	**1280729**	**1907238**	**127820**	**631046**
Kharif Crops																	
Paddy	00	16.00	0:0	18.9	-	60.0	-	960.0	600	-	576000	-	27625	-	442000	-	134000
Maize	62.9	51.0	74.4	60.4	18.5 21.3	30.6 43.0	1163.65 1339.77	1560.60 2193.00	500 100	581825 133977 715802	780300 219300 999600	11088	18337	697435	935187	18367	64413
Forage Crops	21.6	17.5	25.6	20.7	208.6	250.4	4505.76	4382.0	50	225288	219100	6275	6275	135540	109813	89748	109287
Total	**84.5**	**84.5**	**100**	**100**	**-**	**-**	**-**	**-**	**-**	**941090**	**1794700**	**-**	**-**	**832975**	**1487000**	**108115**	**307700**
Summer Fodder	-	2.85	-	-	-	282.68	-	805.62	70	-	56393	-	7500	-	21375	-	35018
Grand Total										**2349639**	**4389377**			**2113704**	**3415613**	**235935**	**973764**

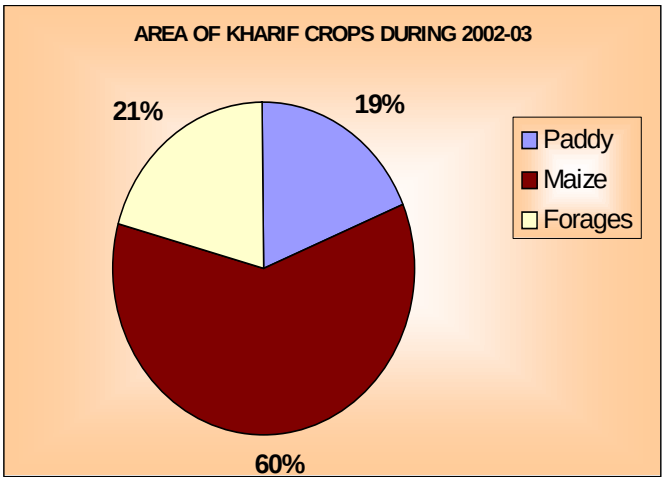
The significant conclusions from the crop production data are:

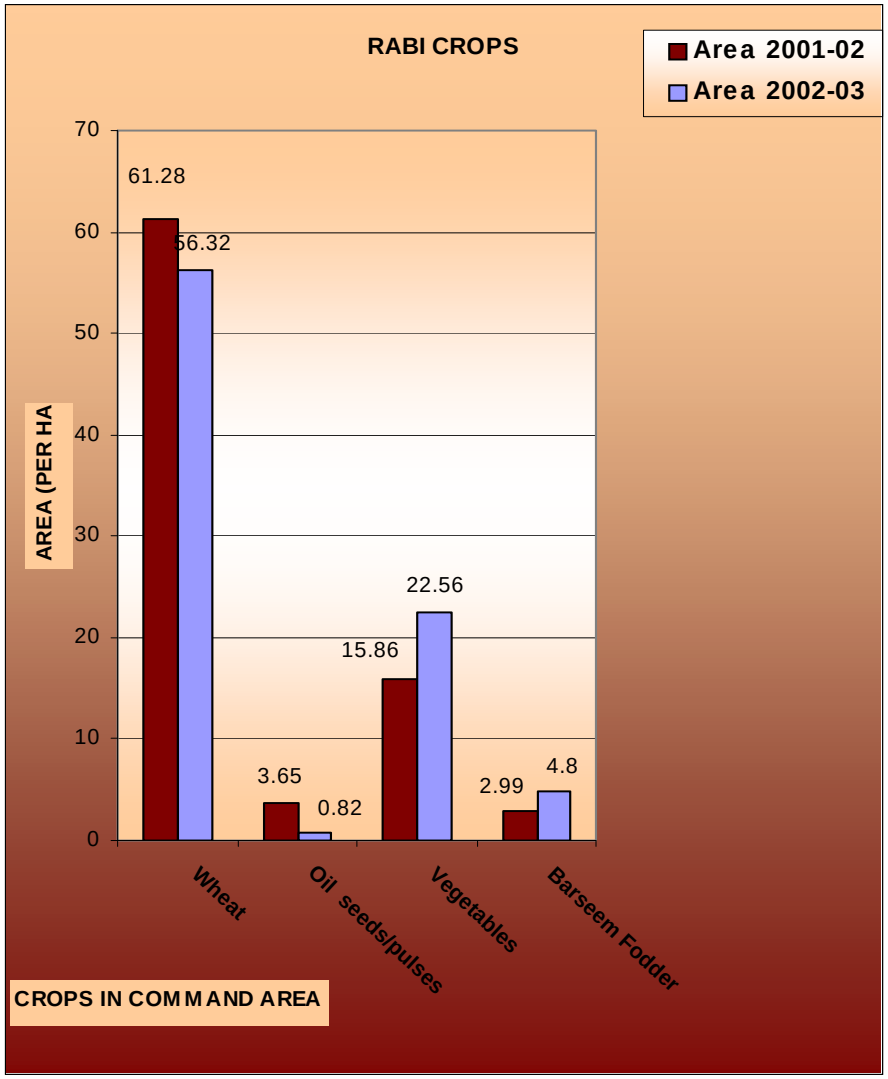
- The crop of wheat, vegetable seed production and paddy significantly contributed to raise net income of the farmers.
- The crops of gram, taramira and lentil were not remunerative and likely to be discontinued.
- Barseem fodder being a necessity would continue to be grown in spite of negative net returns.
- Since most farmers own land, they have free domestic supply of manure and they contribute most labour from their own resources. Hence, the real net returns are much higher to a family than actually worked out in this exercise.
- The fact remains that farming as enterprises has generated additional employment opportunities at their own farms or in there own village.
- The interest in land development has increased. Most farmers have levelled their land and have added manure to maintain fertility of soil.










RABI CROPS
Area 2001-02
Area 2002-03
AREA (PER HA
70
60
50
40
30
20
10
0
61.28
56.32
3.65
0.82
15.86
22.56
2.99
4.8
Wheat
Oil seeds/pulses
Vegetables
Barseem Fodder
CROPS IN COMMAND AREA

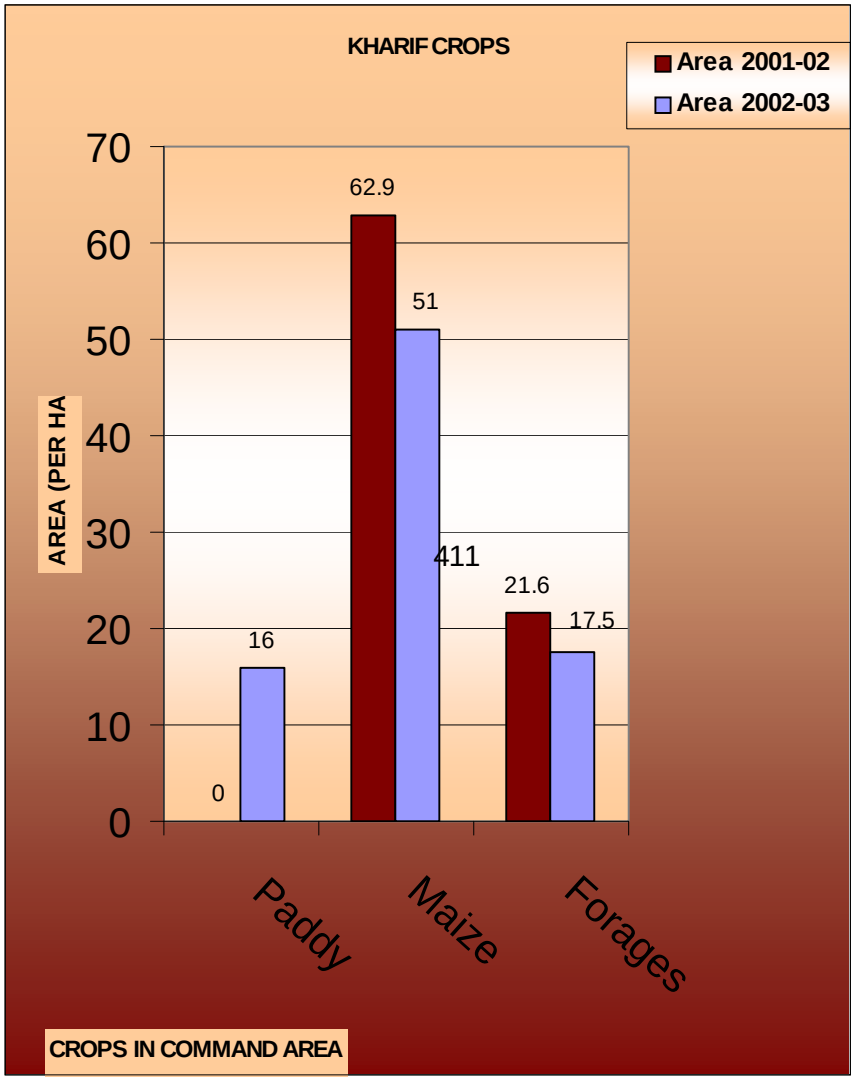

KHARIF CROPS
Area 2001-02
Area 2002-03
AREA (PER HA
70
60
50
40
30
20
10
0
0
16
62.9
51
411
21.6
17.5
Paddy
Maize
Forages
CROPS IN COMMAND AREA

Table 4.1.2: Summary of Crop production details of command area in Bharauli Water Harvesting Dam

Crop	Area (ha.)		Yield (q/ha)		Total Net returns (Rs.)		Net returns Rs/ha.
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2002-03
Wheat	61.28	56.32	18.35	30.8	43245	204104	3624
Paddy	0.00	16.00	-	60.0	-	134000	8375
Maize	62.9	51.0	18.5	30.6	18367	64413	1263
Forage Crop	21.6	17.5	208.6	250.4	89748	109287	6245
Summer Fodder	-	2.85	-	282.68	-	35018	12287
Onion	1.61	2.08	295.65	369.74	60569	97022	46645
Radish	13.08	15.68	5.33	7.50	11721	69196	4413
Cauliflower	0.25	2.40	4.16	4.93	7731	98010	40838
Carrot	0.92	2.4	4.60	6.04	58177	209100	87125

The area under Rabi crops in command kept on fluctuating for first three crop seasons and finally stabilized at around 56 hectare. Area under oil seeds and pulses was gradually allocated to vegetable seed crops (Table 4.1.3).

Table 4.1.3: Area (ha) under various Rabi crops in command of Bharauli WHD

Name of the Crop	2000-01	2001-02	2002-03	2003-04	2004-05
Wheat	59.06	61.28	56.32	54.23	55.55
Oil, seed & pulses					
Gram	-	0.30	0.32	0.20	0.55
Lentil	-	1.11	0.50	0.59	-
Mustard	-	2.24	2.24	-	-
Masri	-	-	-	-	0.35
Sub-Total		3.65	3.06	0.79	.90
Total	**59.06**	**64.93**	**57.14**	**55.12**	**56.45**
Vegetables					
Onion crop	-	1.61	2.08	3.64	1.20
Onion seed	-	-	-	0.36	1.27
Radish seed	14.57	13.08	15.68	12.30	18.10
Cauliflower seed	-	0.25	2.40	2.66	2.55
Carrot seed	-	0.92	2.40	-	-
Methi	-	-	-	-	0.33
Sub-Total	14.57	15.86	22.56	18.96	23.45
Fodder					
Barseem	-	2.99	4.80	6.50	5.32
Sugarcane	1.38	-	-	-	-
Total Cultivated Crops	**75.01**	**83.78**	**84.50**	**81.11**	**85.22**
Fallow	10.43	12.68	11.95	4.33	0.80
Grand Total	**85.44**	**96.46**	**96.45**	**85.44**	**86.02**

Before dam construction, only radish seed was raised over 14.57 ha with very limited water available from a traditional Kuhl (a channel, which brings perennial flow from rivers and streams by gravity a lands, located along banks). But subsequently, crops of onion both as green and seed, and cauliflower seed were introduced. Farmers started with carrot seed on 0.92 ha area in 2001-2002 and increased it to 2.4 ha but then discontinued carrot seed crop. This happened because area under paddy was increased and hence more reservoir water was used for paddy. As a result, less water was left for Rabi Crops. Since carrot is sown later than radish and it matures late in March and by that time all water is exhausted resulting in adverse affect on crop yield due to no irrigation near crop maturity. The water requirement of radish being less than other vegetable seed crops hence area under radish was increased. The area under barseem was reduced from 6.5 ha in 2003-04 to 4.32 ha in 2004-2005 precisely due to the same reason i.e. non-availability of irrigation water at the fag end of the crop season when it is more critical for crops due to on set of summer season. The crop of sugarcane was also eliminated. The fallow area varied from 10 to 12 ha in first 3 seasons but was levelled and brought under crops subsequently.

CROP PRODUCTION IN 2004-05

In the year 2004-05, the area under Kharif and Rabi Crops remained almost the same but onion seed replaced area under onion bulbs. The area under radish was substantially increased from 12.30 ha in 2003-04 to 18.10 ha in 2004-05, mainly because of its low water requirement, less damage by wild life and assured price under contract system (Table 4.1.4). The crop yields in 2004-05 remained almost unchanged accept Barseem to which all required irrigations could be provided. When compared to 2002-03, the overall total gross returns increased from Rs. 4,389,377 to Rs. 4,736,588 and total net returns from Rs. 973,764 to Rs. 1,291,133. In the year 2004-05, a significantly higher contributions to net returns were made by forage crops of sorghum and Bajra in Kharif season and onion and cauliflower seed during Rabi season. The cropping system of Bharauli started almost stabilising at this level and further increases in crop yields would come only from precision farming, better management and continuous availability of water from the reservoir. The siltation of their reservoir and fear of reduced water of availability is, therefore, becoming a matter of serious concern with the villagers.

TABLE 4.1.4 Area, Yield, Production, Gross and Net Returns from different crops in command area of Water Harvesting Dam at Bharauli in 2004-05

Name of Crop	Area (Ha)	Yield (q/ha.)	Production		Rate		Gross Income		Cost of Cultivation Rs./ha.	Total cost of Cultivation (Rs)	Net returns (Rs)
			Grain	Stalk	Grain	Stalk	Grain	Stalk			
Kharif											
Maize	50.10	26.00	1302.5	1626.5	600	150	781500	243975	18525	928103	97372
Paddy	11.75	58.13	683.0	410.5	600	10	409800	4105	27884	327637	86268
Sorghum (gram)	16.05	421.34	-	6762.5	-	70	-	473375	6310	101276	372099
Bajra	2.00	7.75-305.00	15.5	610.0	800	70	12400	42700	4515	9030	46070
Toria	0.30	5.0	1.5	-	1600	-	2400	-	7970	2391	9
Groundnut	0.20	50.0	10.0	12.0	2000	200	20000	2400	18100	16290	6110
Pulses (urd.)	0.40	2.25	1.5	2.5	2000	250	3000	625	5350	2140	1485
Fallow	4.10	-	-	-	-	-	-	-	-	-	-
Sub Total (Kharif)							1229100 1996280	767180		1386867	609413
Rabi											
Wheat	55.55	29.58	1643.3	1975.0	650	200	1068145	395000	22140	1229877	233268
Gram	0.55	13.64	7.5	8.0	1800	200	13500	1600	8411	4626	10474
Lentil	-------	-------	-------	-	------	-	-	-	-	-	-
Mustard	-------	-------	11.25	-	2100	-	23625	-	-	11250	12375
Masri (Pulse)	0.35	2.50	0.875	-	2200	-	1925	-	-	1505	420
Sub Total	56.45						1107195 1503795	396600		1247258	256537
Onion Crop	1.20	246.88	296.25	-	325	-	96281	-	43262	51914	44367
Onion seed	1.27	3.81	4.875	-	55000	-	268125	-	61170	77686	190439
Radish seed	18.10	7.00	126.75	-	4200	-	532350	-	25995	470509	6184
Cauliflower seed	2.55	5.15	13.125	-	15500	-	203437	-	35540	90627	112810
Methi	0.33	-	-	-		-	-	-	--	--	--
Sub Total	23.45						1100193			690736	409467
Others											
Barseem	5.32	320.37	--	1704	--	80	--	136320	22670	120604	15716
Fallow	--	--	--	--	--	--	--	--			
Sub Total	6.12		1704					136320	22670	120604	15716
Total (Rabi)	86.02							2740308		2058598	681720
Grand Total								4736588		3445456	1291133

- Mustard as mixture with wheat crop and not as pure crop. Methi crop was destroyed by wildlife.

4.2 Ibrahimpur Project

In case of the command area of Ibrahimpur water harvesting dam, the main increase in income was provided by wheat crop. The area under wheat was 17.80 ha in 2001-02, which increased to 23.32 ha during 2002-03 (Table 4.2.1). The availability of two irrigations provided at pre-sowing and CRI-(Crown-root initiation) stage from the reservoir stored water increased the mean grain yield from 10.55 to 15.19 q/ha and straw yield from 12 to 17 quintal. This raised the total grain production from 187.79 to 354.23 quintals, straw production from 213.60 to 396.44 quintals, gross income from Rs. 150,348 to Rs. 282,631 and net income from Rs. 3,943 to Rs. 58,176 just in a period of one year. The crop of Raya was discontinued in the second year and area under Taramira was reduced from 1.0 to 0.4 hectare. However, the yield of Taramira recorded a jump from 5.25 to 8.62 q/ha but the gross income came down from Rs.8400 to Rs. 5,520. The net income remained almost unchanged. The area under sugarcane decreased from 1.40 to 1.16 ha and so did the gross income from Rs. 15,715 to Rs. 13,560. However, gram was raised over 1.30 ha with a low yield of 4.63 q/ha thus contributing Rs. 9,331 to the gross income and Rs. 1,076 to the net income. Similarly, lentil was introduced in 0.40 ha with quite low yield of 4.78 q/ha, which provided gross income of Rs. 3,438 and net income of Rs. 1,168. Earlier, the area under Eucalyptus was 11.60 ha and after harvest of crop, it remained 7.82 ha. Area under mango increased from 0.40 to 1.20 ha. Still sizeable area remained fallow. However, it decreased from 15.00 to 12.60 ha, in a period of one year.

The total gross returns from command area increased from Rs. 174,463 to Rs. 314,480 and net returns from just Rs. 4,138 to Rs. 62,520. No vegetable seed production or Barseem fodder production could be taken up due to limited amount of water, available from the reservoir. The analysis of crop production for kharif crops was not attempted for Ibrahimpur as no discernible change was reported in kharif crops.

Cost of Cultivation

The cost of cultivation for both the years and both the projects was worked out in consultation with farmers where crop-cutting trails were laid out (Table14.2.2, 4.2.3,4.2.4). The cost of inputs such as seed, fertilizer, manure, pesticides/weedicide and water rent and all types of labour costs were included. In addition, the prevalent land rent, management costs and interest on money borrowed for inputs was also considered. The labour rate of Rs. 80 per day was considered for both the years. The market rates of produce and contracted rates of vegetable seeds were taken into consideration. It is seen that cost of cultivation has variably risen in the most of the crops due to increased use of inputs and more labour intensive operations.

TABLE 4.2.1: Area, Yield, Production, Gross and Net returns from different crops in command area of Water Harvesting Dam at Ibrahimpur during 2001-02 and 2002-03.

Crops	Area (ha)		%Area Under Crop		Mean Crop Yield (q/ha)		Total Production (q)		Rate (Rs./ha)	Gross Income (Rs.)		Cost of Cultivation Rs./ha		Total Cost of Cultivation (Rs.)		Net Returns (Rs.)	
	2001-02	**2002-03**	**2001-02**	**2002-03**	**2001-02**	**2002-03**	**2001-02**	**2002-03**		**2001-02**	**2002-03**	**2001-02**	**2002-03**	**2001-02**	**2002-03**	**2001-02**	**2002-03**
Wheat	17.80	23.32	37.55	48.38	G-10.55 S-12.00	15.19* 17.00	187.79 213.60	354.23 396.44	630 150	G-118308 S- 32040 150348	G-223165 S- 59466 282631	8225	9625	146405	224455	3943	58176
Raya	0.20	-	0.42	-	3.75	-	0.75	-	1700	1275	-	5600	-	1120	-	155	-
Taramira	1.00	0.40	2.11	0.83	5.25	8.62*	5.25	3.45	1600	8400	5520	5300	6200	5300	2480	3100	3040
Sugarcane	1.40	1.16	2.95	2.41	95.0 25.0	98.0 28.0	133.0 35.0	113.68 32.48	105 50	13965 1750 15715	11936 1624 13560	12500	12500	17500	14500	-1785	-940
Gram	-	1.30	-	2.70	-	4.63	-	6.02	1550	-	9331	-	6350	-	8255	-	1076
Lentil	-	0.40	-	0.83	-	4.78	-	1.91	1800	-	3438	-	5675	-	2270	-	1168
Eucalyptus	11.60	7.82	24.47	16.22	-	-	-	-	-	-	-	-	-	-	-	-	-
Mango	0.40	1.20	0.84	2.49	-	-	-	-	-	-	-	-	-	-	-	-	-
Fallow	15.00	12.60	31.66	26.14	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	**47.40**	**48.20**	**100**	**100**	**-**	**-**	**-**	**-**	**-**	**174463**	**314480**	**-**		**170325**	**251960**	**4138**	**62520**

G- Grain, S- Stovers/straw * One pre-sowing and one post sowing irrigation from harvested water.

Table 4.2.2: Average cost of cultivation (per acre) of different crops at Bharauli during 2001-02

Cost Items	Wheat	Gram	Taramira	Lentil	Barseem	Onion	Carrot seed	Radish seed	Cauliflower seed	Maize	Fodder Crops
A. Cost of Input											
Seed	250	150	50	50	500	2000	100	50	1120	250	200
Fertilizer N	240	240	120	120	480	480	480	240	960	240	240
P	230	130	230	230	460	460	460	460	920	-	-
K	-	-	-	-	120	-	-	-	200	-	-
Others	-	-	-	-	-	-	-	-	150	-	-
Manure	700	-	-	-	1400	1200	-	-	2800	700	-
Weedicide	200	-	-	-	-	200	-	-	-	150	-
Pesticide	-	-	-	-	-	150	300	300	600	-	-
Water rent	70	70	-	-	350	190	280	280	420	-	-
Any other	-	-	-	-	-	-	-	-	-	-	-
Sub Total	**1690**	**590**	**500**	**500**	**3310**	**4980**	**1620**	**1330**	**5170**	**1340**	**440**
B. Labour cost											
Preparatory tillage	600	300	400	400	400	400	800	500	1000	400	400
Sowing operation	200	200	200	200	80	1200	800	400	650	80	80
Weeding, hoeing, thinning	-	-	-	-	-	1200	650	1200	1600	-	-
Application of weedicide/pesticide/irrigation	100	70	-	-	350	490	280	500	240	-	-
Watch and ward/fencing	140	140	140	140	140	140	140	140	140	140	140
Harvesting	400	200	200	200	900	800	400	400	320	200	200
Transport, if any	-	-	-	-	-	-	-	-	-	-	200
Threshing	400	200	200	200	-	-	300	450	320	600	-
Cleaning/Packing in bags	-	-	-	-	-	300	100	250	-	-	-
Carriage to market	150	50	40	40	-	-	-	-	-	-	-
Any other	-	-	-	-	-	-	-	-	-	-	-
Sub Total	**1990**	**1160**	**1180**	**1180**	**1870**	**4530**	**3470**	**3840**	**4270**	**1420**	**1020**
C. Miscellaneous Costs											
Land rent	2000	1500	1500	1500	2500	2500	2500	2500	2500	1500	1000
Market Charges	50	15	15	15	-	-	-	-		25	-
Management cost	200	-	-	-	-	200	100	200	400	50	50
Interest on capital	100	50	50	50	150	300	120	100	250	100	-
Any other	-	-	-	-	-	-	-	200	-	-	-
Sub Total	**2350**	**1565**	**1565**	**1565**	**2650**	**3000**	**2720**	**3000**	**3150**	**1675**	**1050**
Total	**6030**	**3315**	**3265**	**3265**	**7830**	**12510**	**7810**	**8170**	**12590**	**4435**	**2510**

Table 4.2.3: Average cost of cultivation (per acre) of different Rabi season crops at Bharauli during 2002-03

Cost Items	Wheat	Gram	Taramira	Lentil	Barseem	Sorghum/ Bajra	Onion	Carrot seed	Radish seed	Cauliflower seed	Paddy	Maize	Fodder Crops
A. Cost of Input				No area									
Fertilizer N	240	240	240	240	720	480	960	480	240	960	480	480	240
P	460	460	460	460	460	460	460	460	460	920	460	460	-
K	-	-	-	-	120	-	150	-	-	200	240	-	-
Others	-	-	-	-	-	-	-	-	-	150	150	-	-
Manure	700	-	-	-	1400	-	1400	-	-	2800	700	700	-
Weedicide	200	-	-	-	-	-	200	-	-	-	150	150	-
Pesticide	-	-	-	-	-	-	500	300	450	600	400	-	-
Water rent	210	140	140	140	490	350	700	450	350	420	350	-	-
Any other	-	-	-	-	-	-	-	-	-	-	-	-	-
Sub Total	**2060**	**890**	**890**	**890**	**3690**	**1400**	**7370**	**1790**	**1550**	**5170**	**3380**	**2040**	**440**
B. Labour cost													
Preparatory tillage	800	400	400	400	400	400	600	800	600	1000	800	600	400
Sowing operation	200	200	200	200	80	80	1500	800	480	650	1000	80	80
Weeding, hoeing, thinning	-	-	-	-	-	-	1400	650	1600	1600	-	-	-
Application of weedicide/ pesticide/irrigation	7	160	160	160	560	400	700	450	640	240	400	-	-
Watch and ward/fencing	140	140	140	140	140	140	140	140	140	140	140	140	140
Harvesting	500	320	320	320	1000	1200	1000	400	480	320	1000	200	200
Transport if any	-	-	-	-	-	-	-	-	-	-	-	-	200
Threshing	500	300	300	300	-	-	-	300	525	320	300	700	-
Cleaning/Packing in bags	-	-	-	-	-	-	500	100	320	-	-	100	-
Carriage to market	200	50	50	50	-	-	-	-	-	-	350	100	-
Any other	-	-	-	-	-	-	-	-	-	-	80	150	-
Sub Total	**2740**	**1570**	**1570**	**1570**	**2180**	**2220**	**5840**	**3640**	**4785**	**4270**	**4070**	**2070**	**1020**
C. Miscellaneous Costs													
Land rent	3000	2000	2000	2000	3000	2000	3000	3000	3000	3000	3000	3000	1000
Market Charges	60	15	15	15	-	-	-	-	-		50	25	-
Management cost	300	-	-	-	-	-	200	100	300	500	250	50	50
Interest on capital	150	85	85	85	150	120	532	120	150	300	300	150	-
Any other	-	-	-	-	-	-	-	-	450	-	-	-	-
Sub Total	**3510**	**2100**	**2100**	**2100**	**3150**	**2120**	**3532**	**3220**	**3900**	**3800**	**3600**	**3225**	**1050**
Total	**8310**	**4560**	**4560**	**4560**	**9020**	**7500**	**16742**	**8650**	**10235**	**13240**	**11050**	**7335**	**2510**

Table 4.2.4: Average cost of cultivation (per acre) of different crops at Ibrahimpur during 2001-02 and 2002-03

Cost Items	Year 2001-2002				Year 2002-2003			
	Wheat	**Raya**	**Taramira**	**Sugarcane**	**Wheat**	**Gram**	**Taramira**	**Lentil**
A. Cost of Input								
Seed	250	50	50	500	250	150	50	50
Fertilizer N	240	240	120	240	240	240	120	120
P	-	-	-	-	-	-	-	-
K	-	-	-	-	-	-	-	-
Others	-	-	-	-	-	-	-	-
Manure	-	-	-	-	-	-	-	-
Weedicide	200	-	-	-	200	-	-	-
Pesticide	-	-	-	250	-	-	-	-
Water rent	-	-	-	-	200	-	200	-
Any other	-	-	-	-	-	-	-	-
Sub Total	**690**	**290**	**170**	**990**	**890**	**390**	**370**	**170**
B. Labour cost								
Preparatory tillage	400	400	400	400	400	400	400	400
Sowing operation	100	100	100	400	100	200	100	200
Weeding, hoeing, thinning	-	-	-	320	-	-	-	-
Application of weedicide/pesticide irrigation	-	-	-	80	160	-	160	-
Watch and ward/fencing	-	-	-	-	-	-	-	-
Harvesting	500	200	200	960	600	200	200	200
Transport if any	-	-	-	-	-	-	-	-
Threshing	500	150	150	-	600	150	150	150
Cleaning/Packing in bags	-	-	-	-	-	-	-	-
Carriage to market	-	-	-	600	-	-	-	-
Any other	-	-	-	-	-	-	-	-
Sub Total	**1500**	**850**	**850**	**2760**	**1860**	**950**	**1010**	**950**
C. Miscellaneous Costs	-				-			
Land rent	1000	1000	1000	1000	1000	1000	1000	1000
Market Charges	-	-	-	50	-	50	-	50
Management cost	100	100	100	100	100	100	100	100
Interest on capital	-	-	-	100	-	50	-	100
Any other	-	-	-	-	-	-	-	-
Sub Total	**1100**	**1100**	**1100**	**1250**	**1100**	**1200**	**1100**	**1150**
Total	**3290**	**2240**	**2120**	**5000**	**3850**	**2540**	**2480**	**2270**

4.3 SOIL ANALYSIS

A detailed soil analysis was carried out from farm lands of selected villages. The results are summarised in table 4.3.

Table 4.3: Soil analysis of farm lands in selected dam villages

Name of dam village	Soil Type	pH	E.C m.mhos	O.C %	Total P (Kg/ac)	Total K (Kg/ac)
Nanheri	Sandy loam, loam, loamy sand	7.4-8.2 (7.72)	0.13-0.4 (0.28)	0.21-0.3 (0.25)	84-5.85 (3.80)	84-126 (102.94)
Kathgarh	Sandy loam, loam, loamy sand	7.2-7.9 (7.54)	0.10-0.68 (0.28)	0.19-0.31 (0.25)	2.24-8.67 (3.80)	76-126 (102.6)
Nawan Goan	Sandy loam, loam, loamy sand	7.2-8.2 (7.71)	0.12-0.45 (0.26)	0.21-0.45 (0.31)	2.12-4.43 (2.88)	70-104 (85.06)
Bhagwanpur	Sandy loam, loam, loamy sand	7.6-8.1 (7.83)	0.10-0.42 (0.24)	0.18-0.33 (0.25)	2.12-6.17 (3.64)	80-121 (98.89)
Ibrahimpur	Sandy loam, loam, loamy sand	7.6-8.0 (7.81)	0.09-0.34 (90.23)	0.19-0.33 (0.26)	2.12-6.17 (3.86)	80-128 (105.9)
Taska	Sandy loam, loam, loamy sand	7.5-8.2 (7.71)	0.15-0.45 (0.29)	0.13-0.39 (0.27)	2.8-6.11 (3.65)	75-140 (108)

The above results are typical of cultivated lands of the Shivaliks. The results show a high degree of uniformity across the sample area in Yamunanagar District, irrespective of soil type.

Soil Type :- Three soil types are recognised out of which sandy loams dominate, loamy sands and loams are less common. Given the predominance of sandy loam soils will have serious implications for soil structure, soil erosion and soil moisture retention capacity.

Soil PH :- The pH of all soil samples is within 1° of neutral. A few samples show a pH 8.0, none show an acidic pH. Acidity in these soils at this point does not appear to be a problem.

Electrical-conductivity (EC in mmhos) :- Normal conductivity is 0-0.8, mmhos. All of the results show averages falling between 0.24-0.29, well within the “normal” criteria. It can be concluded that the saline build up is not critical. Electro-conductivity must be monitored with the increased use of irrigation, leading to increase salt build up and the possible increased use of artificial fertiliser.

Organic Carbon (%): - Organic Carbon is universally low, in fact very low. It is surprising that some crops are not more chlorotic. Farmers practice is to apply urea, which is immediately taken up, before it is either washed away or leached, probably accounts for the lack of chlorosis. Nevertheless, the chronic shortages of organic carbon

will impact on soil structure, leading to poor capillarity and low yields experienced by many farmers or poor tree growth rate experienced by foresters. All crops require different amounts of Nitrogen throughout their growing cycle; farmers appear to be providing nitrogen through urea and DAP application on an almost hydrophonic basis. These results demonstrate the very low nitrogen retention and other macronutrients.

Phosphate :- It is understood that the analyses assess total phosphate (P_2O_5), different from available Phosphate. In many soils less than 5% of total Phosphate is available, suggesting that very small quantities of Phosphate are available. These low figures suggest the application of DAP takes place on an infrequent basis. The levels of phosphate are significantly below the demands for many agricultural crops and tree growth. Phosphate is important for root development, which may account for the poor establishment of agricultural crops and tree plantations.

Potassium:- There are luxury levels of Potassium, in spite of the potassium being technically at “medium” levels. With these very high potassium levels some release of Phosphate may be inhibited, thus even less phosphate may be available.

Recommendations

Poor crop performance, poor tree growth rates, poor establishment is readily understandable in the light of the soil analyses results. The paucity of N and P is not unexpected, but typical of these lateritic soils and of the farming system that they are subjected. Soils at this level of basal infertility will not retain artificial fertiliser beyond each growing season. In addition, because of their sandy and unstructured nature will be highly susceptible to all forms of soil erosion, particularly gully and rill erosion.

Clearly farmers need to build the quantity of organic matter in their soils, through the application of farmyard manure (traditionally applied prior to the Kharif seasons), use of mulch and of green manures. Including tree crops into a rotation is also a method of increasing soil organic matter.

The augmentation of soil organic matter needs to be set in a strategic context. Every year practices should be aimed at cumulative acquisition of soil nutrients and soil organic matter. In the longer term, a strategic approach to soil fertility increase will pay dividends, which will enhance soil structure, increase the C:N ratio, increase the organic matter available in the “A” horizon and increase the soil moisture retention capacity.

4.4 Land Levelling

An area of 5.82 hectare of uncultivated land lying barren for long along the main torrent was levelled, manured and brought under cultivation by six farmers of Bharauli. The availability of water form WHD prompted them to bring this land under productive use by raising vegetable crops for seed production and wheat crop.

Table 4.4: Uncultivated land levelled and brought under cultivation in command area of WHD at Bharauli During 2003-04

Name of Farmer	Fathers Name	Land levelled (acre)	Crops raised on levelled land
Amarjit	Aflatoom	0.75	Onion
Pirdia Ram	Lakhn Ram	1.00	Radish seed
		3.00	Wheat
Singh Raj	Narata Ram	0.25	Cauliflower seed
Raj Kumar	-Do-	0.25	Radish seed
Bala Ram	-Do-	0.37	Wheat
Mohinder Singh	Bachna Ram	0.20	Wheat
Total		**5.82**	

4.5 Improvement in crop production in the command area of WHD Mirpur

A 14.5-m high earthen dam was constructed at Mirpur during 2002-03 to store 21.70 ha m of water from 70-hectare forest watershed and provided the facility of irrigation to 60-hectare command area. A survey was conducted during 2002-03 to ascertain the crop production levels during the base year, which covered 35 farming families having 34.20 hectare of land in the command area. A similar survey of the sampled families was conducted during Rabi season of 2004-05 to assess the impact of water harvesting on crop productivity (Table 4.5.1).

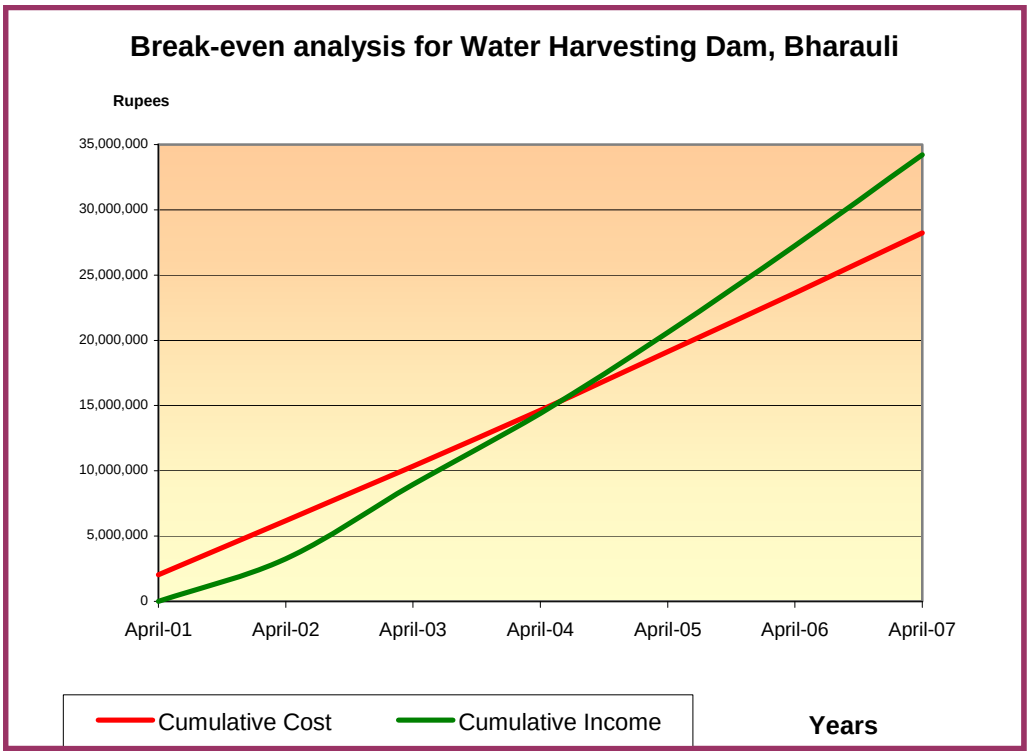
Table 4.5.1: Crop production in command area of Mirpur WHD during 2002-03 and 2004-05

Crop	Area (ha)		Mean crop yield (q/ha)		Total crop production (q)		Monetary value of crops (Rs.)	
	2002-03	2004-05	2002-03	2004-05	2002-03	2004-05	2002-03	2004-05
Wheat	27.45	28.48	15.86	30.37	435.25	864.88	274208	544874
Gram	0.35	0.10	7.14	20.00	2.50	2.00	4500	3600
Oilseeds	2.65	-	6.51	-	17.25	11.25*	34500	22500
Onion Crop	0.20	1.40	100.00	352.68	20.00	493.75	7000	172813
Onion Seed	-	0.34	-	5.15	-	1.75	-	87500
Barseem Fodder	0.20	2.08	125.00	319.23	25.00	664	2000	53120
Oats Fodder	0.95	-	117.24	-	111.38	-	6683	-
Fallow	2.40	1.80	-	-	-	-	-	-
Total	**34.20**	**34.20**	**-**	**-**	**-**	**-**	**328891**	**884407**

* Mustard was raised as crop mixture with wheat.

The salient highlights are as under:

- The wheat crop yield and production almost doubled.
- The oilseed and pulses earlier raised under rainfed conditions were replaced by vegetable crop of onion and onion seed.
- The barseem fodder production recorded a quantum jump from just 25 to 664 quintals.
- The onion crop production jumped from 20 to 493 quintals.
- The monetary value of crops increased from Rs. 3,28,891 to 8,84,407.



4.6 Break-Even Analysis

An impact assessment of one of the first dams constructed by the project (Bharauli), focusing on increased crop and milk yield, was carried out in 2004-05. This analysis showed that all costs of construction and farmer investments were recovered by increased crop and milk yield through year-round irrigation after only 3.5 years of the establishment of the dam (Fig.). The economic life of the dam is expected to be at least 25 years.

Table 4.5.2: Water Harvesting Dam, Bharauli – Costs and Benefits during seven years

Costs:	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	Total, 7 years
Project cost for dam	2,026,863	1,469,503	-	249,926	84,140	-	-	3,830,432
Community cost for dam	-	31,500	44,000	16,415	12,398	10,000	10,000	124,313
Farmers' cost for crops	-	2,113,704	3,415,613	3,272,050	3,596,087	3,600,000	3,700,000	19,697,454
Farmers' cost for milk	-	548,376	713,064	748,717	800,000	850,000	900,000	4,560,157
Cost for fish production	-	-	-	-	-	10,000	20,000	30,000
Total cost	2,026,863	4,163,083	4,172,677	4,287,108	4,492,625	4,470,000	4,630,000	28,242,356
Income:								
From crops	-	2,349,639	4,389,377	4,090,063	4,711,301	5,000,000	5,200,000	25,740,380
From milk	-	913,960	1,296,480	1,361,304	1,500,000	1,600,000	1,700,000	8,371,744
From fish	-	-	-	-	-	30,000	70,000	100,000
Total income	-	3,263,599	5,685,857	5,451,367	6,211,301	6,630,000	6,970,000	34,212,124
Cumulative Cost	2,026,863	6,189,946	10,362,623	14,649,731	19,142,356	23,612,356	28,242,356	
Cumulative Income	-	3,263,599	8,949,456	14,400,823	20,612,124	27,242,124	34,212,124	
Net Benefit	(2,026,863)	(2,926,347)	(1,413,167)	(248,908)	1,469,768	3,629,768	5,969,768	
				IRR:	-41%	-7%	12%	
				BCR:	1.08:1	1.15:1	1.21:1	

Year = May – April

Projected cost/income from 2005-2006, and for 2004-2005 milk production

4.7 Salient changes in area, crop yields and net returns in dam villages

The baselines for crop production in dam villages were established just before starting the work. The status of area, yield levels and crop production was again studied during Rabi and Kharif of 2006-07 in 17 dam villages. The changes thus recorded are reported in summary tables of all villages (Annexure). Out of these data sets salient changes in land use, crop yields and net returns are highlighted as under. Area under various crops in the baseline denotes the entire command area, whereas current area denotes the area sampled for the crop survey only.

Changes in land use

- Area under wheat was reduced to add more area under barseem fodder and vegetable crops.
- Most of the oilseed crops like taramira, sarson and pulses like masoor, gram were gradually replaced in favour of other remunerative crops.
- Paddy was introduced in a big way in all dam villages by replacing maize. Wildlife damage to maize crop promoted this change.
- In view of sizeable livestock population sorghum and bajra continue to remain on farms, but were shifted to relatively poor quality lands and best lands were put under paddy.
- Depending on the facility of contract farming, vegetable crops like green onion and vegetable seed crops like carrot, cauliflower and radish were introduced in several dam villages, but mostly in Panchkula district and not in Yamuna Nagar.

Crop yield levels

- A significant increase in crop yields was noted, particularly in Rabi season crops like wheat.
- Paddy was cultivated in some villages over small areas by lifting water from perennial nallahs and yield levels were low. There was a lot of improvement in paddy yields after dam irrigation.
- Fodder crops like sorghum are now raised in leveled fields and supplemental irrigation is applied when rains fail. This has boosted the yield of sorghum.
- The yield of rainfed sugarcane also improved with supplemental irrigation.
- Not much improvement in the yield of maize was reported, partly as the farmers are not shifting to HYV and hybrids and partly because of damage by wildlife.

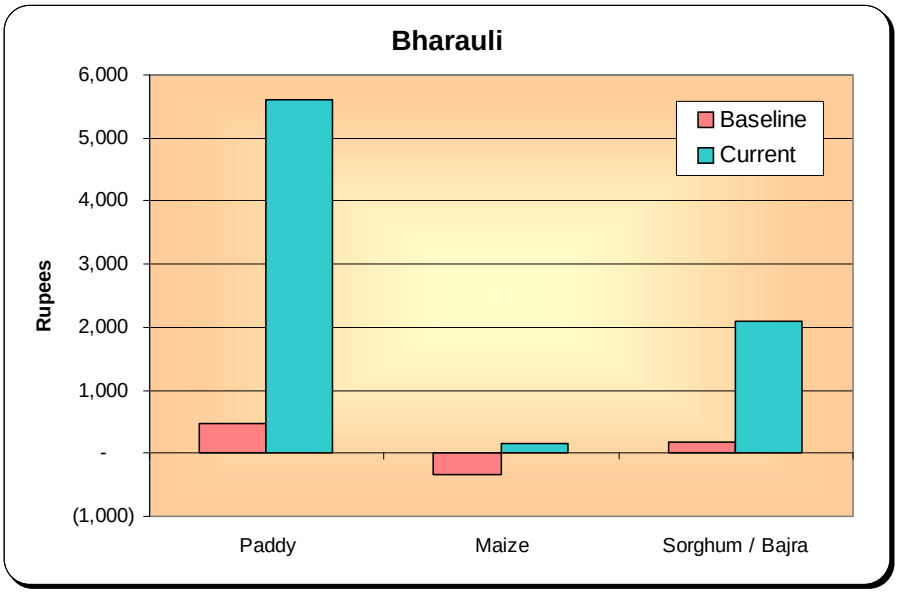
Net Returns

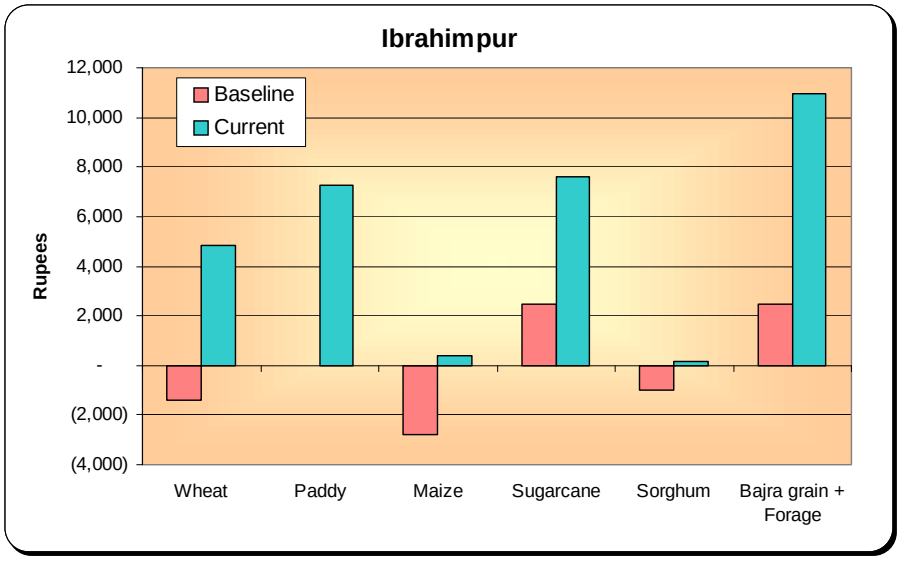
- Farmers with rainfed agriculture were ending up with negative farm returns in most of the crops. However, after the facility of irrigation, the benefits have exceeded

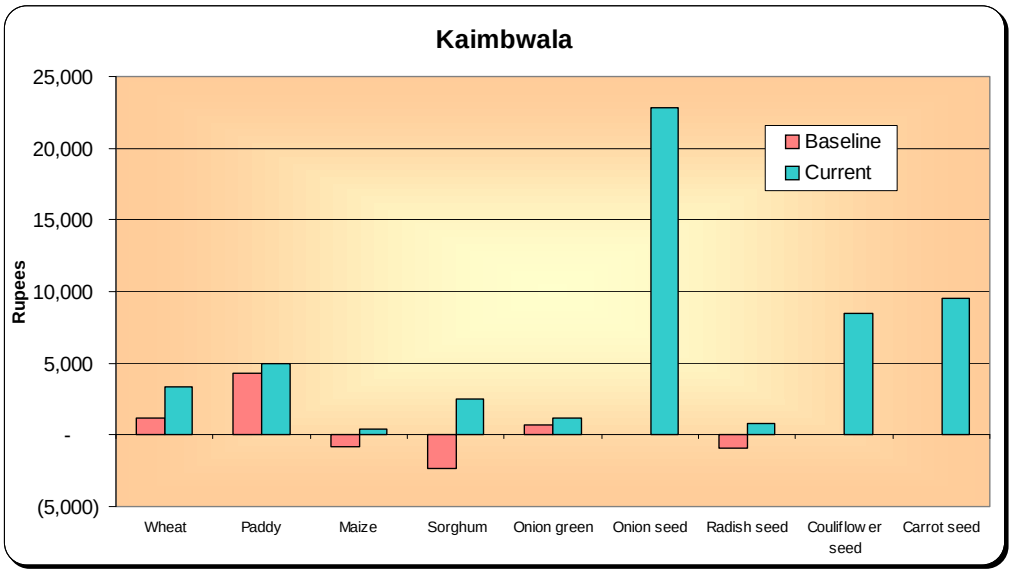
costs in most of the crops.

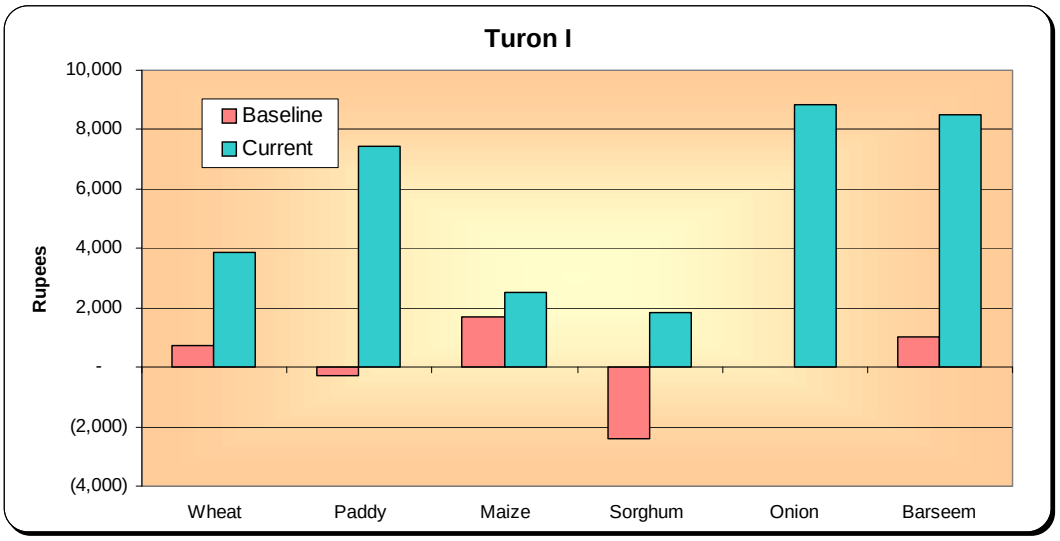
- Vegetable crops and sugarcane in general have given high net returns as compared to other crops.
- Paddy crop has also given good net returns when its yield was around 20q/acre.
- Barseem crop gave excellent returns when the yield levels increased above 200q/acre.

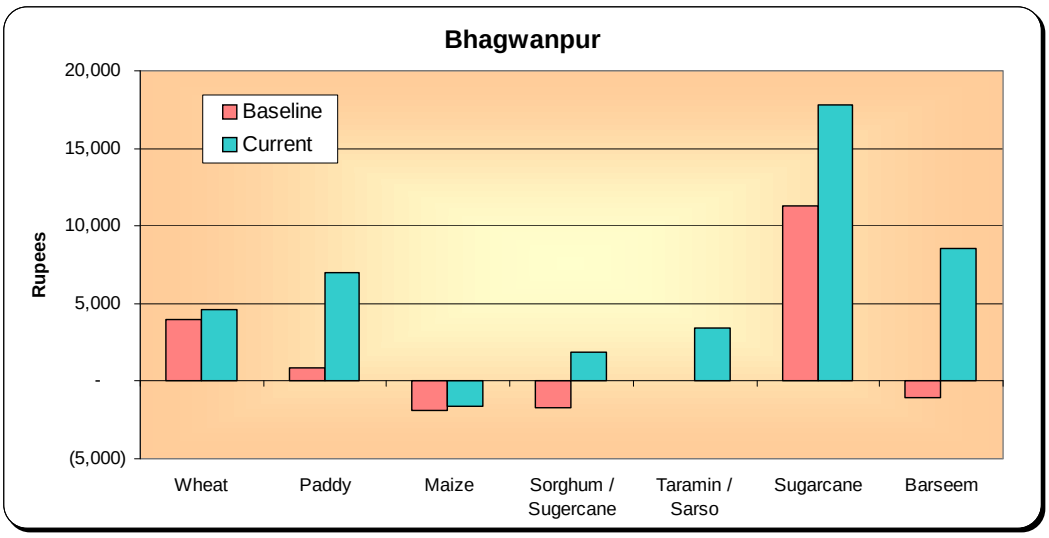
Changes in Net Returns per Acre for Selected Crops

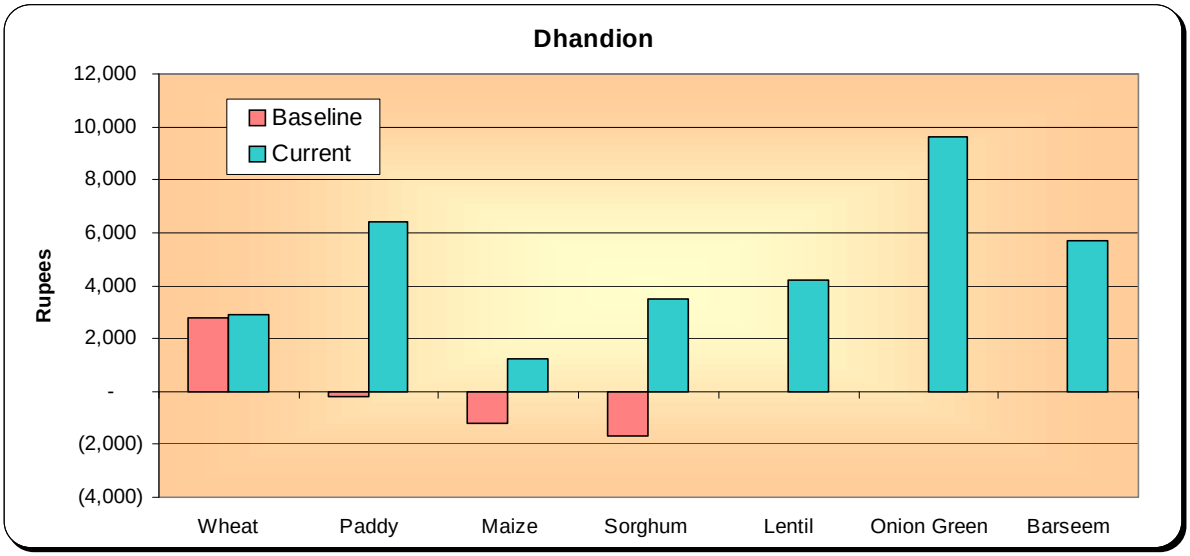







Turon I
10,000
8,000
6,000
4,000
2,000
-
(2,000)
(4,000)
Rupees
Baseline
Current
Wheat
Paddy
Maize
Sorghum
Onion
Barseem


Bhagwanpur
20,000
15,000
10,000
5,000
-
(5,000)
Rupees
Baseline
Current
Wheat
Paddy
Maize
Sorghum / Sugercane
Taramin / Sarso
Sugarcane
Barseem


Dhandion
12,000
10,000
8,000
6,000
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2,000
-
(2,000)
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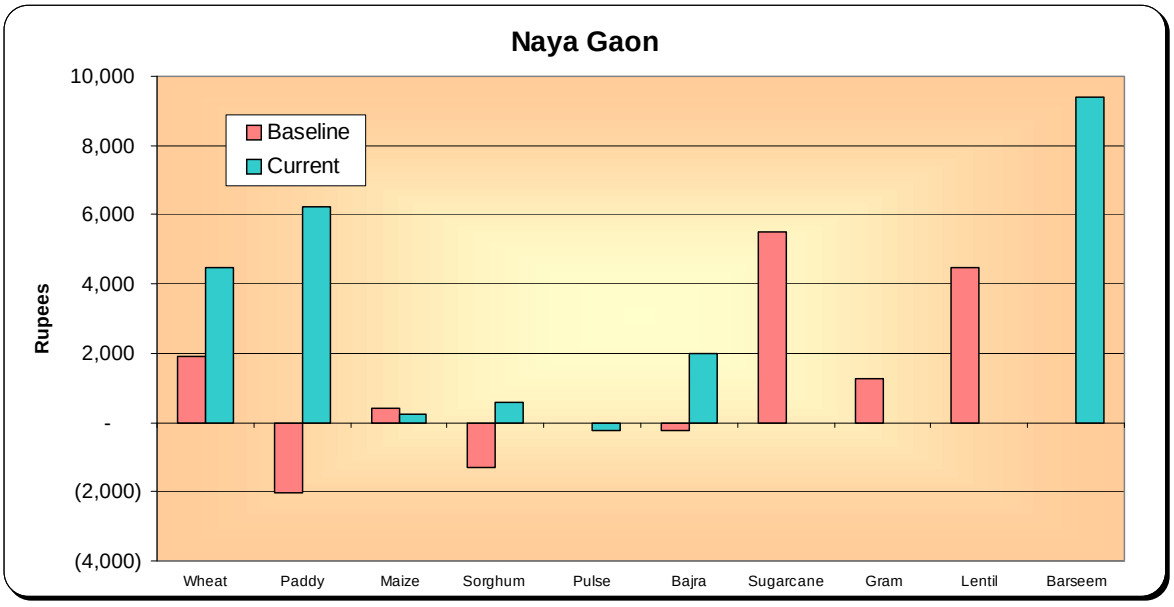
Rupees
Baseline
Current
Wheat
Paddy
Maize
Sorghum
Lentil
Onion Green
Barseem


Naya Gaon
Baseline
Current
Rupees
10,000
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-
(2,000)
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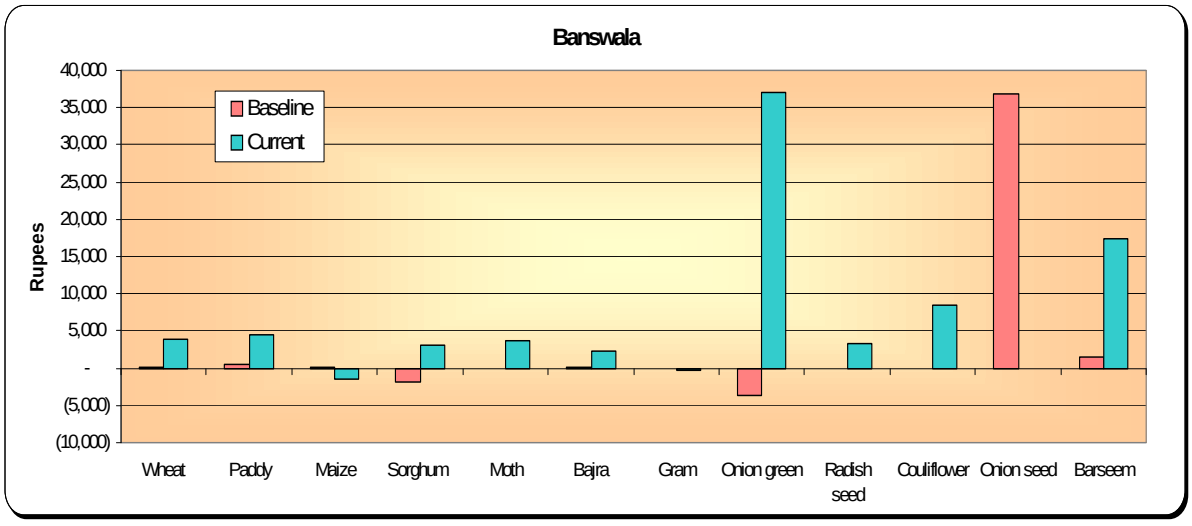
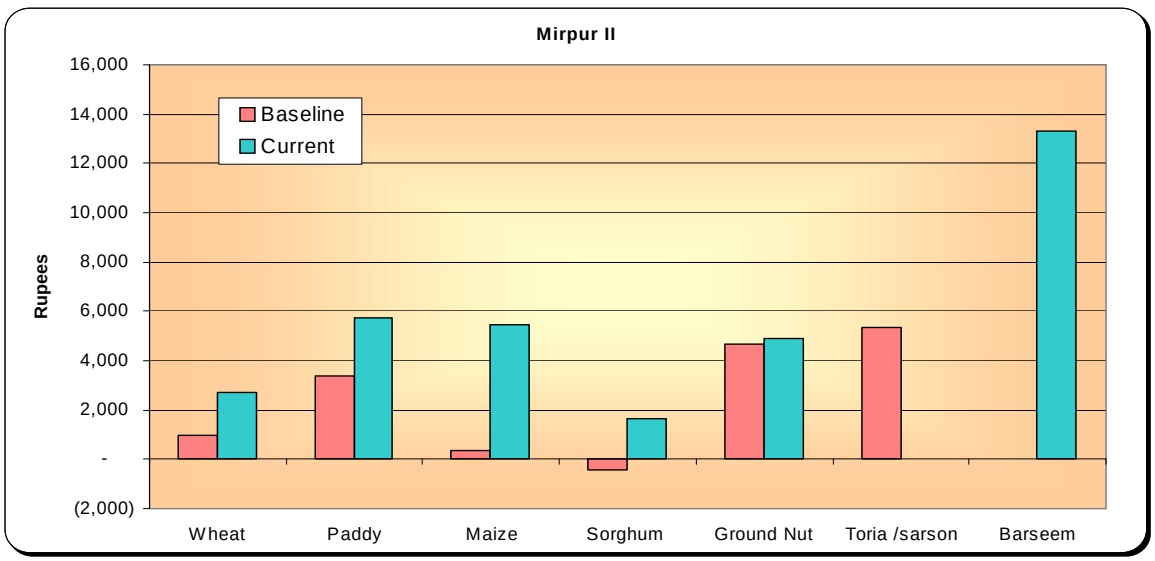
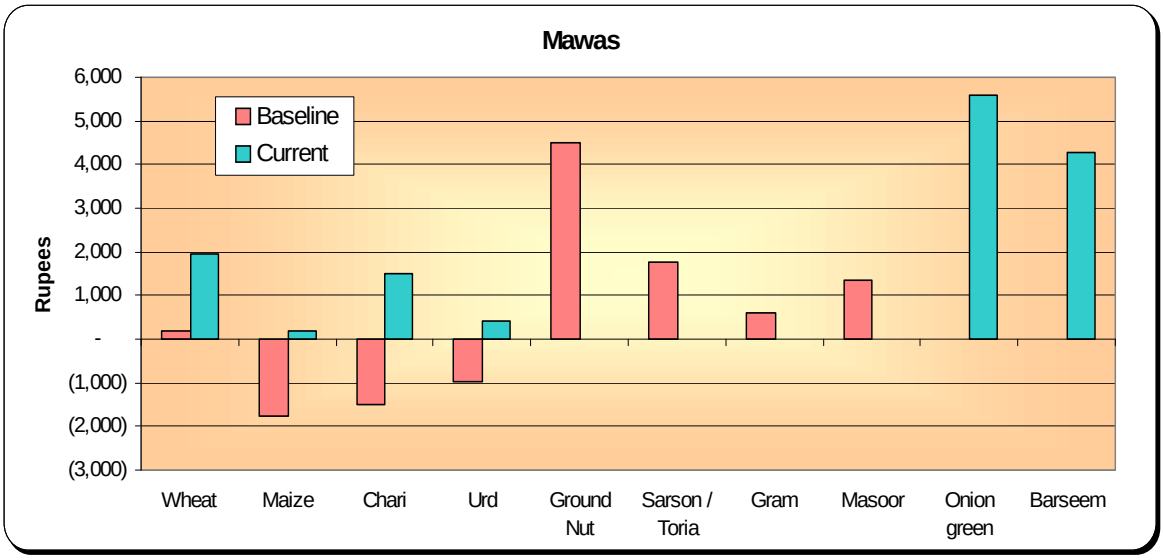
Wheat
Paddy
Maize
Sorghum
Pulse
Bajra
Sugarcane
Gram
Lentil
Barseem


Banswala
Baseline
Current
Rupees
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
-
(5,000)
(10,000)
Wheat
Paddy
Maize
Sorghum
Moth
Bajra
Gram
Onion green
Radish seed
Couliflower
Onion seed
Barseem


Mirpur II
Baseline
Current
Rupees
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
(2,000)
Wheat
Paddy
Maize
Sorghum
Ground Nut
Toria /sarson
Barseem


Mawas
Baseline
Current
Rupees
6,000
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4,000
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(1,000)
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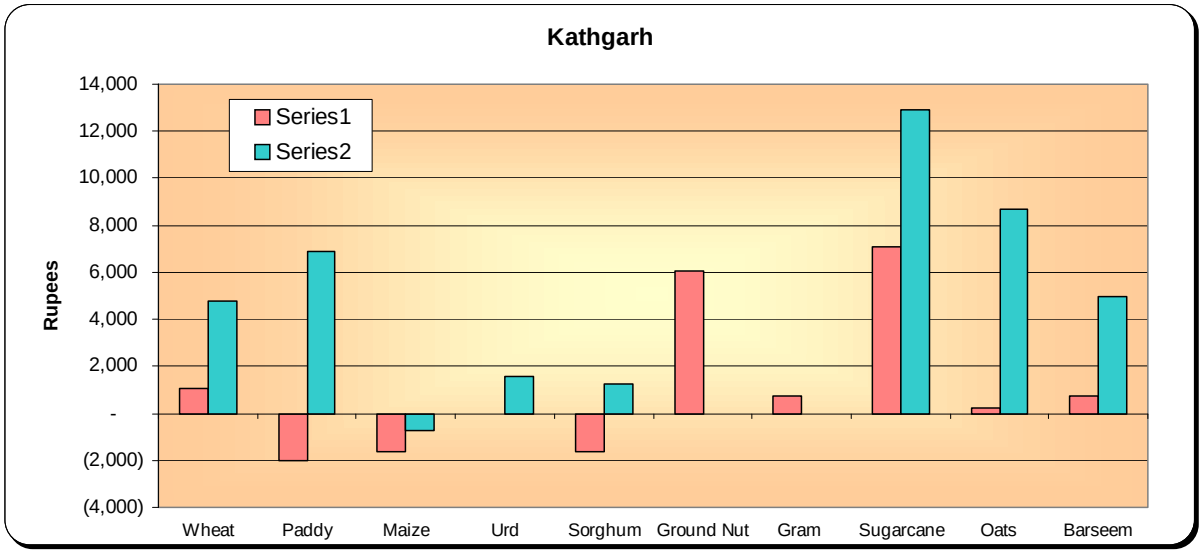
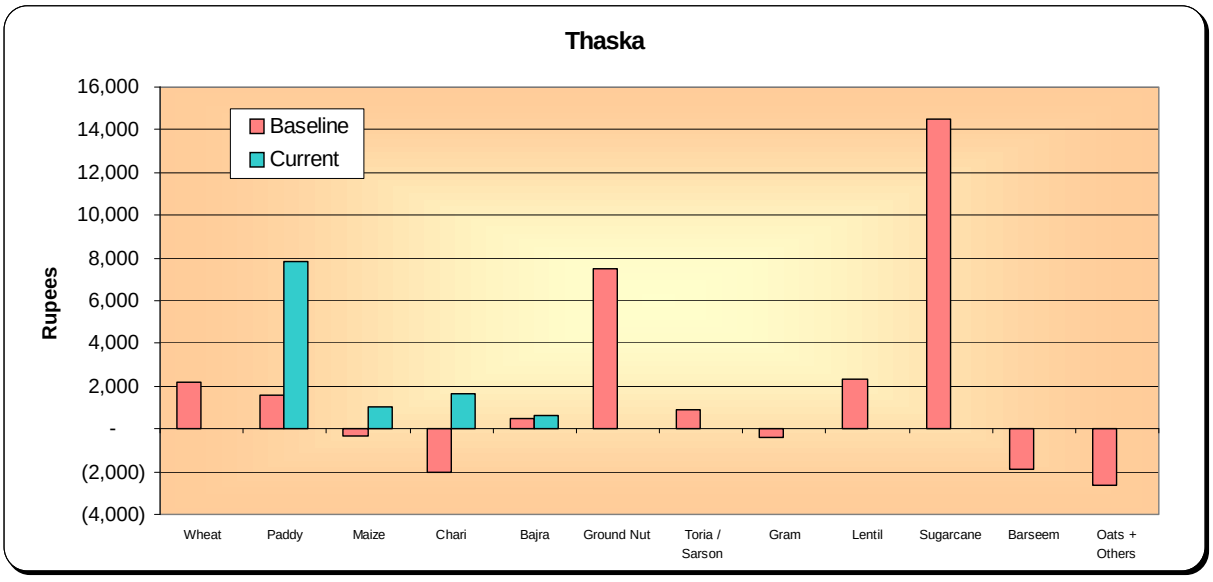
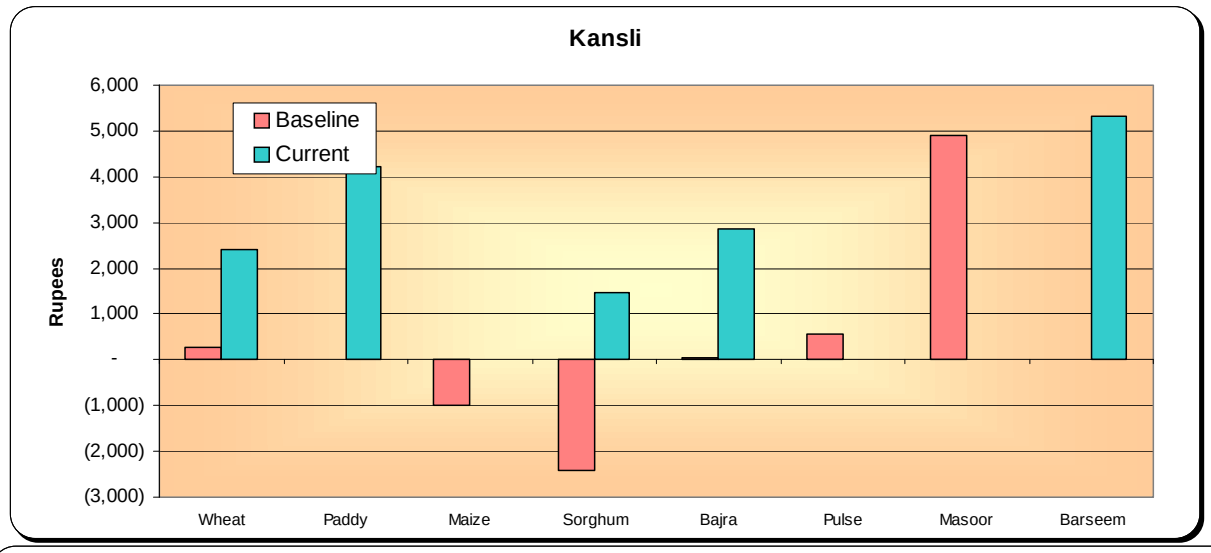
Wheat
Maize
Chari
Urd
Ground Nut
Sarson / Toria
Gram
Masoor
Onion green
Barseem


Kathgarh
Series1
Series2
Rupees
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
(2,000)
(4,000)
Wheat
Paddy
Maize
Urd
Sorghum
Ground Nut
Gram
Sugarcane
Oats
Barseem


Thaska
Baseline
Current
Rupees
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
(2,000)
(4,000)
Wheat
Paddy
Maize
Chari
Bajra
Ground Nut
Toria / Sarson
Gram
Lentil
Sugarcane
Barseem
Oats + Others


Kansli
Baseline
Current
Rupees
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(1,000)
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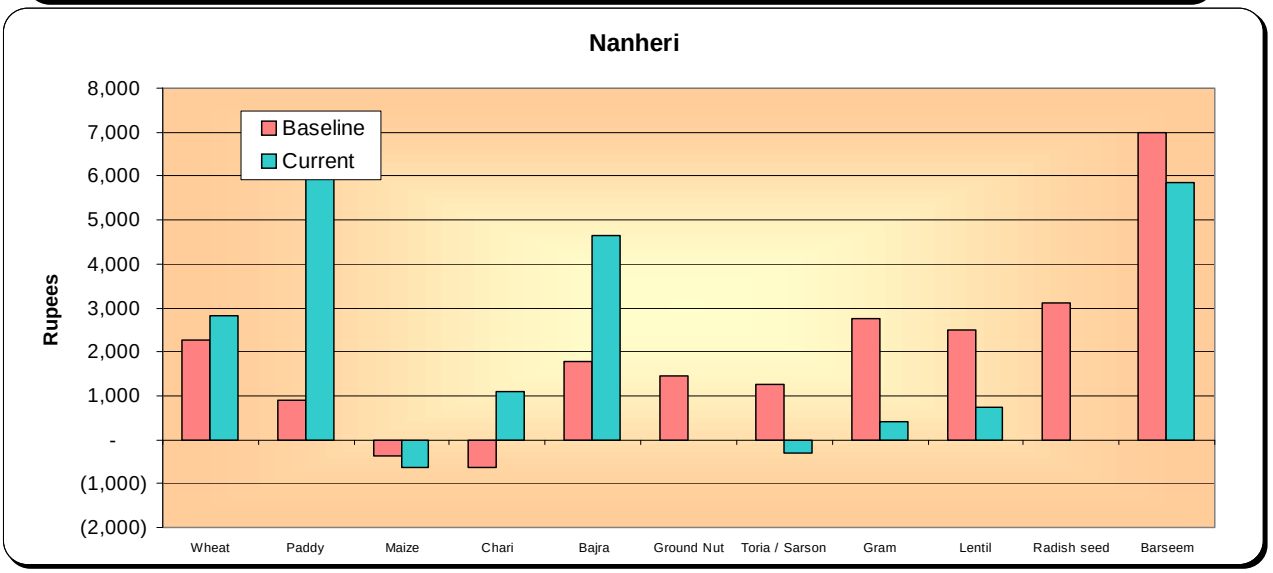
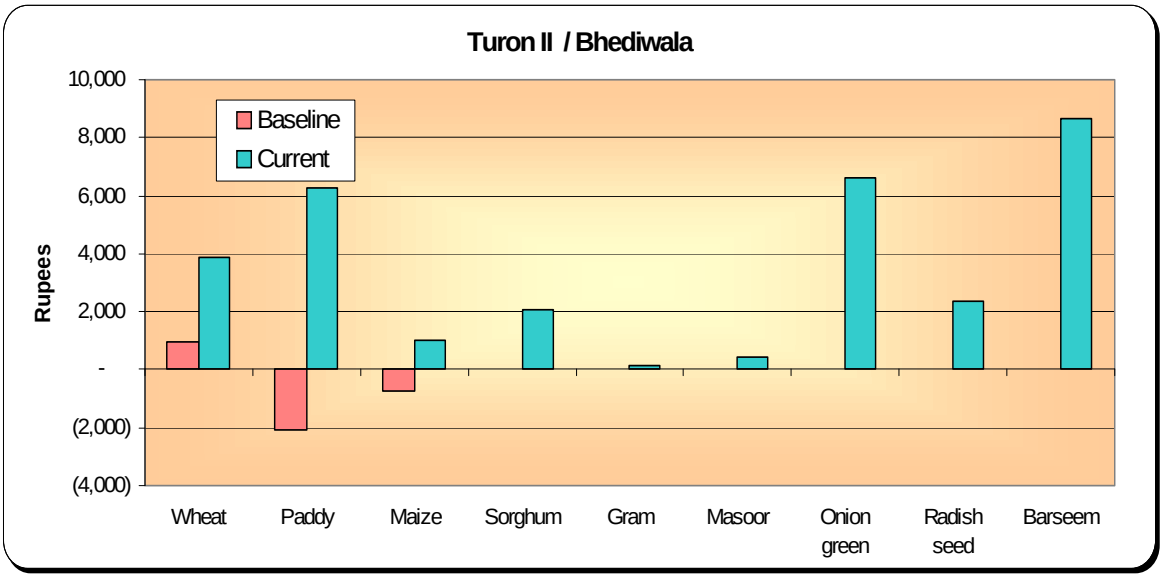
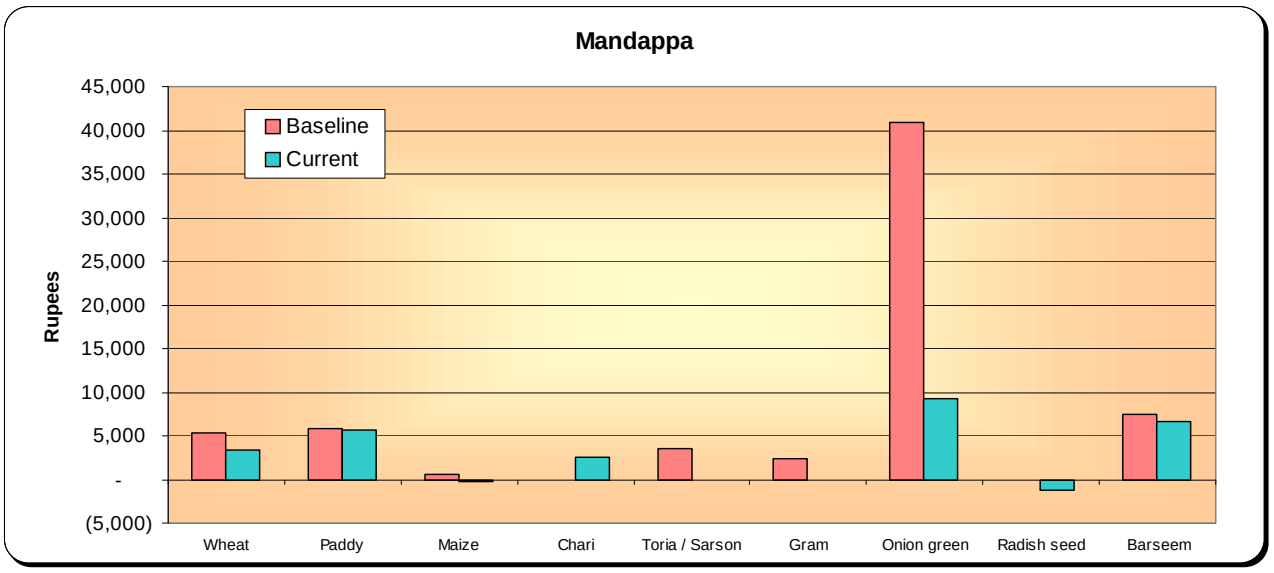
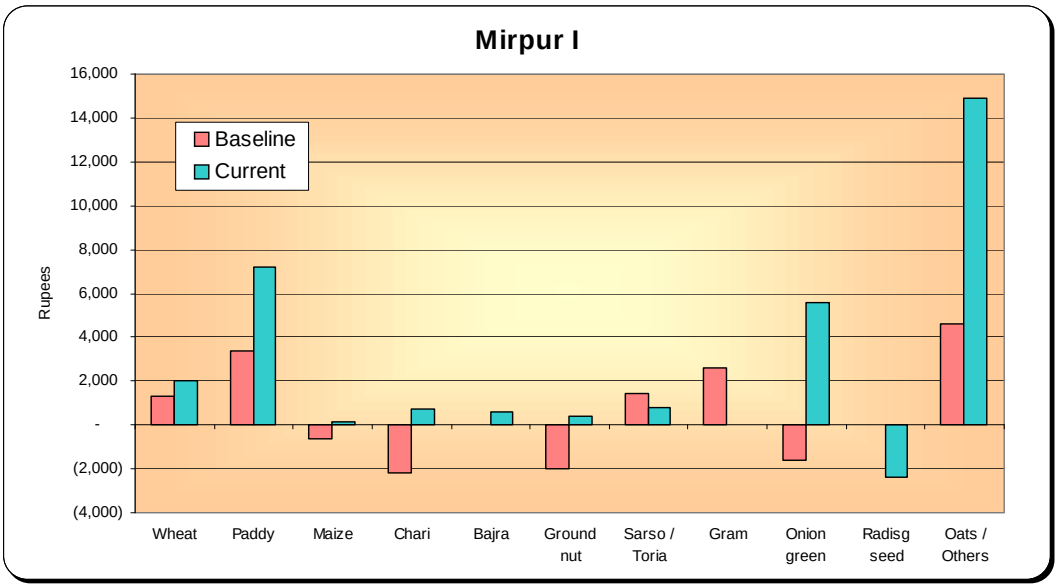
Wheat
Paddy
Maize
Sorghum
Bajra
Pulse
Masoor
Barseem


Nanheri
Baseline
Current
Rupees
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
(1,000)
(2,000)
Wheat
Paddy
Maize
Chari
Bajra
Ground Nut
Toria / Sarson
Gram
Lentil
Radish seed
Barseem


Turon II / Bhediwala
Baseline
Current
Rupees
10,000
8,000
6,000
4,000
2,000
-
(2,000)
(4,000)
Wheat
Paddy
Maize
Sorghum
Gram
Masoor
Onion green
Radish seed
Barseem





4.6 FODDER PRODUCTION

The scarcity of good quality green forage limits milk production in the foothill villages of Haryana Shivaliks. The availability of harvested water in Bharauli reservoir prompted the farmers to raise a third crop of summer fodder in the command area during summer 2003. This was not possible earlier when there was no facility of water in summer months. Summer fodders like Bajra, Maize + Bajra mixture and Sorghum were raised by 38 farmers in an area of 57 kanals (7 acres) in command area of Bharauli water harvesting dam (Table). Five to six irrigations were provided from the harvested water. These farmers used 204 kg of urea fertilizer & 15 kg of DAP. A total production of 805.6 quintal green fodder was worth Rs. 80,562. This much benefit was against no possibility of summer fodder before. The availability of green fodder during summer season helped in increasing milk production.

In fact it was necessary that the reservoir-stored water be utilized before the end of June 2003 so that run-off of coming monsoon rains could be stored to the full extent. The utilization of left over water from Rabi crops for raising summer fodder production not only helped in making reservoir empty but in the process also produced much needed green fodder for milch cattle. Incidentally, the milk production in summer months due to green forage availability is a boon to the farmers because milk prices are highest during this period of the year.

As indicated earlier, the area under crop of barseem increased from 2.99 to 4.80 hectares and overall green Barseem fodder production increased from 358.8 to 888 quintals between 2001-02 and 2002-03. The dry roughage is necessary for livestock. The wheat straw is most common roughage and its production increased from 1225.6 quintals to 1875.46 quintals. The wheat straw (Bhusa/Turi) produced as dry roughage is mixed with Barseem to make it a balanced ration for livestock. Major supply of dry forage is obtained from kharif crops. This forage after drying is preserved and used during winter months. There was a production of 4505.76 and 4382.0 quintals of such forage during 2001-02 and 2002-03, at Bharauli. Maize stalks are also preserved as dry roughage and chaffed with Barseem and fed to livestock.

5. MILK PRODUCTION IN DAM VILLAGES

The baseline survey of Bharauli village carried out in Sep 2001 indicated that buffalo is the most favoured animal which is being reared by almost all landed households. Out of total livestock population of 518, there were 233 adult buffaloes and 117 young heifers, thus making the total number of 350 or about 68 percent of total livestock . There were 82 cows, 79 bullocks and only 7 goats with 78 families for which data were collected. In case of Ibrahimpur again, out of total 395 livestock, buffaloes constitute 239 or 60 percent of total. There were 37 cows, 82 bullocks and 37 goats with 59 families, which were surveyed. The livestock data also included average milk yield, total milk produced and milk sold by these families. Such a survey was repeated in Jan 2004 for Bharauli village utilising the services of link workers of the project. It was observed that over a period of almost 27 months of project operation, the number of adult buffaloes decreased from 233 to 207 but the number of buffalo heifers increased from 117 to 186, i.e. an increase of 50 percent (Table 5.1).

Table 5.1: Livestock statistics, milk produced and sold in village Bharauli in Sep. 2001 & Jan. 2004

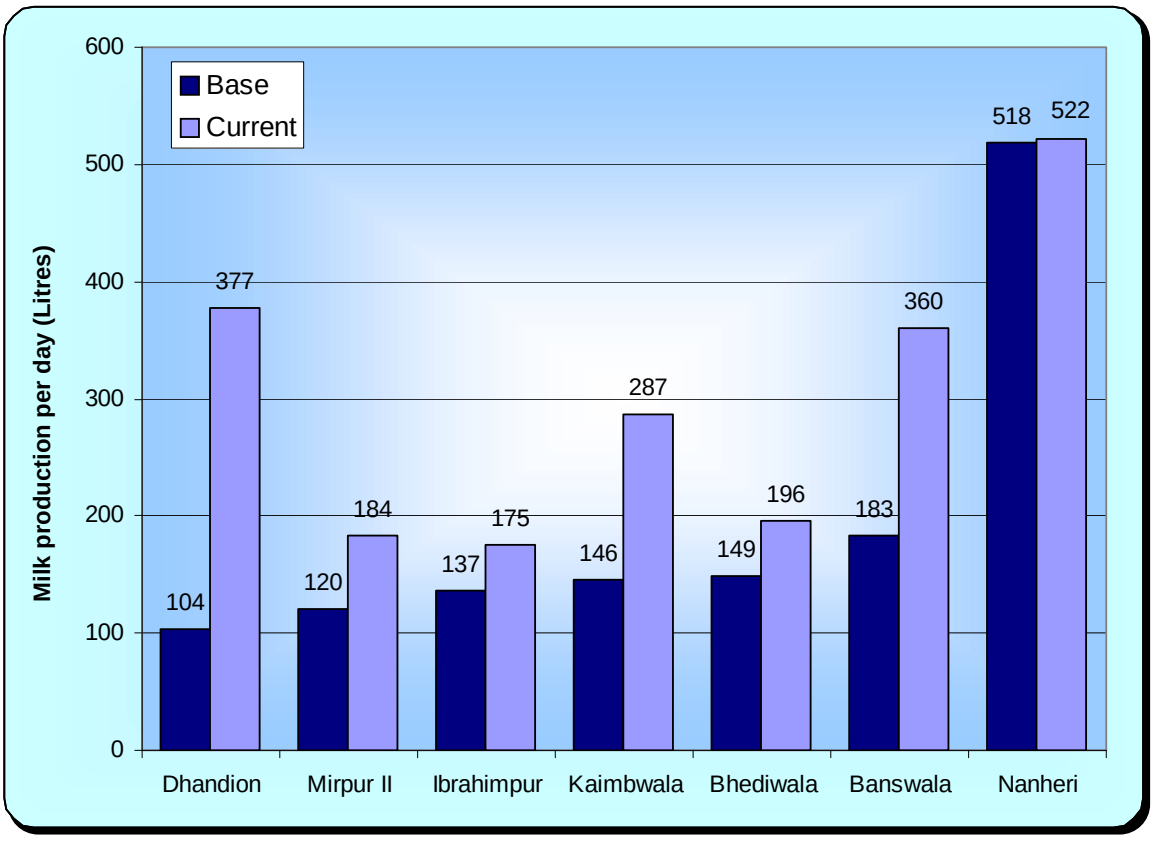
Particulars	Livestock	Before Project (Sep-01)	After Project (Jan-04)	% increase (+) or decrease (-)
Buffaloes	Adult	233	207	(-) 11.2
	Young	117	186	(+) 59.0
	Sub Total	**350**	**393**	**(+) 12.3**
Cows	Adult	41	42	(+) 2.4
	Young	41	37	(-) 9.8
	Sub Total	**82**	**79**	**(-) 3.7**
Bullocks	-	79	94	(+) 15.6
Goats	-	7	33	
	Total	**518**	**599**	**(+) 19.0**
Milk Yield litres/day/animal	Cow	1.8	2.21	(+) 22.8
	Buffalo	2.55	3.65	(+) 43.1
Milk Produced litres/day	Cow	74	93	(+) 25.7
	Buffalo	595	744	(+) 25.0
	Total	**669**	**837**	**25.1**
Total milk sold litre/day		**313**	**444**	**(+) 41.9**
Value of milk sold (Rs./day)*		**2504**	**3552**	**(+) 41.9**
Value of milk sold/year (Lakh Rs.)		**9.14**	**12.97**	**(+) 41.9**
Families surveyed		**78**	**89**	**(+) 14.1**
Value of milk sold/family/year (Rs.)		**11,717**	**14,567**	**(+) 24.3**

- Price of milk in the village – Rs. 8 /litre
- All the milk is sold through local vendors
- Average milk yield has been computed over the lactation period and converted to overall milk yield per day for full year

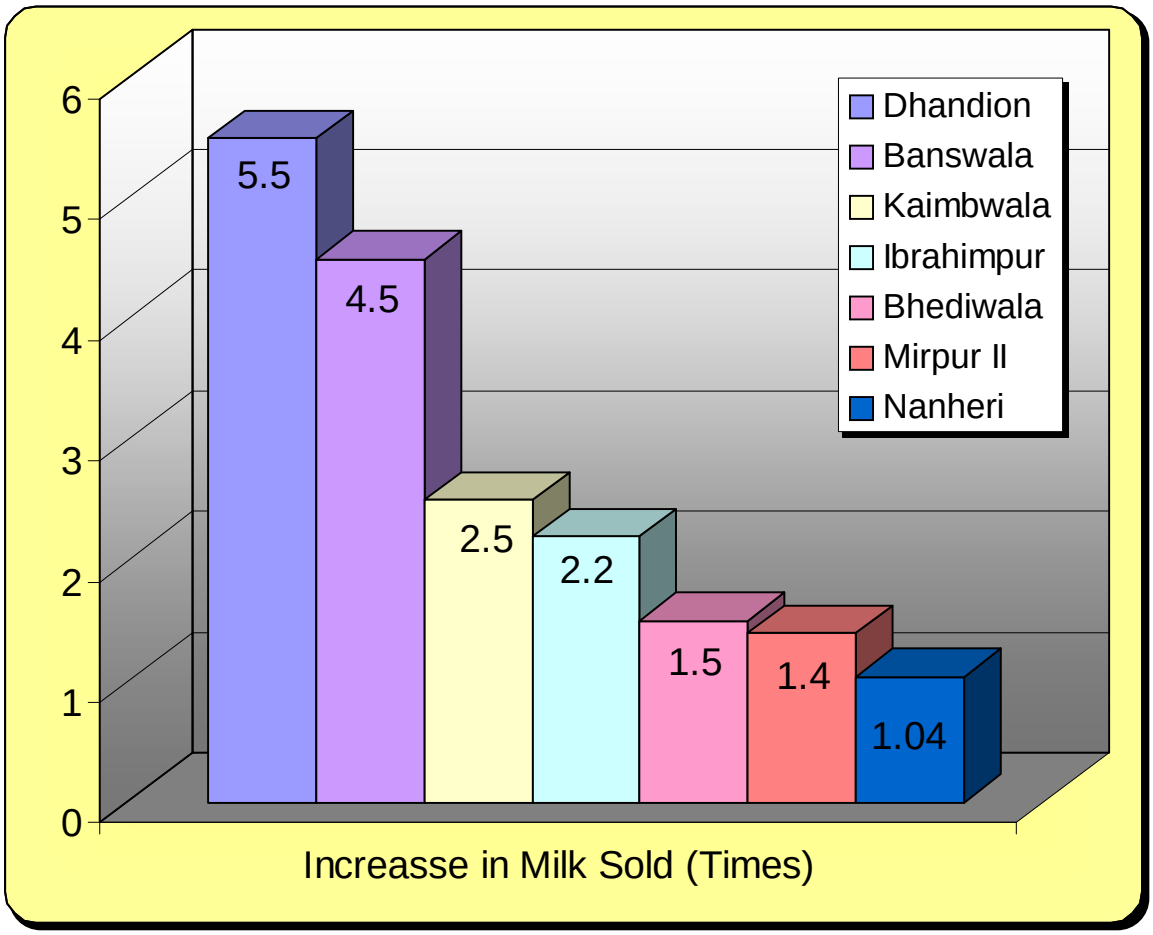
While there was no significant change in the number of cows, number of bullocks for draft power increased from 79 to 94. Only one family was keeping a herd of goats and their number increased from 7 to 33. The overall livestock population increased by 15.6 percent in this period.

There was however a significant increase in milk yield of cows i.e. from 1.8 to 2.21 litres/day (+22.8%) and in case of buffalo the milk yield increased from 2.55 to 3.65 litres /day (+43.1%). The total milk produced in the village increased from 669 to 837 litres/day (+25.1%) and milk sold to local vendors increased from 313 to 444 litres/day. The corresponding value of this milk was Rs. 2,504 and Rs. 3,552/day or Rs. 9.14 and 12.97 lakh/year (+41.9%). The income of the 78 families from milk production was Rs. 11,717/year, which increased to Rs. 14,567/year (+24.3%), after the project in 2004 when number of families increased from 78 to 89. Such an increase in milk production in other dam villages is given in fig.

Milk Production per day (Litres)



Increase in Milk Sold (Times)



Dairy - an Emerging Agri-Business at Kaimbwala

As the supplies of green and dry forage improved due to the facility of assured irrigation from the harvested rainwater, the beneficiary farmers of Kaimbwala village of Panchkula district lost no time to shift to dairying as a profitable agri-business. Live stock rearing was their age-old profession but due to scarcity of fodder, it was not possible to keep good quality milch cattle. The scrub cattle were mainly dependent on grazing in the adjoining forest. The construction of two earthen dams at Kaimbwala and Banswala by the HCFP during 2002-03 and 2003-04 revolutionised dryland agriculture of this foothill village. Not only did the crop yields vastly improve, but farmers diversified to forage, vegetables and vegetable seed production.

In a short span of 4 years (2002-03 to 2006-07), the number of buffaloes increased

from 97 to 134 and cows from 18 to 43 (Table 5.2). Joginder Ram of Kaimbwala explained that neither pure buffalo nor pure cow based dairy farming is successful. The mixed stock ensures regular supplies of milk for market. The price of pure buffalo milk goes very high and normally buyers cannot afford to pay for it. Mixing of cow and buffalo milk has become a common practice and buyers have accepted this as a reality.

The total milk production of 16 families of Kaimbwala village has gone up from 146 to 287 litres/day. Astonishingly, earlier they were selling 92-kg milk/day after keeping 54 kg (146-96) for domestic consumption. Now they sell 234 kg milk per day after keeping same quantity of 53 kg (287-234) for home consumption. While they have not increased home consumption, market surplus has gone up by 2.5 times. Earlier each family was selling milk worth Rs. 57.50 per day, but now each household sells milk worth Rs. 175/day. One finds electricity or diesel engine operated chaff cutters in every compound. Four farmers have gone for commercial dairy farming and have increased the herd size to more than 10 milching buffaloes. New breed of Murrah buffalo has recently been added to improve the quality of stock. Women are seen busy in taking care of the dairy cattle. Dairying and vegetable seed production have ushered an era of prosperity in Kaimbwala. Decent dwellings are replacing the old thatched roof houses.

Table 5.2: Livestock status, milk produced and sold before (base) and after (current) the project at Kaimbwala dam village

Particular	Base	Current
Buffalo Adult	60	81
Young	37	53
Sub-Total	**97**	**134**
Cows Adult	12	23
Young	6	20
Sub-Total	**18**	**43**
Goats/Sheep -	0	6
Bullocks -	22	20
Total	**137**	**203**
Milk Production litres / day		
Buffalo	125	225
Cows	21	62
Total	**146**	**287**
Milk Produced/Animal/day		
Buffalo	2.08	2.78
Cows	1.75	2.70
Milk sold litres/day	92	234
Milk sold litres/day/family	5.75	14.6
Value of milk sold Rs./day/family	57.5	175

- Based on data of 16 families both at base and current level.
- Milk sold at Rs.10/ litre at base and Rs.12/ litre at current level.

Changes in livestock population and milk production

The economies of beneficiary farmers of dam villages are transforming at a very fast rate both due to significant increases in crop, forage and milk production. The changes in livestock number, composition and increases in milk production are clearly indicated by baseline and current data generated for almost all dam villages. The following observations are worth reporting.

- The number of both adult and young buffalo maintained by beneficiary farmers has increased by 20 to 50 percent.
- Farmers continue to maintain local cows and their number has also increased in many villages. The cows help farmers to have bullocks as off springs, and make available more manure at much less extra cost as cows are mostly fed by grazing and feeding of roughages of wheat and paddy straw.
- The number of draft animal mostly bullocks is either constant or has slightly decreased as custom hiring of tractor and farm machinery is now easily available. Some farmers have switched on to one bullock drawn neumatic tyre carts instead of two bullocks for transporting fodder from the fields.
- While sheeps are almost non-existing, the population of goats keep on changing as mature goats and rams are sold for meat and young one's keep on adding regularly. Only few families keep larger number of goats and have made goat rearing as their occupation. Most others keep only 2 to 3 goats to supplement milk production. Goats supply milk when cow or buffalo go dry at one or the other point of time in a year.
- The overall milk production has increased invariably but at a variable rate. In some villages the increase is 20 to 50% but in some e.g. kaimbwala, milk production has almost doubled.
- It appears that dairying as an agri-business is becoming popular mainly because of cash flow generated by daily sale of milk and this activity generate employment at home particularly for women and landless families.

PERCEPTIBLE CHANGES IN LAND AND LIVESTOCK MANAGEMENT

Land Improvement

- Distress sale of land after dam construction has stopped.
- All hitherto uncultivated lands have been brought under plough and put to productive use.
- All existing cultivated lands have been levelled. Newly introduced paddy cultivation has prompted farmers to level lands so as to ensure uniform impounding of water
- The use of nitrogenous fertilizers has increased from one bag (50 Kg) of urea (46% N) to two and sometimes 2.5 bags

- Most farmers have started adding 50 Kg/acre of DAP as basal dose which was not added earlier to rainfed crops.
- The FYM dose has also been increased from two trolleys to 4 trolleys per acre. Manure is now added before paddy sowing
- The average land rent has increased from Rs.1000 to Rs.5000/acre/year.
- In a period of last 3 years, the price of land has increased about 4 to 5 times in command areas against two times increase in the price of land in general even outside command areas

Crop Production

- Wheat continues to remain the main Rabi season crop. Barseem as green fodder has now been added by almost all farmers, replacing gram, masoor, and taramira. Many farmers intercrop mustard with wheat.
- Paddy has been added as main Kharif crop by replacing maize. Sorghum remains the main source of fodder. Onion is also finding favour with a number of farmers.
- In some villages seed crops of radish, cauliflower, carrot is being raised under contract farming system.
- Improved varieties of wheat and hybrids of paddy are becoming popular in dam villages.
- Kitchen gardens have received a big boost after the availability of water. Almost every family has started raising potato, onion, garlic, chillies, tomato, bringal, peas, cucurbits, cauliflower, cabbage in small plots.
- Wheedicides are becoming more common, particularly for wheat
- Agroforestry is now becoming more popular particularly in Yamunanagar villages. Poplar, eucalyptus and fruit trees are being raised in more numbers on field bunds.

Farm Machinery

- There are more tractors and trolleys in dam villages and custom hiring of machinery has increased. The number of scrapers (Karahs), disc plughs, harrows, diesel engines or electric operated chaff cutters, spray pumps, storage bins has particularly increased in dam villages.
- Though harvesting of most crops is still done manually, threshing of wheat, maize, vegetable seed crops is being done by machinery.
- In view of loss of irrigation water in unlined channels, the pipelines have been extended in a number of villages. Rubberised pipes are now used to carry water to individual fields from common outlets. At places, farmers have formed groups and jointly purchased such rubberised pipes.
- The practice of taking crop loans form Agricultural Cooperative Societies (State Department of Cooperatives) has become much more prevalent. Fertilizers

(particularly DAP) and weedicides/insecticides are purchased from these societies on credit.

- The habbit of keeping accounts is gradually increasing. Many of them count on fingers the input costs and net returns. Market intelligence is also improving. As the purchase price of wheat was increased from Rs. 750 to Rs. 1000/quintal by the central Government, many farmers increased area under wheat, even by discarding crops like radish seed.

Livestock Management

The increased availability of farm grown forages has made discernible changes in farm economy, e.g,

- Migration with livestock has considerably decreased.
- Open grazing has been replaced by stall feeding.
- The number of women and men going to forest for grass cutting has come down. Farmers now meet most of their forage needs from farm grown forages and crop residues
- The number of buffaloes has increased in each family/ village.
- The milk production has registered a quantum jump and it has become a viable subsidiary income generating activity.
- The number of scrub animal is decreasing and better quality animals are reared. Murrah buffaloes have replaced local buffaloes in many villages.
- Wheat and paddy straw was earlier purchased from outside. Almost each household was purchasing at least one trolley load.
- Dairy farming as an enterprise is emerging very fast. Some farmers have kept 10-12 buffaloes and are taking 30-35 litres of milk daily to the market or milk collection centers. They have purchased motorcycles for milk transport. Quite a number of families from Bharauli, Mirpur, Turon, Dhandion have sifted their dairy animals to Raipur Rani town. Young farmers are taking this enterprise with enthusiasm.
- Unfortunately the veterinary services have not improved in the area and farmers are paying very heavy fees to veterinarians for doorstep services.

BHARAULI PANCHAYAT TAKES OVER THE VRMC (Case Story of 2005)

The VRMC of Bharauli village is more than three years old and exhibited fascinating experiences throughout its short span of operational life. The executive committee was changed twice and finally came under the control of village Panchayat. Lack of effective management of VRMC funds and maintenance of accounts and absence of any mechanism for audit remained the main problem defying solution.

The first VRMC headed by Mr Bant Ram did reasonably good work at the establishment phase. This committee could wean people around water resource

created and could manage contribution of Rs. 50,000 as community share in digging of pipeline. The first auction of reservoir was done for Rs. 18,000 and second for Rs. 35,000 with built in commitments for maintenance, democratic distribution of water as per predictated terms and conditions. Most of the team members were wise but illiterate. No proper records of income and expenditure were maintained. This traded in confusion, doubts and misunderstanding. Some how Bant Ram completed his tenure of two years and asked for election of new executive. The election was held in April 04 and new executive with Jit Ram an existing member as chairperson was elected. But again several members were illiterate in the new executive. The financial problem, however, remained unsolved.

The new executive asked for details of accounts and handing over of records. A meeting of new executive was called to sort out financial matters. The previous records were got completed and cash book written and balance was accounted for. Some discrepancies remained and these were put under suspense account. In the new executive, cashier was illiterate. The link worker was asked to write cash book on his behalf. Some money was spent on dam repair. The choked pipe outlet was desilted and made operational. Some bricks and cement was purchased for raising haudi and spillway. The reservoir was auctioned for Rs. 35,600 this year out of which Rs. 11,600 was to be paid as first instalment within seven days of auction.

The new contractor took six weeks to pay the first instalment. A rumour spread in the village that the top three members of executive had lot of drinks with the contractor on the day of auction and again on the day of part payment. It was also held that lot of hot exchanges took place amongst the management trio. In writing the cash book, more money was shown than actually spent on cement purchase. The cashier kept the auction money with himself and did not deposit in the bank. When asked to do so, he avoided and slipped away. After lot of pressure, he deposited only Rs. 7,600 and not the full amount of Rs. 11,600. The trio was evasive when asked to render full accounts. Finally a general body meeting was called and the trio was especially notified to attend the meeting. This meeting witnessed lot of hot exchanges. Bant Ram was also criticised for lapses. Jit Ram Pardhan was held responsible for the mess in accounts. He finally tendered the written resignation and admitted his inability to run the affairs of the VRMC. The executive was dissolved.

The general body debated the option of forming new executive. No group or individual came forward to take the responsibility. The community was awakened to the dangers of misappropriation of common funds. The general house finally decided to assign this responsibility to village Panchayat if Sarpanch agrees. The young Sarpanch agreed to the proposal and crisis were averted for the time being. The old VRMC handed over the records to the Sarpanch. The issue of recovering the misappropriated

amount still hangs. The story of Bharauli is not new one. When money comes in the hands of few cash starved poor and illiterate persons and fear of punishment is non existent, no wonder the honour and pride are put to stake. The most satisfying fact is that all the problems were gradually solved. New VRMC was again formed with Bant Ram as Pradhan and it started functioning quite well.

DARKNESS VANISHES FROM DHANDION VILLAGE

Dhandion is a small interior village of Morni hills of Panchkula district, having 24 families comprising a population of 180 Hindu Gujjars. The farmlands are located in the valley along the main Nallah and Government forest land is situated on hill slopes. Out of totally 76 acres of land, 20 acres are under forest and 56 acres under agriculture, 7 acres were under torrent bed and 7 highly eroded sloping land not available for cultivation. Out of remaining 42 acres, only 10 acres were occasionally irrigated by pumping water from Nallah bed and 32 acres were rainfed. The crop yields were very low and crop failures were quite common. Livestock rearing was the important source of income. Almost all families used to take cattle to Satluj or Yamunanagar riversides for 6-8 months in a year. People were having mud houses and leading a very poor life. Dhandion is a typical foothill village, whose economy was based on grazing, fuelwood and fodder extraction from forest, leading to over exploitation, denudation and deforestation.

Haryana Community Forestry Project constructed a 14 metre high earthen dam during 2003-04 to harvest rainwater from 31 ha forest catchment to store 9.86 hectare metre of water at a total cost of Rs.17.10 lakh. An underground pipeline was laid to carry the stored water to farm lands through gravity. The community was organised into a Village Resource Management Committee (VRMC) that shared cost of digging and lying out of pipeline. All the best farmlands received the benefit of irrigation except an 8-acre block, which was at a higher elevation.

The facility of irrigation revolutionised their unviable, risk prone rainfed agriculture to a diversified and profitable agriculture. Animal husbandry received a real boost when farm raised green fodders (Barseem) and dry forages from wheat; paddy ,sorghum and maize became abundantly available, which obliterated the need of migration. During an impact evaluation study, Dhandion was revisited on 16-1-08 and changes observed in this small village are worth reporting.

QUANTUM JUMP IN WHEAT YIELD

The yield of rainfed wheat was 2-3 q/acre in bad, 6-7 q/acre in good and 5 q/acre in average years. In every 5 years, one wheat crop was sure to fail. This Rabi 2007-08, there was no rainfall from September 2007 to early January 2008. In more than 60% rainfed areas around Dhandion, sowing of Rabi crops has not been possible. Some

farmers attempted wheat sowing in their best rainfed lands, but germination was just 40%. Small drizzle occurred on January 12, which raised the hope to get 2 to 3 q/acre of wheat. The farmlands of the command area of Dhandion have become an oasis of lush green wheat fields surrounded by barren/empty lands. The last year wheat yield was reported as 15-16 q/acre in best and 10-12 q/acre in medium type lands against the 5q/acre they were getting before. They had no words to express their gratitude to HCFP for constructing the dam, which made the lands productive.

LAND IMPROVEMENT

All farmers have levelled their lands and heavily manured them, as manure is available in abundance due to livestock integrated with farming system. Three farmers, Jasmer, Roshan and Hansa, have reclaimed 7,5,9 bigha (4.2 acres) of land from the Nallah bed which because of dam construction does not erode the land located on banks. Surprisingly, they put the price of reclaimed land as Rs.12 lakh @Rs.4.00 lakh/acre, which was worth nothing before. Excellent barseem, onion and wheat crops are being raised on the reclaimed lands.

LAND PRICES SHOOT UP

The cost of land in this village was Rs.50-60 thousand per acre before dam construction, which is quoted as Rs.4 to 5 lakh/acre after the facility of irrigation. The land prices in general have risen everywhere. The cost of rainfed lands earlier quoted as Rs.50-60 thousand per acre has gone to roughly 1.2 to 1.5 lakh/acre, but the price of land in command areas has risen almost 10 times.

FORAGE SUPPLIES IMPROVE

All families raise half to one bigha of barseem (one bigha is 0.2 acres) and mix it with dry forages and feed the livestock. A significant contrast noted was that when the project was constructing the dam in 2003, women in large numbers used to go to the forest for grass cutting. We noticed none on our full day visit on Jan 16,2008. We asked women the reason. The crisp reply was that now only fools would waste time in forest for a bundle of grass. We have enough farm grown forage now. One could see chaft cutters, either diesel engine or electricity driven, in almost all houses. There were only 2 to 3 manually driven chaft cutters before. Fodder was not chopped earlier. Now they chop and mix it with barseem. Most of them have constructed Pucca mangers to save fodder.

DAIRYING AN EMERGING INTERPRISE

The biggest change was in the wealth of stallfed buffaloes. Their small houses are full with buffaloes. Almost 70% farming families shifted to dairying after dam construction. Each of these families has added 2 to 5 buffaloes and selling 3 to 12 litres

of milk daily, worth Rs.36 to Rs. 144. We could see the milk canes loaded on motorcycles, visiting Dhandion.

IMPROVEMENT IN LIVING STANDARDS

Several Pucca houses are under construction. Many have added rooms, bathrooms, plastered old houses and constructed boundary walls, purchased TV, motorcycles and mobiles. The old kachha road has been metalled. There is large number of solar light sets in the village.

VRMC MANAGEMENT

The reservoir is regularly auctioned by the VRMC. The money is used for maintenance of the dam and irrigation system. The contractor is charging Rs.20/hour of water supply. Interestingly a block of 8 acres located at a higher level was not receiving water. Now four farmers have joined and purchased rubber pipe of 3 inches diameter and 600 feet length at a cost of Rs.30000. The VRMC improvised a connection from the nearest riser of the pipe and started irrigating 8 acres of additional land. Banta, the Chairman of the VRMC, said he got only 2 quintals of wheat from his 0.8-acre of rainfed (out of 8 acres) and this year he expects at least 12 quintals. Two irrigations to wheat have already been applied.

The transformation in the rural economy with the facility of harvested rain water is evident. We were regarding Dhandion community as a bunch of illiterates and backward people. Fortunately they have learnt the art of common resource management and have set 24 most poor families on a trajectory of sustainable economic growth. A school bus from an English medium school was seen dropping the students in uniforms and ties. Well that shows that darkness of ignorance from Dhandion has vanished

6. BENEFITS TO THE LANDLESS

The benefits of irrigation from harvested rainwater would naturally accrue to the landowners and not the landless. Incidentally, out of 19 beneficiary communities, 11 have landless as part of the societies. There are several incidental /associated benefits which are likely to accrue to the landless but such benefits are seldom quantified. Since HCFP by design attempted to target disadvantaged groups like women and landless, it was considered imperative to gain insight into how the dams and access to irrigation has benefited the landless both directly and indirectly. The information thus generated would inform future project design, activities, contribute to policy changes and may also help achieve the goals of inclusive growth.

The methodology adopted for the landless study included the search of M&E data base to find out the numbers and names of the landless in dam villages. Out of 368 landless families in 11 dam villages, a sample of 190 was taken for survey. It was decided to break the landless survey into a quantitative survey of 145 landless households (39% sample) and further a qualitative survey of 24% households included in quantitative survey. The quantitative survey conducted in December 2006 attempted to seek information before and after situation on pre-decided set of indicators like main occupations and income, subsidiary occupations and income, human and live stock, litigation, debt, house quality, access to electricity, drinking and irrigation water, live stock number, milk production, fodder production and availability and extent of stall feeding. In addition, farmer group discussions were held to gain insight into the information collected. The qualitative survey included 38 families where semi-structured interviews based on checklist were conducted. The results of the landless study are summarised as under: -

a) Income And Employment Sources

- Landless have multiple sources of revenue but opportunities for employment comes at different times in a year and are governed by crop seasons and construction activity. Lack of employment at home villages prompt migration for a variable period .
- The irrigation facility has increased crop intensity and yields, eliminated crop failures and introduced vegetable seed production and forage production which resulted in more local employment opportunities both for men and women. The amount of cash flowing through landless community through paid work has evidently increased.
- The women from landless families are employed during peak periods of farm operations like paddy transplanting and harvesting, wheat harvesting and

weeding of all crops. Such an employment increases the working hours of women as other routine household work remains with them throughout the year.

- There remains an employment gap during Monsoon period when farm work is at low key and building construction work diminishes due to the non-availability of bricks. Grasses in farm and forest lands are enough which keep women folk occupied in grass collection for livestock.
- Shivalik hills produce large quantities of Bhabar grass (Eulaliopsis binate) used for rope and paper making and as forage grass. Excessive and unrestricted livestock grazing had reduced the availability of such grasses which were a major source of sustenance for livestock of the landless. The villagers are committed to reduce/ eliminate livestock grazing in the forest catchments of dams. The reduced grazing pressure has increased the availability of Bhabar and forage grasses from the forest. The landless who mainly depended on such supplies have been benefited and a cut and carry system has become prevalent instead of open grazing.
- Farmers of dam villages have started raising paddy in command area which was not possible without assured supply of irrigation water. This change has definitely helped the landless in terms of more on-farm employment in paddy transplanting (mostly by women) and harvesting and more availability of paddy straw as roughage for livestock. Purchasing paddy straw from outside used to add cost of transporting, loading and unloading and wastage of time in locating the source. Similarly, labour intensive, vegetable seed production in some villages have improved the chances of employment for landless.
- Local employment for landless has decreased in some villages where farmers started using weedicides thus eliminating the need of manual weeding. In addition, there is an increase of seasonal labour from Uttar Pradesh and Bihar, which work in-groups and carry out paddy sowing and harvesting on contract basis. They help in finishing the work more quickly, as they work in large groups.
- Nevertheless, a quantum jump in crop production and elimination of crop failures has provided better opportunities to landless for local employment. Many of them get paddy/wheat grains/straw in lieu of work. In this way, they ensure food grains for family for 4-6 months in a year. On an average, a landless family earns wages worth Rs. 8,480 per year from farm operations. The percent increase in employment days vary from 6 to 50 percent across dam villages.
- All landless keep livestock which keep the women engaged in animal rearing activities throughout the year.

b) Human Migration

Small towns like Raipur Rani, Naraingarh, Kala-Amb, Sadaura, Bilaspur, Chhachhrauli, Khizrabad (all 6 to 8 km from dam villages) are expanding fast. The booming industrial and business activity is generating lot of semi-skilled employment which is attracting labour from interior villages to these towns. The land owners remain pegged to the land but the mobility of landless being easier, many young boys are moving to these towns for better wages and regular employment. This is a general trend in the area and reflected in the dam villages as well. Some landless families have shifted to dairying in small towns like Raipur Rani, many have opted for transport of materials in towns, small repair shops, fruit shops and others work in grain markets. The fundamental question is the increased human migration in the backdrop of increased on-farm employment opportunities in dam villages. The specific reasons which came out after discussions are:

- Better wage rates in nearby towns with less physical work involved.
- Increased availability of food grain and forage at home fuelled their imagination to more enterprising avenues outside the village.
- Easy credit flow for income generating activities for BPL.
- Easy availability of illiterate Bihar labour at lower rates prompting local landless to migration to towns where opportunities for semi-skilled labour are opening up.

c) Debt

The overall debt level has increased among all landless households and the increase varied from Rs. 1,408 to Rs. 6,117 per family with corresponding increase varying form 10 to 73 percent. Dam construction has no effect on the level of debt as such but establishment of SHGs and better exposure, reduced risk and increased confidence and better access to credit in recent times appears to prompt landless to take loans to add more productive assets like a buffalo or an extra room to the house, get electricity connection or start small business enterprises to settle their educated but unemployed children.

There is wholesale house refurbishment from poor to good quality housing which is considered a status symbol. As is clear from their debt figures, major part of investments have come from their family earnings and not from debt. The scope of getting sizeable subsidiaries is also prompting landless to take loans (50% subsidiary) on purchase of buffalo.

d) Housing Quality

There has been a significant increase in house quality in the entire area but landless in general are benefited from easy loans, grants and subsidies. The dam construction does have indirect influence on housing quality because the increased economic activity within the community acted as an assurance. Many of landless

families interviewed have added a room, a kitchen, a bathroom, a veranda, a boundary wall or plastered the old brick house.

e) Access to Electricity

All communities of eight villages except one registered an increase in number of households having electricity connections and all invariably held that they have the capacity to pay the monthly bill varying from Rs. 80-150/month. Quite often one house gets the connection and he gives access to the neighbour, thus saving expenditure on connection and meter rent. The bills are shared as per mutual convenience.

f) Access to Drinking Water

The drinking water supply through government funded system increased from 44% households before the dam to 86% after the dam. However, this increase is because of government commitment for all such villages irrespective of dam construction. Any disruption in water supply results in diverting to the nearest wells or hand pumps. The water points at present are for group of households and gradually landless families are opting for hand pumps or extending pipes to individual households by payment which comes from their extra earnings in dam villages.

Livestock

- **Migration with Livestock**

  Landless generally keep smaller number of animal and hence do not migrate with livestock. The landless interviewed were strongly focussed on developing a milk production business and increased fodder availability after dam construction acted as a catalyst for such a change.

- **Livestock Ownership**

  The overall livestock ownership amongst the landless for all livestock (buffalo, cow, bullocks, goats) has increased (particularly buffalo and cows) after dam construction which is attributed to the increased access to animal fodder.

Milk Production

The daily milk production in 5 communities out of 8 have reported increase ranging from 3 to 11 litres/day and almost no change in the remaining three. The number of farmers not having milk production before dam construction decreased from 65 to 48, thus showing that 17 more families out of 38 (qualitative sample) have started selling milk after dam construction and this is attributed to increased fodder availability after dam construction. Such an increase in annual income per household from milk sale varied from a low of Rs. 17 to a high of Rs. 3,713.

Fodder Production and Availability

There has been a very significant indirect impact on the economy of landless through increased fodder availability both of green forages in the form of barseem in winter and Sorghum in summer and dry roughages in the form of wheat and paddy

straw. The number of fodder types available increased from 2-7 before to 3-8 after dam construction. In winter months, the number of fodder available has increased from 5 to 8. In addition, the availability of fodder grasses which was short-lived earlier has recorded more spread over time. The substitution of low protein forages with high protein and better digestibility forages has improved animal health and increased milk production. Reliance on straws has considerably reduced for milching cattle. As a result of all this, the grazing period has reduced and stall feeding has become more popular. The time taken for women from landless families to collect fodder grasses has been reduced to half. Reduced grazing has helped in better regeneration of tree species in catchment areas. The practice of hay making has not yet caught the imagination of the farming/non-farming communities.

The fact is that the dam construction has benefited the landless in more than one way. However, most of the landless perceive that only benefit of dams is irrigation, which landowners have appropriated and other benefits though large in number are not clearly perceived by them.

Awareness among Landless

On the basis of group discussion with landless families of five typical landless villages, the views of communities on selected issues were taken including sharing of harvested water. The results are presented as under:

- **Sharing of Harvested Water**

  It was told before dam construction that water collected in dam should be distributed equally among the landowners and landless. But landless families in spite of the knowledge of above decision did not receive any share of water. One landless family each in Bharauli and Nawagaon has taken some land on rent from a landlord and they are receiving water as usual on their turn.

- **Contributions by Landless**

  Most landless families have paid their membership fee to the VRMC except in Kansli where only two families paid membership fee. In few villages e.g. Kathgarh and two families in Bharauli, the landless have also contributed their share of dam construction through wages.

- **Participation in Decision Making**

  - It is clear to the landless that they are represented in the VRMC through their elected member(s), but only these members know about the meeting of VRMC, auction of dam, training programmes and study tours.
  - Landless families from more than 80% dam villages affirmed that all the villagers are invited for General Body Meetings including landless. But major decisions are taken by landowners and no suggestions are taken from landless.

- VRMCs neither take the views or suggestions from landless nor do the landless give their views/suggestions.

- **Forest Protection**

All landless families know that the forest catchment area earlier used by them are now closed for grazing and collection of fuelwood. They are reconciled with this and now they are using other common areas of the village for grazing and fuel wood.

- **Associated Benefits**

All landless agree that availability of green and dry fodder and water has increased in the village after dam construction and they get more fodder and employment as farm labourers than before.

Survey of the Impact of Water Harvesting Dams on Landless Households

Some major findings are:

- Increased earnings from farm labour has been spent on improved housing – 77% of the landless now live in brick houses, as against 39% before the dams were built.
- Common and private lands have become satisfactory alternative sources of fuel, wood and fodder in lieu of the now closed catchment areas.
- The dams have resulted in the landless having year-round access to high protein fodder, increasing milk production.
- There is a 25% increase in landless women's involvement in animal husbandry and a corresponding decrease of women being regarded as primarily housewives.
- Women's employment as farm labour has also increased.
- More than 40% of landless households are, however, still largely dependent on migratory work for their livelihood, partly due to the arrival of cheaper farm labour from Bihar.

Table 6.1: Impact of Water Harvesting Dam on the economy of landless scheduled caste population of village Bharauli

Indicators	Particulars	Status before & after the project		
		Before, 2001	**After, 2005**	**Remarks**
1. Type of households	Thatched Pucca	18 2	4 20	10 houses made pucca under Indira Awas Yojna
	Total	**20**	**24**	
2.Electricity	With electricity Without electricity	6 14	14 10	4 houses share with neighbours
	Total	**20**	**24**	
3. Live stock ownership	Buffalo (milching) Heifers (not in milching) Cows Goats (stallfed) Mare	9 6 3 - -	14 15 5 3 1	Used for horse cart
	Total	**18**	**38**	
	Chaff cutters	5	8	shared
4. Employment as Agriculture labour a) Man days employment b) Value of employment	Wheat crop Vegetables	15 6	40 37	Mostly by women
	Total	**21**	**77**	
	Wheat crop Vegetables	1058 400	3750 1850	
	Total	**1458**	**5600**	
5. Occupations	Tailor shop Shoe maker Crockery shop Transport Horse cart Three wheeler Teacher Tractor Driver Petty contractor Other jobs	- 1 - - - - - - 1	1 2 1 1 1 1 1 1 2	At Kaimbwala
	Total	**2**	**11**	

7. CATCHMENT STUDIES

The Haryana Forest Department started the construction of water harvesting dams following Sukhomajri concept which demonstrated that communities start protecting the forest catchments when direct, visible, quick and substantial benefits from harvested water start flowing to the farmers cultivating high risk rain fed crops in the lower areas. The protection to forests through closure was socially imposed mainly to reduce the threat of siltation and prolong the life of much need reservoirs which became source of irrigation and in turn improved livelihoods of poor farmers. The same concept of catchment protection by controlling grazing and fuelwood extraction was enforced and popularised in all the water harvesting dam villages by the HCFP staff. The catchment studies were initiated at selected locations to ascertain the impact of WHDs on vegetation cover complexes.

The studies were conducted at two stages, first at pilot phase in Bharauli and Ibrahimpur and then for Mirpur, Turon and Nanheri in the final phase. The results of both the set of studies are summarised in this section.

Catchment Studies of Phase I at Bharauli and Ibrahimpur

The vegetation studies in catchment area of two model water harvesting dams constructed by the Haryana Community Forestry Project during 2001 were conducted to quantity the changes in the stock of trees, bushes and gasses 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 objective, 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 gained growth in terms of increase in height and girth. The number of miscellaneous types of trees has particularly went 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 a period of 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/m^2 on lower hill slopes. The number of superior grasses like Bhabar had particularly come down.
- It was surprising to note that overall air dry mean glass 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 numbers have decreased but clump size has 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%) and 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 m^2 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 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/m^2 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 reason of low accumulation of forest litter.
- The overall improvement 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.

Management Issues

The repeat vegetation studies in the catchment areas of water harvesting 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 in the stock of upper areas where steep slopes and cliffs are more common which are prone to erosion.
- The livestock of Bharauli village does not go for grazing in the catchment area but the livestock from village Sherwala located just above the upper slopes from where watershed boundary starts is stealthily let loose for grazing. There were clear signs of grazing, nibbling and branch cutting in the plots located in the 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 area (137%) thus 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 even bushes to provide cover. It may take some more years for bushes to check soil erosion from these areas. Trees would come thereafter as the biophysical conditions improve.
- Though the number of grass clumps have declined but overall grass yield has increased. More aggressive bushes smothered obviously weaker clumps. The increase in leaf litter and decrease in soil erosion is a positive sign 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. The catchment area needs vegetative measures for erosion control particularly in drainage lines. 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 middle 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 recorded high mortality in the lower areas, extract of mature trees was noted which needs to be taken care of.
- 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. The number of grass clumps has come down because of forest fire. As such the problem of siltation is not at all serious, in this catchment.
- Grazing in lower areas where livestock is allowed to go to the reservoir for drinking water, forest fire and extraction of mature trees are the problems which needs to be addressed.
- Lack of livestock drinking water is a serious problem in Ibrahimpur but also in adjoining villages which trigger migration of livestock to riverbanks. The Ibrahimpur reservoir has provided a big relief to livestock of all these villages.

On a survey related visit, more than 100 buffalo were seen in the reservoir on a hot summer afternoon. The associated grazing in the periphery of reservoir is an inescapable reality but relief to livestock is equally rewarding to the community.

Catchment Study Part-II

The base line status of vegetation cover before the construction of WHD's was established by laying out 10m x 10m sample plots on upper, middle and lower hill slopes where tree and bush density, grass yield, litter accumulation, soil pH, Ec and organic carbon were recorded. These observations were repeated after a lapse of 3 to 4 years after the base line during which period the local communities protected the forest catchments of the WHD's. A pilot study was first carried out for Bharauli and Ibrahimpur WHD's and subsequently three more sites namely Rana/Mirpur-II, Bhediwala/Turon-II and Nanheri were taken up for base line and final survey. The catchment area of 54, 54 and 146 hectare was divided into micro-catchments from where 27, 27 and 54 sample plots were laid for the study. The baseline survey was carried out in May 2005 and the final survey in October-November 2007. This work was assigned to Chandigarh based professional NGO namely Society for Promotion and Conservation of Environment (Space). The results of the baseline survey have already been reported. The result o final survey and salient changes are summarised in this report.

- The mean tree stocking before and after the project in the forest catchment of Rana decreased from 1550 to 1540 (-0.65%), Bhediwala from 778 to 700 (-10.0 %) but increased from 1302 to 1420/ha (+9.1%). The marginal decrease in Rana was due to mortality of planted Khair and in Bhediwala due to cloud burst which caused land slides, mortality of young stock and continued grazing pressure. Though some plots in Nanheri were affected by forest fire but trees regenerated there after. All tree species gained diameter, height and crown cover as number of trees in lowers girth/height classes decreased and number of trees in higher classes increased in this peroid of 2.5 years. The catchment of Rana and Bhediwala are dominated by khair but by chall in Nanheri.
- The bush density increased by 92.1% (3411 to 6554/ha) in Rana, by 25.9% (9711 to 12225/ha) in Bhediwala and by 40.1% (4290 to 6010/ha) in Nanheri. Bush density was more (Bhediwala) when tree stocking was relatively less. By and large bush cover was higher on lower hill slopes as compared to dry and dessicating upper hill slopes.

- While air-dry grass yield increased by 22.6, 16.4 and 34.8%, the number of grass clumps increased by 53.4, 75.2 and 47.0% in Rana, Bhediwala and Nanheri catchments respectively. While Bhabar and Dholu grass dominated Rana forest, Dholu alone dominated in Bhediwala and Bhabar, Dholu and Sarala dominated Nanheri catchment.
- The leaf litter accumulation (a combined index of vegetation cover) registered an increase of 24% (23.48 to 29.11 q/ha) in Rana, 15.0% (15.15-17.43 q/ha) in Bhediwala and 53.5% (11.86 to 18.20 q/ha) in Nanheri.
- The soil moisture content both in upper (0.15cm) and lower (15.30 cm) depths registered an increase on all the three hill slopes of all the three catchments. The increase was more in lower soil depth as compared to the surface soil.
- The overall soil pH increased in both 0-15 and 15-30 cm soil layers and Ec showed decreasing trend in all the three catchments. The overall organic carbon decreased from 0.35 to 0.21%, from 0.61 to 0.33% and from 0.42 to 0.16% at Rana, Bhediwala and Nanheri catchments. The loss of soil humus with run-off water appears the probable reason of this trend.
- The soils of Rana are heavy textured, medium textured in Bhediwala with high percentage of gravels, but soils in Nanheri are light textured. The slope in drainage lines is very steep in Nanheri, steep to very steep in Bhediwala and moderate to steep in Rana. The landslide prone area was 30% in Rana, 20% in Bhediwala and 10% in Nanheri. Four soil conservation structures were constructed in the catchment of Rana, by HFP, three in the catchment of Bhediwala by Kandi project but none in the catchment of Nanheri. As per the silt loads generated, there is a need of biological and mechnical measures to further reduce the siltation rate of reservoirs.
- The grazing pressure is high in Bhediwala, moderate in Rana and slight in Nanheri. Much more dialogue is needed with these communities to persuade them to reduce grazing and opt for stall-feeding. As such grazing pressure is much less than the one before the dam construction. The increased forage production in farm lands due to the facility of irrigation have reduced dependence on forests for grazing but some landless families stealthily take live stock to catchment area.
- Few trees from sample plots were either cut for fuel wood or for feeding to goats by goat graziers. This practice has drastically reduced but not totally eliminated.

8. PRODUCTIVE ASSETS CREATED IN DAM VILLAGES

The facility of irrigation in dam villages improved crop and milk production, increased employment opportunities which raised the family income of both farm and non-farming families. Whether the increased income resulted in creation of productive assets was not precisely known. A special study was, therefore, commissioned in December 2007 in which an assessment of the productive assets created in selected dam villages was carried out. Out of total 19 dam villages, two representative dam villages namely Dhandion and Turon were selected from Ambala district, five dam villages - Bharauli, Kaimbwala, Mandappa, Mawas and Mirpur from Panchkula district and five dam villages - Bhagwanpur, Kathgah, Nanheri, Nawagaon and Thaska from Yamuna Nagar district. A total of 122 beneficiary families were interviewed and data collected in a pre-designed proforma. Special focus was given to land development, crop husbandry, livestock and changes in socio-economic changes. The results of the study are summarized as under.

1. FARM DEVELOPMENT

1A) Land Improvement

a) Purchase of land: In Ambala, Panchkula and Yamuna Nagar districts, 15,14 and 27% farmers purchased more land either outside command area or outside the village. Such a purchase of land in adjoining villages was by less than 5% of the families. Land purchase was particularly high in Kathgarh (40%) and Nawagaon (45%), dam villages of Yamuna Nagar district.

b) Land Levelling: Overall, 60% farmers improved the quality of their land by land levelling and such a percentage was much higher in Yamuna Nagar district.

c) Land Reclaimed: After dam construction, the flood water is harvested and drainage ways cease to function. Farmers reclaim such flood prone lands and put them to productive uses. About 40% of the respondent farmers reclaimed their land from nallah beds or reclaimed lands not cultivated earlier for want of assured irrigation.

d) Land Taken on Rent: Some farmers from outside the command area or some landless families take land inside command area on rent to raise barseem and other fodder crops with irrigation facility. Some farmers inside command also get land on rent from absentee landlords. About 17% of respondent farmers took land on rent to increase their income.

e) Addition of More FYM: Almost all-respondent farmers have started using higher quantities of farmyard manure after the facility of irrigation. The

introduction of paddy, barseem, fodder and vegetable crops has prompted this change.

f) Cost of Land: Consequent upon the introduction of irrigation facility, the price of land in dam villages has skyrocketed in a short span of time. While the price of land in other villages has doubled in last three or four years, in dam villages, the price of land has gone up almost four times.

g) Land Rent: The overall land rent in dam villages has gone up from Rs. 2596 to Rs. 7179/ acre. There has been increase in land rent in other villages as well, but that increase vary from 30 to 50% only.

1 B) Farm Machinery

Tractors: No tractor was purchased in two villages of Ambala district but 12 respondents purchased tractors in Panchkula and 16 in Yamuna Nagar districts out of 50 and 52 respondents, thus constituting 24 and 31% of total surveyed population. The practice of tractor hiring became common in 20, 50, and 63% of the families in Ambala, Panchkula, and Yamuna Nagar districts respectively. The increasing use of tractors at farms provides an indirect evidence of improving farm management in dam villages.

Threshers: While only 6.5% of total respondents purchased threshers, custom hiring of threshers has increased considerably. About 3/4th of the farmers hire threshers.

Cultivators: Cultivators were neither purchased nor hired by large number of farmers, indicating that they still prefer bullocks for ploughing and planking.

Tillers: Roughly 18% farmers of the total population have purchased tillers and an equal number are hiring tillers for cultivation.

1C) Farm Houses: Farmers of dam villages are improving their assets is indicated by the fact that 45, 12 and 35% respondent farmers have constructed a shed or/and added a room in the existing farm houses. This activity was more common in Kathgarh and Bhagwanpur villages of Yamuna Nagar district.

2 CROP HUSBANDRY

2A) Change in Cropping Pattern and Input Use: Almost 100% respondent farmers have added new crops in their farming system and all of them have replaced some old crops consequent upon the introduction of irrigation in rain-fed farming.

a) Improvement in Land Preparation /Tillage: The change in cultural farm operations can be noted from the fact that between 80-88% farmers have improved land preparation and tillage practices by not purchasing new tillers

and cultivators, but by tractor hiring in which case the implements are of the tractor owner.

b) Use of New High Yielding Varieties and Hybrids: Between 55 and 69% of farming families in the three districts have started using new high yielding varieties of crops and hybrids to improve crop production.

c) Increased Fertilizer Use: Except the remote dam village of Mawas where there is no approach road for easy transport, rest of almost all the farmers have increased the fertilizer use. In general, the use of nitrogen through urea has doubled and those not adding phosphorous have started adding diammonium phosphate at the rate of 50 kg per acre.

d) Insecticide and Pesticide Use: The use of agro-chemicals in rain- fed farming was very much limited in the project area. Such a use is still limited in remote villages where vegetable crop production has yet not picked up. But in rest of dam villages, chemicals use has been started by 50 to 70% of project farmers.

e) Use of Organic Manure: The organic manure is abundantly available with project farmers because of large number of cattle they keep, but land holdings are small. The use of organic manure has been increased by almost 98% of the farmers.

f) Use of Vermi-compost: Only 5% of the farmers have opted for vermi-compost use so far. In fact this activity was not promoted as vigorously in dam villages as it was pushed in other project villages.

2 B) Post Harvest Technology

a) Harvesting Operation: All the harvesting operation in dam villages of the three districts are being carried out manually and no machinery is used for this purpose.

b) Threshing: Unlike harvesting operations, almost all threshing work is being carried out by hired threshers.

c) Grain Storage: The use of grain storage bins has become a common practice with 75% farmers of Ambala, 86% of Panchkula, and 94% of Yamuna Nagar districts.

d) Processing/Value addition: The practice of food processing, grading and other value addition has not become common so far in project villages.

2 C) Improvement in Irrigation System

a) Laid More Pipeline: No respondent farmer in Ambala, 14% in Panchkula and 58% in Yamuna Nagar district have laid more pipe line to bring additional area under irrigation.

b) Use of Rubber Pipes: Gravity irrigation through unlined field channels result in lot of loss of precious water. Almost half of respondent farmers have started using rubber pipes for water conveyance from pipe outlets to individual fields.

c) Furrow Irrigation: The method of furrow irrigation is much more efficient than the usual border irrigation method. Now almost 88% of the farmers use this method of irrigation.

d) Improvement in Irrigation Efficiency: Except Mawas village, in all other project villages, the farmers claim to have improved the irrigation efficiency through land levelling, furrow irrigation and better water conveyance system.

2 D) Farm Management

a) Arrangement of Inputs: More than 90% of the project farmers, make all necessary arrangements to procure farm inputs well in time.

b) Credit Arrangement: Similarly, more than 93% of the farmers arrange credit mainly from the local co-operative societies for the purchase of farm inputs.

c) Arrangement of Machinery: So is the case for the arrangement of farm machinery. More than 95% of project farmers arrange machinery, mostly tractor and implements for timely completion of farm operations.

d) Negotiate Better Prices: Except Mawas village, where there is hardly any market surplus, 83 to 100% of farmers negotiate better prices for their produce.

e) Maintenance of Accounts: Though majority of farmers are not keeping ledgers and cash books, almost 90% of them work out investments and returns and calculate the gains in their own crude ways.

2 E) Marketing

a) Keep or Sell Produce: In case farmers have marketable produce, 97% of them do not keep it but sell it immediately as they are to repay their loans and fulfil family needs.

b) Follow Market Trends: However, for vegetable crops where prices are not controlled by the Government procurement system, more than 94% of the farmers follow market trends.

c) Capture Better Market: As the telephone facilities are available in project villages, more than 91% of farmers capture better market.

3 LIVESTOCK

3A) Livestock Feeding: Almost 97% of the respondents feed concentrates to the milching cattle. Similarly, almost all arrange green fodder and have sufficient stock of dry forage for the cattle. Only few families who have very small land holdings do experience some forage shortage. The migration with livestock continues with 65% households in Ambala district, but only 12 to 15% of livestock owners migrate with livestock in Panchkula and Yamuna Nagar districts.

3B) Livestock Health Care: The drinking water availability for livestock after dam construction has improved in 95 to 97% households. Almost the same percentage of respondents arranges medicine for sick animals. The veterinary services have not improved at all in interior villages like Turon, Mawas, Nawagaon and Nanheri. In rest of the villages, such services improved at a variable rate of 25 to 100%. Sufficient local veterinary services are available in bigger and well connected villages like Kathgarh and Thaska, but in rest of the villages such an availability varies from 10 to 30% of livestock owners.

4 ADOPTION OF AGROFORESTRY/HORTICULTURE

4A) Change in number of Trees

a) Timber Trees: No new timber trees have been introduced by the respondents of two villages of Ambala district and nor that of Kaimbwala, Mirpur and Kathgarh villages in other two districts. However, in rest of the villages, new timber trees were added at a variable rate of 10 to 100%.

b) Fodder Trees: There has been very negligible change in the status of fodder trees in the dam villages.

c) Fruit Trees: Around 50 to 67% of households have introduced fruit trees, but in small numbers varying from 3.6 to 7.8 per household.

d) Other Trees: No tree of any other kind was introduced in dam villages.

4B) New Plantation: On overall basis, 47% of respondents have raised new plantation on field bunds where the average number was 69.7, 23.8 and 437.4 per household in Ambala, Panchkula and Yamuna Nagar districts respectively. In case of block plantations, 10, 14 and 52% respondents in Ambala, Panchkula and Yamuna Nagar districts have opted and the numbers of plants raised are 125, 533 and 762 per household in respective districts.

4C) Back Yard Plantation: Except Dhandion farmers, others have not gone for backyard planting. In fact already they have raised backyard plants for shade and other multiple uses.

5 ANY OTHER AGRIBUSINESS

a) Vegetable Farming: Almost one third of the farmers of dam villages have started raising vegetable crops for marketing, which was not possible without irrigation.

b) Vegetable seed production: In the contract farming system, 83 and 90% farmers of Bharauli and Kaimwala villages of Panchkula district have started the agribusiness of vegetable seed production. Few farmers in other villages of Ambala and Panchkula districts also do the same, but this practice is totally absent in all the villages of Yamuna Nagar district.

c) Bee Keeping, Mushroom, Floriculture, Medicinal Plants: No respondent farmer of any dam village has adopted the above said agribusiness due to the lack of marketing facilities.

d) Income Generating Activities for SHG: All these activities have remained either at a very low key or are totally absent in the dam villages.

e) Shop or Other Enterprise: Almost one third of the respondent population of dam villages have adopted one or the other enterprise to supplement family income.

6 CHANGES IN SOCIO- ECONOMIC CONDITIONS AND LIVING CONDITIONS

6A) Increase in Spending Capacity :

a) Clothing: Almost 98% households reported increased spending on clothing and attributed this to better family income after dam construction.

b) Food: So was the case with respect to increased spending by 94 to 100% respondents of the three districts.

c) Social Functions: Almost all sampled households admitted increased spending on social and religious functions performed.

d) Entertainment: 100 and 55% respondent of Nawagaon and Nanheri villages report no increase in entertainment expenditure, but in rest of the villages 60 to 100% households admitted such an increase.

e) Litigation: There has practically been no increase in litigation related spending by these families.

6B) Change in Social Status:

Only 15 to 25% respondents of Bharauli, Kaimbwala and Mawas reported change in social status and rest reported no change, which is not understandable. In rest of the villages, 60 to 90% respondents reported change in social status. Leaving Turon, Nanheri and Nawagaon, where only 18 to 27% respondents got the chance to become Sarpanch/Panch or Executive Committee members; in rest of the villages, 35 to 70% respondents occupied one or the other position of high social status in the village.

6C) Change in Energy Use

a) Gas Connection: Only 10 to 12% families could get gas connection which seems not related to dam related influence, but represents general developmental change.

b) Kerosene Use: 92 to 100% respondents agreed that the Kerosene use has increased due to better living conditions.

c) Increased Fuel-wood use: Same is the case with fuel-wood use. More than 94% respondents of the entire sampled population admitted increased use of fuel-wood since dam construction.

d) Use of Cow Dung Cakes: Almost 98% sampled families continue to use cow dung cakes for cooking and heating in homes.

6D) Change in Houses

a) New Room Added: The changing face of dam villages can be judged from the fact that 45, 72, and 69% of sampled households of Ambala, Panchkula and Yamuna Nagar districts added a new room in their houses.

b) Plastered Old Houses: Almost a quarter of the population reported that they have plastered the old house after the increase in family income.

c) Boundary Wall Made: In one house after every 10 houses, a boundary wall was made.

d) Electrification of Houses: Except Mawas, where there is still no electricity and solar lights are provided, in rest of the villages, 90 to 100% owners have electrified the houses.

e) Water Supply: The domestic water supply has been arranged by 82% of total sampled households.

6E) Change in Family Assets

a) Television: Except Nanheri and Mawas, where no family could afford to purchase television, in rest of the villages, 27 to 92% families own television sets.

b) Telephone/ Mobile: Again only 14 and 27% families of remote villages of Nanheri and Mawas own telephone sets, but in rest of the villages, 50 to 83% of families have purchased telephone/mobile.

c) Washing Machines: No family owns a washing machine in these project villages.

d) Motor cycles/ Scooters: On an average, 20, 46, and 54% families of Ambala, Panchkula and Yamuna Nagar disticts respectively own motor cycles/ scooters. None in Mawas, but all families in Bharauli, own the bikes.

e) Electrical Appliances: Almost 82% houses use electrical appliances, but electric fan is the most common appliance in the houses. Even in Mawas, electric fans are run on solar energy.

f) Furniture/Sofa, Palang, Almira: Almost 50% of the households in dam villages have furniture items like Sofas, Palangs and almira.

g) Any Other: The respondents reported no other family assets.

6F) Expenditure on Health and Education

a) Health Care: More than 94% of sampled families spend more on nutrition after dam construction than before.

b) Medicine: So is the case with respect to medicines. Now more than 91% families spend more on medicines.

c) School and College Fees: More than 80% sampled families reported more expenditure on school/ college fees.

d) Books and copies: More than 70% respondents reported additional expenditure on books and copies.

7 DEBT POSITION

Generally, farmers take crop loans from co-operative societies on season to season basis. In addition farm machinery is also purchased on credit. The debt status is reported in this section.

a) Respondents Under debt: Almost 69 % of households are under one or the other type of debt. The amount of debt highly varies across villages and range from Rs. 4,375 to Rs. 151,500 per family.

b) Debt Repayment: Only 8% farmers have paid the previous debt. They return only part of the debt and again borrow from the society. Many think that farm loans would be waived off by the Government as was done on one or two occasions.

c) New Debt: Only very small fraction of about 2% farmers has taken new debt.

d) Capacity to Repay Debt: The increase in capacity to repay the debt is agreed only by 23% of respondents

9. Issues in Management of Dams and Irrigation Systems

The 17 earthen water-harvesting dams constructed between 2001 and 2005, have a total irrigated command area of 867 hectares (Table 9.1). Underground pipelines convey water through gravity force from the reservoir to the command area; varying from 30-100 Ha. The harvested water, applied to Rabi season crops has acted as a catalyst to increase production of many Rabi season crops. It has also prompted farmers to increase their paddy area, as paddy is their most profitable crop. Irrigation provides farmers with the potential to cultivate high value crops such as vegetables and off-season crops. There are fast and very visible benefits from the dams, indicative of their huge, but very localised potential. Dam construction is a labour intensive activity. Consequently, it has generated considerable employment opportunities, particularly to the poor and landless of individual recipient villages. The construction phase is ephemeral lasting 6-9 months. It is probable that there will be social, technical and institutional issues associated with the dam construction process.

Once a water harvesting dam has been constructed and tested, responsibility for the management and maintenance of the dam is transferred to the Village Resource Management Committee. The VRMC roles and responsibilities are:

- Manage and ensure the equitable distribution of irrigation water.
- Manage and properly maintain forestry plantations.
- Manage, maintain and monitor all the natural resources (natural forest, soil erosion, soil fertility and other natural resources) within the dam catchment and the village land area.
- Ensure that the dam infrastructure (pipeline, dam wall, spillway and outlet) is properly maintained and kept in good repair.

The VRMC's is were established with the purpose of managing all the project derived village resources; the irrigation water, the forestry plantations and maintaining the project established self-help groups (SHG), training, capacity building and the development of income generating activities. The VRMC is a village level institution, made up of elected representatives. The elected members among themselves elect a President, Secretary and Treasurer. Quarterly meetings are held (frequently more than quarterly), minutes are taken and the financial position of the VRMC is regularly reported. A VRMC committee is elected for 2 years.

Water harvesting dam construction created the potential to irrigate Rabi and summer season crops. Whereas prior to dam construction, the Rabi season

crops cultivated were entirely rainfed, now with access to irrigation within a command area, the potential to obtain improved crop and milk yields has significantly increased. The economic impact on landowners with access to irrigated land is profound. Farmers with good market access have started to diversify into other crops (radish, cauliflower and carrot seed production). Overall, HCFP monitoring data has shown excellent economic improvement and overall development, commensurate with the investments made.

Despite the evident success and positive impact that the water harvesting dam construction has had on the lives of farmer, cattle owner and the landless the post dam construction activities needs a hard look. To realise and fully exploit the potential, a number of issues concerning the maintenance of the dam, the equitable distribution of water, the conservation and management of irrigation water as well as the development of the VRMC as a village level, farmer managed institution need to be recognised and resolved. Ultimately, with good leadership and excellent management skills, the VRMC has the potential to become an engine of development. However, the requisite management expertise and leadership of the VRMC is currently lacking. It is important to flag some of the critical but inter-linked institutional, technical, economic and social issues which require intervention, albeit on a decreasing scale over time.

Institutional Constraints

The VRMC is a newly created village level institution. The project has given capacity building to all VRMC in all 19 dam villages on dam and irrigation system management. However, the management of a water resource, in a highly individualistic society, with little history of group work for the collective benefit of all, remains a problem. A modus operandi, in several communities is being developed, but is confounded by farmer's lack of appreciation of crop profitability water demands vis-à-vis allocation and prioritisation. The main institutional constraints are discussed as under:

- **Dam Maintenance**

  The VRMCs were imparted training in dam maintenance, but none of the 19 VRMCs had much in the way of practical experience. Initially, during the acquisition of practical experience, a watching brief need to be maintained, that decreases over time, to be completely phased out after a period of time. Progress was noted when one community had a blocked pipe, which was cleared. Other was successful in repairing damaged, broken or blocked pipes. Still another extended the pipeline by contributing 50% share of cost

from their common fund. Dam maintenance is costly, requiring access to financial resources greater than that generated through the sale or auctioning of irrigation water. In addition, the expertise required to de-silt and/or maintain a dam is absent at the farmer level. The VRMC realises that it has to maintain and upgrade the irrigation pipelines: an activity, which is undertaken with assistance from Forestry staff. Nevertheless, some work on defining different quality standards in pipeline repair may be required. Not with standing the need to develop sustainable sources of finance, the revenue for the auction of the dam water provides a useful funding source within the village for different types of low cost repairs and maintenance works.

- **VRMC and Water Contractor Coordination**

  An absence of coordination exists between the water contractor and the VRMC. The water contractor oversees the distribution and allocation of water but the VRMC must monitor the water contractor and regularly access the volume of water left in the dam. To manage the irrigation water, a monthly balance needs to be struck between water used, anticipated future need and the volume of water remaining in the reservoir. This will help the VRMC to make conscious decisions about efficient use of stored water. The VRMC should know whether the current level of water usage be maintained or changed for reasons of limited water availability, enterprise mix and profitability. In that case which crops or enterprises should receive priority water allocation may be decided the VRMC. The VRMC must have access to such information to make informed choices. The VRMC has a weak capacity to make such informed decisions. With practical experience and further capacity building, VRMC may start to address the problems created by the absence of the water contractor-VRMC communication link.

- **Power Relations with Other Village Level Institutions**

  Power relations between the Gram Panchayat and the VRMC are almost non-existent and further articulation is required. The VRMC has access to hard cash through the auction or sale of water. Technically, the funds are for the maintenance of the dam and the pipeline as well as funding further capacity building and community development activities. The VRMC has access to a revenue source, which may be a source of friction between the two institutions. These two institutions should be seen as complementary, linking community generated income sources and activities of the local

government. The two institutions working in concordance have the potential to fund community development independent of government funding.

- **Dam Projects by Other Agencies**

  A number of communities in Panchkula District, less so in Yamananagar District, have dams constructed by other projects and departments. For each dam constructed, a committee is established, similar to the VRMC, whose purpose is to manage and maintain the dam, the pipeline and the irrigated command area. In some villages, 3 different institutions or projects have constructed 3 dams. No coordination exists between each dam construction activity. Yet each dam has its own coordinating committee. Sometimes, the same individuals sit on these different committees. It is evident that institutionally the current set-up is inefficient. Rationalisation is recommended.

Technical Constraints

- **Irrigation Process**

  The allocation of irrigation water is key to exploring the full potential of the water-harvesting dams, in terms of maximising returns or benefits. The communities use either the "warabandi" system or a first come first serve system. The "warabandi" is equitable; the VRMC decides how much water is assigned to a unit area. No irrigation is allowed outside the irrigation cycle.

  The first come first serve system is based on demand; farmers request for a quantity of irrigation water, the water contractor delivers. Farmers with better access to financial resources receive more irrigation water. This system does not allow the optimal application of irrigation water but generally it operates in periods falling outside the prevalent irrigation cycle like summer season or off-season vegetable growing period. The concept of irrigation depth applied to a field is poorly understood. To the farmers, if the field has been covered with water, then the field has been irrigated, regardless of depth or penetration of water into the "A" and "B" horizons. Over irrigation is commonly done particularly at early stages of crops.

- **Dam Water Volume**

  VRMCs do not have the capacity to calculate the volume of dam/water remaining and to express the volume in terms of irrigation hours and acreage which could be covered. Irrigation depth is understood but needs to be linked to the remaining dam water volume. These calculations, though imprecise, can become basis for better managing and prioritising the remaining water (Table 9.1).

TABLE 9.1: Salient details of Water Harvesting Dams constructed by Haryana Community Forestry Project

	Water level, storage and hours of water available for irrigation during Rabi 2006 [1]																
	Bharauli	Ibrahim-pur	Mirpur I	Bhag-wanpur	Kaimb-wala	Turon I	Dhand-ion	Bans-wala	Thaska	Kath-garh	Kansli	Man-dappa	Mirpur II	Turon II	Mawas	Nanheri	Nawa-gaon
Water level (m)	12.20	4.23	12.00	7.83	6.75	12.30	5.72	8.50	9.25	11.40	7.65	12.90	11.90	9.65	6.10	10.08	10.84
Total storage of water (ha.m)	26.00	2.80	21.70	5.50	3.30	15.00	1.85	5.40	4.00	7.50	2.40	14.00	18.00	8.10	1.60	18.50	20.90
Dead storage level (m) [2]	7.00	3.00	5.50	4.00	4.00	4.50	4.00	4.00	5.00	5.00	5.00	6.00	4.20	4.60	4.00	5.00	5.00
Loss of storage (ha.m)	6.80	1.70	3.80	0.90	1.00	1.40	0.75	1.03	0.90	1.00	1.00	3.05	1.00	0.75	0.64	4.90	5.80
Available storage (ha.m) [3]	19.20	1.10	17.90	4.60	2.30	13.60	1.10	4.37	3.10	6.50	1.40	10.85	17.00	7.35	0.96	13.60	15.10
Net storage after seepage & evaporation loss (ha.m) [4]	11.52	0.66	10.74	2.76	1.38	8.16	0.66	2.62	1.86	3.90	0.84	6.51	10.20	4.41	0.58	8.16	9.06
Hours to irrigate one hectare (10 cm irrigation) [5]	15	15	15	15	25	12	15	25	20	12	18	20	12	13	20	12	15
Hours of water availability [6]	1728	99	1611	414	345	979	99	655	372	468	151	1302	1224	573	116	979	1359

1- Observations made from August 25-30, 2006.

2- Dead storage level is assumed on the basis of siltation of reservoir.

3- Available storage is total storage minus loss of storage, due to siltation or dead storage.

4- Net storage is taken as 60% of available storage after deducting seepage & evaporation losses during the period between observations taken to actual use of water.

5- Time to irrigate one hectare was noted from the farmers.

6- Hours of water availability worked out assuming 10cm of irrigation and each ha m of water sufficient for 10 irrigations/hectare of land during Rabi season.

Mastering the ability to calculate the volume of stored water and convert the same to number of irrigation hours and acre age will greatly increase the institution's ability to manage the irrigation water and to prioritise the allocation according to crop requirement or other criteria.

- **Irrigated Command Area Boundaries**

  The allocation of irrigation water is further complicated by the often blurred and imprecise irrigated command area boundaries. Moreover, within the command area, some areas of unlevelled land also exist. The technology and expertise is present in the village. Over time, farmers are funding and undertaking the land levelling and this problem will diminish over time. Tension often exists between farmers within and outside the command area. Land outside the command area is frequently irrigated using rubber pipes. The contractors supply water to earn more money. Extension of the command area, such that demand outstrips supply, will have a significant impact on water supplies within command at critical times. The concept of command area (demand) vs. the supply (dam irrigation water) needs to be further emphasised and explained. This is a key concept, which is under continuous and sustained pressure.

- **Water Saving in Conveyance System**

  Farmers readily recognise that water conservation is an issue. They realise and admit that their "open channels" are often poorly maintained, leading to high water losses through seepage and breaches for which they have to pay for. Consequently, many farmers have taken to using flexible plastic pipes to convey water to their fields, thereby saving water and money. To reduce the wastage, the VRMC should perhaps consider investing in and/or laying large bore plastic pipes or constructing concrete lined channels along commonly used secondary irrigation channels. Other water conservation measures widely used include the construction of less wider borders/segments. Not with standing segmentation and flexible plastic pipes, other practices must be considered, such as the use of vermi-compost or manure applications to increase soil moisture retention capacity, ridge and furrow systems and mulching.

- **Siltation, Dam Repair and Maintenance**

  The de-silting process is at present outside the VRMC resource envelope and leadership capacity. Nevertheless, to be sustainable, a strategy must be evolved to bring the capacity to organise and pay for de-silting operations into the VRMC management remit. Moreover, training on quality standards must be given, as poorly executed de-silting operations increases seepage and water loss.

  The problem and extent of siltation is a frequent refrain for all; it is a highly significant problem leading to reduced dam storage and blocked outlets. In some dams, where no catchment based silt control facilities exist, de-silting will probably

be required after 5-6 year cycle. De-silting, other dam repair and maintenance operations are expensive and technically demanding, for which VRMC lack capacity and look for government support. In one village, the VRMC installed a 75 mm irrigation water pipeline, reducing from a 100 mm irrigation water pipeline. Irrigation water flow has been significantly reduced and there is no hope of irrigating all the land potentially available for irrigation within an irrigation cycle. Advice, guidance and information is required on pipe diameter, on inexpensive farmer friendly de-silting methodologies and the costs involved. Technical capacity of the VRMC be enhanced such that the VRMC can sustainably undertake de-silting operations and maintenance of pipelines.

Economic Issues

To fully exploit the potential of the water harvesting dams, the VRMC members and community members must realise and appreciate:

I. The economic value of the water
II. The value of the different crops and optimal enterprise mix on their land holdings (however big, small or highly fragmented).

There are several issues of economic importance in the management of irrigation systems, which are given below:

- **Water Value**

  The financial cost of water has been established based on a criteria based on what farmers can afford (affordability) and the potential to maximise their return from the water. The figure is expressed in rupees per hour of irrigation (an irrigation hour). Two irrigation supplied cost recovery models are emerging.

  The first model is based on the VRMC auctions of the dam stored water through annual open bid system. The threshold water value appears to have been fixed in an arbitrary way. The VRMC's have not attempted to calculate the value of their dam stored water before auction because they had no perception of the number of irrigation hours/acre of water available. Farmer's perception of their water value is in the process of being rectified. Transparency in financial matters is an acknowledged problem. Farmers can compute the simple calculation shown in Table 9.2. Different scenarios can be built, by varying the cost of irrigation per hour and the contracted sum, based on the known quantity of water available.

Table 9.2: Expected Water Contractors Revenue from Mirpur (2006)

Dams Criteria	Mirpur 1		Mirpur 2	
	Irrigation depth		Irrigation depth	
	100 mm	50 mm	100 mm	50 mm
Hours of Water Available (hr.)	3,979	7,958	3,023	6,046
Irrigation water rate (Rs./hr)	20	20	25	25
Total expected revenue, if all of dam water is used (Rs.)	79,580	159,160	75,575	151,150
Current Contracted Sum (Rs.)	20,000	20,000	20,000	20,000
Profit loss (Rs.)	59,580	139,160	55,575	131,150

It is evident that the expected returns of water contractors at two different irrigation depths vary a lot. The irrigation depth is at present imprecisely known. The calculation shows that the water contractor has the potential to make a great deal of money, because the VRMC and farmers have seriously under-valued their water. By making the VRMC aware of the under-valuation, it may over time, increase the water's contracted sum. An increase in the water-contracted sum will put pressure on the water contractor to encourage stricter regulation of water, improved water conservation measures and better water allocation. The risk is with the water contractor, who has the task of recouping outlay.

In the second model, no water contractor is appointed, the VRMC appoints an "irrigation water administrator", who receives a commission per irrigation hour of water sold and collect the rent. The VRMC takes the risk, and the water value, less commission (1-2 Rs./irrigation hour) directly goes to the VRMC.

- **Animal and Crop Profitability**

  Paddy and wheat are the principle crops with pearl millet and maize cultivated on unlevelled land. Nevertheless, the most profitable enterprise is milk production; consequently fodder crops are popular (Barseem, sorghum pearl millet and stover from other crops). Barseem is very water demanding at a time of the year (March-April) when irrigation water availability becomes critical.

  Farmers have to make informed decisions, based on the economic benefits of different crops. That crucial economic information is not available at farm level. Farmers have no tradition of working out the production costs or the margin on different crops. Traditionally, these are subsistence farmers. Nevertheless, farmers with good access to markets are starting to change the way they raise crops and the crops they cultivate. The commercial value of crops is starting to become more important than the subsistence value.

  Crops are of lesser importance compared to milk, Farmers sell milk @ Rs. 8-10/litre, a buffalo produces between 2-5 litres/day for a 180-day lactation. The

potential for a sustained income stream is evident. Access to good quality fodder was a problem. Now due to access to irrigation, green and dry forage production has improved, which has prompted farmers to keep more buffaloes and also improve milk yield from his stock.

The paddy area in the 2006 Kharif season doubled as compared to the 2005 Kharif season in some of the dam villages receiving water first time. Paddy is the most profitable crop giving an estimated margin of Rs. 5,000-7,000 per acre. Vegetable seed production gives an estimated margin of Rs. 4,000-5,500 per acre, with pearl millet and maize at Rs. 1,500-2,600 per acre. Margins are low in wheat but wheat straw meets the need of roughages in the stable food of the livestock.

- **Risk Factors**

The irrigation water economics and the returns from different enterprises are key farmer incentives to manage irrigation water in an efficient manner. In some communities, the paddy farmers are taking the major share of available irrigation water. Paddy being a rainy season crop, some requirement is met by rains and rest is supplemented by irrigations from dam. When rains are scanty, more water from the reservoirs is used to save the paddy crop. This saves the paddy but puts at risk all other following Rabi season crops including wheat. In some villages, farmers have burnt their fingers by early use of water for paddy. There was no water left for last two irrigations to a heavily invested onion crop and this resulted in less than half the expected onion yields

Farmers have begun to appreciate these economic drivers, until they fully realise the value of their irrigation water and of the enterprise mix, efficient use and allocation of irrigation water, and risks involved in faulty allocation

Social Issues

The understanding and resolution of social issues is equally important in the managing the water-harvesting dams and their irrigation system.

- **Effect on Landless**

The effect of the dams, increased irrigation water availability and subsequent economic activity on the poor and landless was not clearly articulated. The HCFP is mandated to target the poor, landless and other deprived groups of the society. A study on the impact of water harvesting dams on such groups in dam villages was initiated. It has indicated that landless were employed in dam construction and hence got employment but were not benefited directly from irrigation water. The increased agricultural activity and introduction of vegetable seed production, however, created more on-farm employment opportunities for landless. In addition, increased fodder availability both from farms and forest helped them to increase milk production.

- **Equitable Water Allocation and Water Trading**

  The water-harvesting dams were predicated on the equitable allocation of irrigation water. Those farmers who have more land in the command area are using more water. Water is not equitably or fairly distributed. Equally, the water trading has remained under-developed, as there has been no allocation of water, based on calculated irrigation water availability.

- **Elite Capture**

  Paddy farmers are taking significant quantities of water. Paddy is a highly profitable crop, with assured minimum support price. Appropriation of water resources by elite or wealthy groups is likely to be a problem. One dam has been virtually exhausted with paddy farmers using about 4 ha m of water. It is suggested that water used for Paddy production be charged at a higher rate of 50 Rs./hr, which will still give paddy farmers a good margin. The excessive water use by paddy farmers appears to be a social problem, as much as it is an economic issue.

Conclusions

The dam construction is the start of an overall rural empowerment process, which includes a number of downstream activities and issues, which must be addressed. This should lead to better-informed farmers, charged with the institutional capacity and leadership skills to manage irrigation water, to repair and maintain dams. Capacity building must include time to allow for the acquisition of practical experience and “hands-on” knowledge. Sustainability can be achieved if farmers have the capacity to manage their own dam and command area efficiently.

The water harvesting dams full potential can be achieved, when farmers have information on which they can make rational and informed decisions. Steps are being taken to address the information issue. Farmers must have the institutional mechanisms to acquire, process and transform (calculate) the information. Information is required from different sources, crop profitability, crop water use, animal productivity and fodder production. The information must be available in easy to understand units of measure; for example dam water volume expressed in irrigation hours per acre results in farmers being able to calculate, for themselves, the number of irrigation hours per acre based on their irrigated command area. Key information that allows farmers to plan, prioritise and cultivate different crops with differing water demands and profitability. Availability of economic information will allow farmers to determine which irrigation water models they wish to opt for. And finally relationships to existing administrative structure and issues of landless need to be explored and addressed. Farmers require information, capacity building and guidance in simple and easy to understand modes/modules. More cost effective modes of this type of longer-term farmer and VRMC training, capacity building and development needs to be developed.

10. SOME PRACTICAL PROBLEMS IN THE CONSTRUCTION OF WATER HARVESTING DAMS

The field staff faces variety of problems during construction of water harvesting dams and progress of work is hampered by different types of constraints. The orchestrated rhythm of work is frequently disrupted and cause delay in the completion of execution. Many of the causative factors are not conceived in advance and sufficient precautions are therefore not taken. During the construction of five WHDs at Mawas, Mirpur II, Turon II, Nanheri and Nawagaon, we faced host of such problems. An effort has been made to describe those problems so that managers may become aware of those constraints and take remedial measures well in advance.

1. Availability of water

Sufficient amount of water is needed for the construction of earthen dams. The earthfill in toe, key and core wall has to be puddled. The embankments has to be kept regularly at optimum moisture content for compaction. The pipe outlet has to be tested against any water leakage and the refilling of its trench needs puddled conditions. The construction of anti-seep collars, haudies, spillway and check dams need water almost regularly. Any disruption in the supply of water would put the whole construction activity out of gear. A fool proof arrangement of water is, therefore, necessary. It was seen that:

- The local sources of water like springs, sub-surface flow in nalas, shallow wells etc. do not supply enough quantity of water.
- The tankers employed for water carriage in remote areas face number of mechanical problems like breaking of hooks, punctures, breaking of axle and so on. The repair facilities are not available near the project sites. The machinery has to be taken to the workshop and repair takes time.
- The engines of 5 to 10 hp are kept to either fill the tankers or directly lift water and take to dam site through plastic or rubber pipes. These engines frequently go out of order and hamper the progress of work.
- The conveyance of water through tankers or lifted through pipes face leakage problems and a good share of water is wasted in transit on poor quality bumpy paths.
- When water supply is reduced or hampered, work is not stopped but water lesser than required amount is added on embankments. Ultimately, the quality of work is compromised. It is, therefore advisable to keep extra tankers, spare

engine and good pipes for conveyance. Work must stop when water supply is hindered.

2. Availability of suitable soil as fill material

In the construction of water harvesting dams, sizeable quantity (30,000 to 120,000 m^3) of earth as fill material is needed. The use of most appropriate material would determine the stability of the structure. The geological strata being highly variable in Shivaliks, large variety in soil as fill material is observed. On one side there are textural variations from coarse sand to heavy clays, on the other hand there are admixtures of coarse material like calcareous modules (canker), gravel, stone, shingle in variable quantities. The clays have different types of coatings which give different hues – brown, dull yellow and dull black. The sand is found in a variable state from loose to consolidated and so are silt from friable outer portion to highly compacted material down below. Most clays when put in water get dissolved or collapse. The problems associated with such a variable strata for dam construction include.

- Boulders in the nallah bed at dam site, which has to be removed.
- Stones/gravel in fill material, which has to be removed.
- Consolidated silt & clays locally called Kunthur is difficult to break and difficult to cut from slopes, pose difficulty in excavation of foundations.
- For filling the toe and key trench and core wall, heavy textured, impervious soils are needed. Sometimes such materials are not available near the site. Sometimes good quality heavy soils are buried under the transported debris of stones in the nallah beds. The recovery of soil by removing the overlying debris turns out to be expensive.
- In case material of unsuitable quality is lying close to dam site, its removal becomes necessary from dam base for stability and submergence area for creating additional storage. The disposal of such materials adds to the cost.
- When the fill material of best quality is not available from the proposed submergence area, the tendency becomes either to get soil from the shoulders or from nearby slopes below the dam body. The disturbance in such areas is not desirable both from ecological and stability view point.
- At few places in Haryana Shivaliks, the boundary of Himachal Pradesh runs in such a way that most of the hills are in HP and arable/pasture lands down below are in Haryana. The torrents emerge from HP Shivaliks where slopes are very steep and dam sites are available in Haryana but close to the border.

The reservoirs wholly or partially may be in HP but dams and command areas fall in Haryana. In case dams are proposed close to the HP boundary and fill material has to taken out form submergence area, then there is no way except to enter HP and remove the soil from Nallah beds. The forest department of HP may object to the same. They may object to the submergence of some trees in the reservoir. Such problems were faced at Nanheri and Nawagaon. Somehow, there were not many trees in the submergence areas. The HP forest officers presume that after dam construction, not only the grazing pressure would reduce in their forest areas but moisture regime would also improve. They may agree to compromise with the removal of soil for dam construction. Another problem comes that we cannot do treatment of areas, which fall in HP and no soil conservation measures can be adopted in their territory to reduce silt loads to the reservoir. The possible implications of HP boundary falling close to dam sites should be reviewed in advance and conscious decisions have to be taken by getting HP forest officers into confidence.

- The soil in Shivaliks is very heterogeneous. Quite often heavy soils and light textured sandy strata in semi-consolidated state (sandstone) are lying side by side in horizontal or slanting bands. While taking heavy soil as earth fill for dam construction, unconsolidated sandy strata being unsuited for construction shall have to be discarded or excluded from the fill material. Such an exclusion is time consuming and cause problems. Some of it would be mixed in a smaller proportion with heavy soil and put on lower side of d/s embankment. The mixing under limits could be permitted but when limits are not respected, tendency becomes to dump whatever comes on way of bulldozer/JCB. In order to curb this tendency, a very strict supervision becomes necessary. In case works are contracted out to private contractors, such problems are more severe. When supervising staff leaves the site, such mischief's are committed to push up the progress by sacrificing the quality. The presence of supervising staff all the time is, therefore, necessary.
- When trolleys are loaded with JCB, roots, stones/gravels/pebbles, slabs of sandstone may come in the trolleys. At least 4 to 5 persons are always needed exclusively to remove such materials, which are not suitable in fill and has to be taken out. Here also, these materials can remain buried under the mounds of trolley loads when materials are not spread in thin layers of 20 cm before the layer is compacted. The tendency to dump trolley loads just side by side on the entire embankment and then doing customary spreading and sprinkling

water on top of it would mean that boulders, roots would remain buried, thick layers would not be properly moistured and not compacted properly. Spreading trolley load in thin layer by keeping the tractor slightly moving while off-loading the material is necessary.

- When unequal compaction of thickly dumped layer occurs, the filled up trolleys tend to stuck or tend to tilt. Hence tractor drivers prefer to keep the trolley static and off load the entire fill at one place. Spreading the fill into thin layers by employing bulldozer is the best way. A bulldozer does the best job of uniform spreading, breaking of clouds, maintaining lesser thickness of layer and hence better compaction. Uniform level of embankments is desired and not wavy which usually becomes with tractors.
- Sometimes mounds of impervious heavy soil or sandstone are allowed to remain standing inside the reservoir. They give a very ugly look. Reservoir should have 'D' shape/ horse 'shoe' upon filling. All efforts should be made to remove such mounds from the submergence area to create more storage capacity.
- While calculating lead for fill material, 30 metre extra is added in the distance to ensure that soil is not removed from close to the foot of the dam. This rule is frequently broken. All efforts are made to get the soil from the nearest place may be shoulders, may be slopes above the submergence area or even from behind the dam. This is wrong. We must obtain as much soil as possible from submergence area leaving 30 metre from foot of dam. In case the entire 40,000 m3 of earth is taken out from the submergence area, the storage capacity would increase by 4.0 ha m.
- All the stones excluded from the fill material should be stacked near the spillway and used in spillway construction.

3. Construction Machinery

The progress in dam construction work can be steadily maintained in case proper machinery in proper proportion and according to nature of work is deployed for dam construction. For example, the excavation of toe and key trench can be best done by JBC, the spread of earth in thin layers, uniform compaction and making of proper embankments can be best accomplished by a medium size bulldozer. Bigger bulldozers are more expensive and not that suitable for this purpose. The same purpose can be achieved with medium size bulldozers. The transport of earth from 300 to 400 metres distance is best done by tractor mounted trolleys having tipping arrangements. In case the soil is relatively loose

or ploughed up, then bucket type scrappers does the best job. The soil worked up from hill slopes by dozer is best lifted by JBCs to fill the trolleys. The dam construction work require lot of water. A 10 HP diesel engine having 7.5 cm black rubber pipes for conveyance is the best possibility. One or two water tankers should be kept for use as supplement when ever there is any problem with the engine. The loaded trolleys should pass over the embankment in the process of bringing earth so that more compaction is achieved.

In case lead is shorter, three trolleys to carry the soil filled by one JBC may be sufficient. When lead is more than 250 metres, then four trolleys with one JBC would be required. The whole unit would comprise of bulldozer (1), JBC (2), trolleys (7-8) , tractor with karaha (2), tankers (2) and diesel engine (1) for a medium size dam when work is proposed to be completed in a period of 5 months. An exercise was carried out to find out the requirement of machinery for completing a dam in a period of 5 months. The detail is given as under:

Actual and required equipment/machinery at Nawagaon WHD site

Total earth work provided = 120,000 m^3

Capacity of one trolley loaded = 1.9 m^3 uncompacted, 1.2 m^3 compacted

Total time available = Nov. 1 to March 31st = 150 days

Average number of trips per trolley/day = 30

Output per trolley/day = 30 X 1.2 = 42 m^3

No. of trolleys required for earth fill = $\frac{120,000}{150 \times 42}$ = 19,000

No. of JBCs for 19 trolleys = $\frac{19}{3.5}$ = 5 No.

No. of tankers required = 3 No.

Equipment machinery	Actually employed	Required
Trolleys	9	19 (8+8+3)
JBC	3	5 (2+2+1)
Tankers	3	3 (1+1+1)
Tractor with Karaha	1	2 (1+1)
Bulldozer	1	1
Operational sites	1	3 (1+1+1)
Tractor	13	24

The quality of work may suffers when machinery related problems occur during dam construction. Some examples are cited:

- There is a tendency to continue work of putting soil on embankments even if water supply is disrupted due to break down in diesel pump or tankers. Where only one or two tankers are deployed for bringing water, even one puncture of tyre takes the whole day for resuming the water supply. Inadequate moisture or putting a layer of dry soil is most objectionable as proper compaction is attained only at optimum moisture content. Similarly, due to shortage of water proper puddling in core-wall may not be possible. The whole fleet of machinery, i.e. bulldozer, JCB and trolleys, has to stop if sufficient water is not available to attain optimum moisture content in fill material. The hired tractor and trolley owners have the tendency to earn maximum rounds or hours of work. They ill afford the idle hours due to overhead costs.
- In case tractor with karaha is out of order, thick layers of soil are dumped over embankments. These thick layers are difficult to wet to optimum moisture level. Moreover, stones and roots may remain buried in thick layers. Hence simultaneous spreading of earth into thin layers is necessary. This becomes difficult if karahas do not work in tandem with unloading of trolleys on the embankments.
- It is pertinent to note that bulldozer must work on embankments after every layer of earth for spreading, removing unevenness on embankments, attaining compactions and uniform spread on entire stretch of embankment.
- The carriage of earth and water to embankments becomes increasingly difficult with increase in height of dam. Suitable tracks with uniform gradients may have to be made by the sides of the slopes. Cutting of slopes near dam body are dangerous. This require very judicious decisions to align the tracks connecting fill material sites with dam embankments.
- We often expect winter rains from mid December to end February. All winter rains are useful for dam construction in more than one ways. These rains may bring some run off which should be harvested by putting a 2-metre high coffer in main nallah. In case this runoff gets accumulated near the upstream dam slope, it my cause the problem of carrying soil through this area. Hence as far as possible, all earth available in area above the foot of upper dam slope should be removed first to raise embankments to 2 to 3 metres height. As embankments go high, soil should be taken from higher areas but from within the submergence area.

11. DESILTATION OF RESERVOIRS OF EARTHEN DAMS

The rate of sedimentation determines the useful life of water storage reservoirs. The rate is highly variable and essentially depends upon the extent of vegetation cover, presence of landslide prone vertical cliffs, grazing pressure and inherent nature and properties of soils. In Haryana Shivaliks, some storage reservoirs have silted in less than 10 years (@ 10% storage loss per year) and some are still functional even after 25 years of dam construction. Keeping in view the faster siltation rate of some of the reservoirs, soil conservation measures both vegetative and mechanical are recommended in catchment areas of water harvesting dams.

The Shivaliks are constituted of young, friable, loose heterogeneous mass of mud hills prone to land slides, land slips and accelerated soil erosion , but the intensity of mass wasting through soil erosion processes increases due to removal of protective vegetation cover. The rate of soil erosion varies depending upon the density of protective vegetation cover, extent of soil conservation measures adopted and protection provided by the local communities. Astonishingly, some reservoirs got silted in a period of 5 to 6 years and some have not yet silted even after 25 years of construction. The average life span of reservoirs varied from 10-15 years.

The history of village ponds in India shows that desiltation was a regular activity undertaken by the local communities. Unfortunately, such a tradition has slowly died down. Now people look towards the Government for operation and maintenance of every intervention, which the welfare state has made. In spite of the fact that WHD provide significant benefits to the local communities, they have never been organised, motivated and persuaded to carry out repairs and desiltation of reservoirs at their own level. No fund was established to carry out desiltation operations on year to year basis. Most useful reservoirs were allowed to get silted and no community efforts were made to solve the problem. Not only that investments made have been locked, but poor farmers who enjoyed the benefits of irrigation for few years got disappointed.

The Haryana Community Forestry Project provided for the construction of 18 water harvesting dams and protection of catchment areas with community participation. There was also a provision for desiltation of ten reservoirs. The project attempted to desilt two typical reservoirs and study the technological options and gain experience of desiltation so that lessons learnt are used in the revival of more silted reservoirs.

TECHNICAL CONSIDERATIONS IN DESILTATION

The technology of desiltation of reservoirs of small earthen dams is not well perfected. The options available for enhancing the useful life of such reservoir need to be studied by carrying out a practical exercise on desiltation.

A) Present situation of silted reservoirs

Basically, the silted reservoirs can be classified into three broad categories :

- Completely silted up and hold no water.
- Partially silted up, or have lost about 50% of storage and have the capacity to store rain water for few months after monsoon. Such reservoirs have slush in their lower layers.
- Those reservoirs, which have lost less than one third storage and water remains in the reservoirs until march except in drought years.

The first category would not cause much practical problem in desiltation and work can be taken up any time in winter months but the second and third category would permit working only in May-June.

B) Available options for desiltation

- Raise inlet level, dam height and spillway height. Although this is not a measure against siltation but it enables the reservoir to hold more rain water and use this water for irrigation through a siphon.
- Provide 5 to 6 metre high coffer dam at narrow gorge above the reservoir to create a debris basin and provide a 15 cm diameter pipe outlet (with 90^0 bend upward) about 1 metre above the ground level. This will allow the stored water behind coffer dam to flow to the main reservoir. Proper spillway shall have to be provided with the coffer dam.
- Remove as much silt as practicable to make the coffer dam, to raise the main dam to a redesigned section and put silt on down stream of dam if more funds are available.
- The community may be motivated to contribute about 10 to 15% of the expenditure: The following options could be explored:
  - (i) Get as much money as possible from Village Resource Management Committee (VRMC) funds.
  - (ii) Make household wise collection @ Rs. 200 to 300/acre of command area.

(iii) Ask villagers to contribute labour in the form of 'Sharamdan' or voluntary
labour.

(iv) Provide diesel from VRMC funds to tractor owners of the village and persuade them to carryout desiltation work.

C) Possibility of storage retrieval and cost involved

It would be erroneous to believe that the entire silt deposited to a depth of 10 to 12 metres in a silted reservoir could be taken out and disposed off. This would involve huge expenditure, which would exceed the original cost of dam construction. Let it be clarified with an example of Gobindpur WHD.

The total storage capacity was 22.70 ha.m. or 227,000 m^3 at 12 m net height. Even at a lowest rate of Rs 15/m^3 of earth the cost of 227,000 m^3/earth would come out to Rs. 34 lakh. It would be nearly impossible to arrange so much money for desiltation. Alternatively, remove one or two metre depth of silt from the reservoir area and raise the main dam height by one or two metres and also construct a coffer dam with the same earth. This option is subjected to two conditions a) the presence of slush in the reservoir does not prevent the operation of machinery/labour and b) the silt as fill material is suitable for earthen dam construction.

DESILTATION OF RESERVOIRS UNDER HCFP

Following steps were taken by HCFP to specifically address the problem of siltation of reservoirs.

- Selection of sites with reasonably good vegetation cover.
- Establishment of social institutions with well defined charter to impose pressure against grazing and illicit felling (social fencing) in forest catchments yielding runoff to the reservoirs.
- Provision of soil conservation measures in catchment areas like vegetative barriers, check dams and coffer dam.
- Sensitizing communities to carry out participatory evaluation of the problem of siltation and spend money from its own resources on conservation and protection measures.

The HCFP decided to select those reservoirs for desilting which met the following criteria:

- There should be a strong demand from the community and they are willing to contribute substantially through voluntary efforts.

- The VRMC should be functional.
- Preference shall be given to those reservoirs where water conveyance system and spillway are in perfect condition and do not need any investment.
- Select those reservoirs, which have good vegetation cover in catchment and desiltation is likely to make the reservoirs functional for coming 10 -15 years.

DESILTATION OF RESERVOIRS AT BUNGA AND GOBINDPUR

After careful consideration of the factors given above, two WHDs constructed earlier at Bunga and Gobindpur village were taken up for renovation and desiltation. The salient details are given as under (Table 11.1).

Table 11.1: Salient details of Water Harvesting Dams desilted during 2003-04 under HCFP

Name of the project	Year of construc-tion	Catchment Area (ha)	Dam Height (m)	Dam Length (m)	Storage (ha.m.)	Sub-mergence area (ha)	Command Area (ha)	Cost (Lakh Rs.)
Bunga	1984	127.0	14.0	115	59.63	11.0	243.0	39.5
Gobindpur	1986	52.0	14.0	100	22.70	5.04	59.0	7.90

As per proposal, a provision was made for raising the main dam by 2-metre and construction of coffer dam. The total cost of these two components was Rs. 503,768 and Rs. 395,358 at Bunga and Gobindpur respectively (Table 11.2).

Table 11.2: Cost of raising main dam and cost of coffer dam construction at Bunga and Gobindpur

Name of project	Main / Coffer	Labour/ spillway	Cost (Rs)
Bunga	Main dam raising	EW Labour	156585
		Spillway	46947
		Sub total	203532
	Coffer dam construction	EW Labour	185395
		Spillway	114841
		Sub total	300236
		Grand total	**503768**
Gobindpur	Main dam construction	EW Labour	169718
		Spillway	21548
		Sub total	191266
	Coffer dam construction	EW Labour	131800
		Spillway	72292
		Sub total	204092
		Grand total	**395358**

- EW means Earth Work

Desiltation in Bunga dam

The 14-metre high Bunga Dam was silted up to 10 metres. The storage left in the last 4 metres between contours of 100 and 96 was 13.77 ha.m. The dam height was raised by another two metres, thus raising the storage to 27.56 ha.m. (Table 11.3).

Another 2.42 ha.m. storage was created due to the construction of 3.7 m high coffer dam thus making the additional live storage of 16.21 ha.m. The contours for water storage calculations are given in Fig. 1.

Figure 1

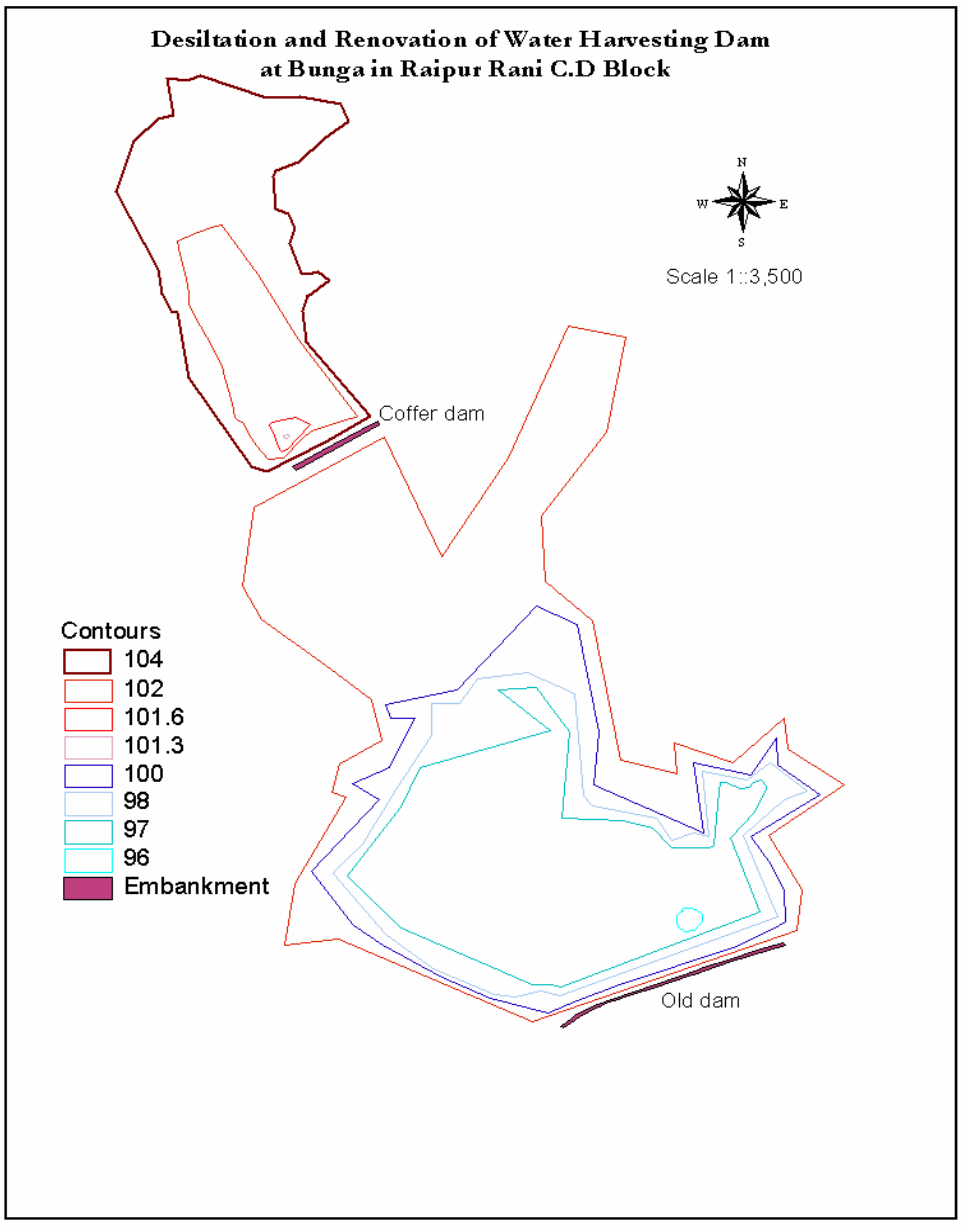


Table 11.3: Water storage at different contours in main and coffer dam at Bunga

Contour		Area (ha.)	Storage (ha.m.)	Mean storage (ha.m.)	Cumulative storage (ha.m.)
Main dam	96	0.02	0.00	0.00	0.00
	97	3.13	3.13	1.58	1.58
	98	4.00	4.00	3.57	5.15
	99	4.49	4.49	4.25	9.40
	100	4.98	4.98	4.37	13.77
	101	6.89	6.89	5.94	19.71
	102	8.80	8.80	7.85	27.56
Coffer dam	101.3	0.01	0.01	0.000	0.00
	101.6	0.04	0.04	0.025	0.025
	102	0.88	0.184	0.112	0.137
	103	1.47	1.175	0.680	0.817
	104	2.58	2.03	1.603	2.420

The cost /m^3 of storage in the renovation process came to just Rs. 3.11 against Rs. 19.75 in a newly constructed dam at Turon. This example clearly suggest that efforts should be made to revive the silted reservoirs having net work of pipelines provided, the VRMC's are fully functional and willing to share part of the cost. The VRMC of Bunga shared Rs. 50,000 in the desiltation programme.

Desiltation of Gobindpur dam

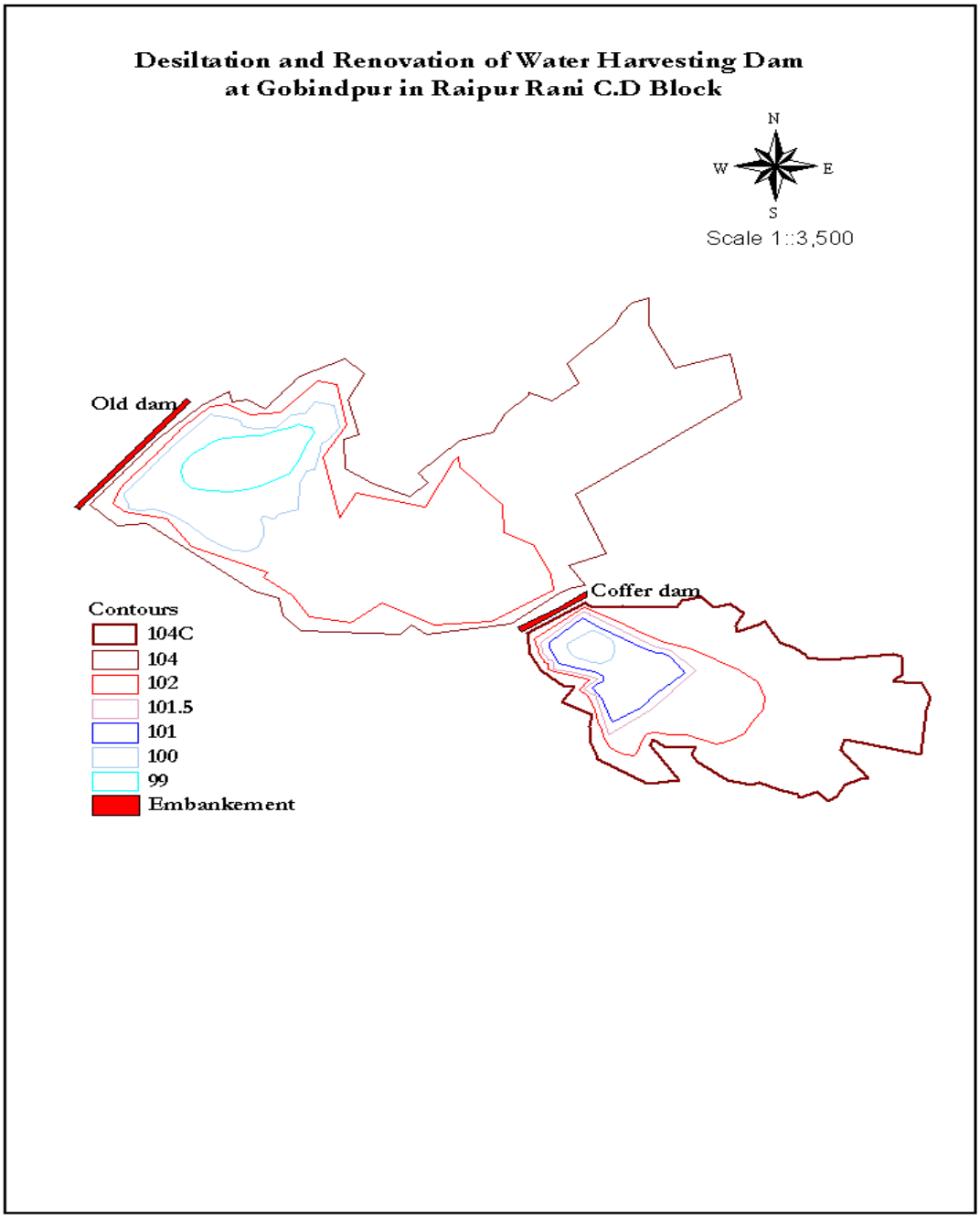
The Gobindpur dam constructed in 1986 at a cost of Rs. 7.90 lakh had a storage capacity of 22.7 ha.m. of water (Table 11.1). The reservoir was silted up to 9 m height out of 12 m net height. The remaining 3 m depth of storage was left in a very small area near the dam and left over storage was only 3.79 ha.m. (up to 102 m contour). This reservoir was taken for desiltation at an estimated cost of Rs. 3.95 lakhs (Table 11.2). Three components were included in the plan; a) raising of main dam by 2 m, b) raising of spillway by 2 m and construction of 6 m high (4 m net) coffer dam above the submergence area. The detail of water storage created in the main and coffer dam are given in (Table 11.4).

Table 11.4: Water storage at different contours in main and coffer dam at Gobindpur

Contour		Area (ha)	Mean (ha.m.)	Cumulative storage (ha.m.)
Main dam	99	0.26	0.00	0.00
	100	0.80	0.53	0.53
	101	1.63	1.22	1.75
	102	2.45	2.04	3.79
	103	3.29	2.87	6.66
	104	4.14	3.72	10.38
Coffer dam	100	0.05	0.00	0.00
	101	0.30	0.17	0.17
	102	0.85	0.57	0.74
	103	1.6	1.23	1.97
	104	2.34	1.97	3.84

The contours for water storage calculations are given in fig. 2.

Figure 2



The cost of water storage created by renovation and desiltation is as under:

Additional storage created in main dam (10.38 - 3.79) = 6.59 ha.m.

(By raising spillway and main dam by 2 m.)

Storage created by coffer dam = 3.84 ha.m.

Total additional storage created = 10.43 ha.m.

Total cost on main and coffer dam = Rs. 395358

Cost /m^3 of additional storage (395358/104300) = Rs. 3.79 lakh

Net storage in new WHD at Dhandion = 9.10 ha.m.
Total cost of new WHD at Dhandion = Rs. 17.34 lakh

Cost/ m^3 of water storage in new dam at Dhandion = Rs. 19.05 lakh

These calculations confirm that desiltation is economically viable. The VRMC of Gobindpur contributed Rs. 30,000 as their share of cost. The renovated system has functioned very well during the monsoon of the year 2004 and is still functional.

CONSTRUCTION OF COFFER DAMS

Coffer dams arrest sediment above the storage reservoirs and help in prolonging their useful life. With such an aim, coffer dams with adequate spillway were constructed during April – May 2004 above the reservoirs of Bharauli and Mirpur dams constructed earlier by HCFP. The estimated cost was Rs. 2.67 and 1.89 lakhs respectively (Table 11.5).

Table 11.5: Cost of coffer dams constructed during 2003-04 under HCFP

Name of Village	E work (m^3)	Total cost (lakh Rs.)		
		E.W.	Material for Spillway	Total
Bharauli	5070	1.89	0.78	2.67
Mirpur	2585	1.29	0.60	1.89

Construction of coffer dam at Bharauli

The WHD constructed at Bharauli during 2001-02 was silted up to 6 m height in three years. Out of 22.45 ha m of original storage up to 12 m of net height, only 14.38 ha.m. storage was left in the remaining 6 m of depth. The coffer dam having net height of 3.26 m had storage of 2.33 ha m (Table 11. 6).

Table 11.6: Water storage at different contours in main and coffer dam at Bharauli

Contour		Area	Storage (ha m)	Cumulative Storage (ha m)
Main Dam	106	0.02	0	0
	107	1.03	0.52	0.52
	108	1.74	1.39	1.91
	109	2.43	2.08	3.99
	110	3.12	2.78	6.77
	111	3.80	3.46	10.23
	112	4.49	4.15	14.38
Coffer Dam	112	0.15	0	0
	112.8	0.45	0.24	0.24
	115.26	1.25	2.09	2.33

The VRMC plans to raise the main dam and spillway by one metre which would create additional storage of 5 ha.m, thus making the live storage (14.38 + 5.0) to 19.38 ha.m. The additional storage of 2.33 ha.m. in coffer dam would further increase the storage (19.38 + 2.33) to 21.71 ha.m. The original live storage of Bharauli Dam was 22.45 ha.m. Thus the retrieval of storage upon renovation (21.71/22.45) would be 96.3%. The raising of main dam and spillway by one metre and construction of coffer dam would retrieve almost the entire original storage and offset the loss of 6 metre storage due to siltation in four years.

The coffer dam has a total height of 5 metres and net height of 3.26 metres with 2.5:1 slope on u/s and 2:1 d/s. The top width of 3 m with 1.5 m free board was provided. A key trench with 1 m width at the base and 1 metre depth was provided & filled with heavy soil. A pucca masonry spillway was provided on one side of the dam body. The entire work was carried out from March to mid April 2004 when there was sufficient moisture in the soil and there was no need of additional water. Slush was present after 10 cm of depth and hindered the tractor operation work. Tractors got repeatedly struck in the slush and had to be pulled with another tractor with great difficulty. Slowly the area was opened up with plough to dry up surface layers. This was repeated and earth from upstream and downstream of coffer dam was removed with tractor operated blades. It was felt that in case the deposited silt used for coffer dam construction contains more sand and is poor in soil strength then a blanket of heavy soil would be needed.

Construction of coffer dam at Mirpur

The 14 m high earthen dam constructed during 2002-03 at Mirpur village created a storage of 24.5 ha.m. It was planned to construct a 4 m high coffer dam with 2.65 m net height to arrest sediment above the reservoir. The cost of earthen coffer dam and spillway constructed in April-May 2004 was Rs. 1.89 lakh. The coffer dam has a storage capacity of 0.73 ha.m. up to 2.65 m height (Table 11.7).

Table 11.7: Water storage at different levels in Coffer dam at Mirpur

Contour	Area (ha)	Storage (ha.m.)	Cumulative storage (ha.m.)
111	0.01	0.00	0.00
112	0.05	0.03	0.03
113	0.27	0.16	0.19
114.65	0.40	0.54	0.73

In case of Mirpur, silt got deposited over one year only and slush was not a serious problem for construction of coffer dam. A spillway was provided by the side of the dam body. The cutting of spillway was a problem at both the locations

because of very hard strata. The construction of coffer dam was completed by mid June 2004. Mainly tractors with scrapers were engaged for the construction work. A pipe outlet was put through the dam at one metre height to discharge runoff water harvested by coffer dam to the reservoir of main dam leaving the silt behind in the reservoir of coffer dam. This pipe could be raised subsequently when part of the reservoir is silted. The height of coffer could also be raised to maintain its sediment trap efficiency. The renovated system has successfully operated in the following monsoon and trapped the entire silt above the reservoir.

It is concluded that silted and defunct reservoirs can be revived and renovated by a) raising height of main dam and original spillway by one or two metres; and b) by constructing coffer dam of 4 to 6 m total and 3 to 4 m. net height with spillway above the submergence area across main drainage lines provided: a) the water conveyance system and spillway are intact and fully functional; b) there is demand from the communities and VRMC's are functional; and c) they are prepared to share up to 10% (or Rs. 50,000) cost of renovation.

The example of Bunga and Gobindpur desiltation projects indicate the possibility to revive 70-80 percent of original storage at a nominal cost of Rs. 3 to 4/m^3 of water storage. In the newly constructed water harvesting dams, this cost comes to Rs. 19 to Rs. 20/m^3 of storage. Each desiltation project may cost Rs. 4 to 5 lakhs and can be executed during summer months. It is erroneous to assume that the entire silt deposited in reservoirs could be removed. The deposited silt can be safely used in raising the height of main dam. In case of coffer dams, excess of sand in fill material may make it unsuitable for construction. In such a case, a blanket of heavy soil may be provided on the outer shell of the dam body.

Table 11.8: Provision for silt control in Water Harvesting Dams

Dam site	Severity of problem	Measures adopted
Bharauli	Severe	Two crate were structures cauffer dam constructed
Ibrahimpur	Slight	No problem of siltation
Kaimbwala	Slight	No problem of siltation
Bhagwanpur	Slight	One check dam already exists.
Mirpur	Severe	3 check dams constructed by Kandli project Cauffer dam constructed
Turon	Moderate	2 check dams already exist 2 check dams constructed
Dhandion	Moderate	One small earthen dam exist to act as silt trap One check dam constructed
Banswala	High	One check dam constructed
Thaska	Moderate	One check dam exists but needs repair One check dam proposed
Kathgarh	Moderate	Two check dam exists but one needs repair One check dam constructed
Kansli	Moderate	One check dam exists One check dam proposed
Mandapa	Severe	One check dam exists repaired One check dam constructed

Need of Silt Control Measures

The catchment conditions and the chances of siltation of reservoirs of all the 19 WHDs were revived in 2007. On the basis of this review the catchments were divided into four categories and measures for silt control were suggested (Table 11.9).

Table11.9: Relative need of silt control measures in catchment areas of earthen dams

Sl. No.	Category of Catchment	Dam Villages	Proposed measures
1	Catchments requiring slight to no treatment	Ibrahimpur Bhagwanpur Thaska Kathgarh Dhandion	- Grazing control - Social pressure against fuelwood extraction
2	Catchments requiring moderate treatment	Kaimbwala Turon I Banswala Kansli Mirpur II Turon II Mawas	- Vegetative checks - Dry stone check dams, - One Crate wire structure - Raising of existing structures
3	Catchments requiring heavy catchment treatment	Bharauli Mirpur I Mandappa	- Intensive vegetative barriers - Dry stone check dams - Crate wire structures at least 2 in each.
4	Catchments where treatment cannot be done due to territorial limitations	Nanheri Nawagaon Rampur Gainda Paniwala	- Spreading of seeds - Social pressure against fuelwood extraction

Sedimentation of Bharauli Reservoir

In the 90 ha catchment area of Bharauli WHD, the faster siltation was expected due to the presence of bare land slide prone areas. As a precaution, three crate wire woven stone check dams were constructed in May-June 2001 but all the three were silted up in one monsoon season. Farmers of this project feel quite concerned because of high suspended sediment in stored water which goes with irrigation water and is depositing silt in the farm lands. The coarse fragments have accumulated at the rim of the reservoir. An effort was made in December 2003 to work out the sediment stored in the upper reaches of main gully bed just above the submergence area, sediment deposited in the reservoir itself and sediment carried with irrigation water to the fields. The combined volume of 4m m^3 or 71986.5 tonnes was worked out from all the three sources. It was noted that in

a period of 3 years over a catchment of 90 hectares, the mean silt load was 266.6 t/ha/yr. The total storage capacity of 24.70 ha.m. was thus reduced by 4.07 ha.m. and this loss came to 16.48 percent of total storage or about 5.5 percent of total storage loss per year.

In view of such a faster rate of siltation, it was proposed to construct an earthen embankment above the reservoir at a narrow gully course and provide a spillway to take silt free water to the reservoir after allowing silt load shedding in a stilling type debris basin. The cost of embankment at 6.5 and 5.5 metre height with 3:1 and 2.5:1 U/s & D/s slopes was worked out as Rs. 284,350 and Rs. 230,100 respectively. In case of 5.5 meter height and 2:5:1 and 2:1 side slopes, the cost of embankment was Rs. 186,875. The spillway cost was Rs. 50,000. Thus, by spending about Rs.2.5 lakhs, the rate of silt load to reservoir could be drastically reduced. The beneficiaries promised to contribute labour to the extent of Rs. 50,000 in this most needed work.

The siltation rate of Mirpur reservoir is also expected to be high. It is evident from the amount of silt deposited behind the water body just with one year of monsoon rains. An embankment similar to Bharauli was proposed at Mirpur also to arrest sediment above the reservoir. However, no serious siltation problem was observed in Ibrahimpur, Kaimbwala and Bhagwanpur reservoirs. In the proposed six WHDs for the year 2003-04, one or two silt detention structures in the main gully above the reservoir has been proposed as part of the catchment treatment package. This would be further supported by vegetative measures for reducing sediment flow to the reservoirs. All the VRMC's would be prompted to enforce social fencing of forest catchments feeding the reservoirs.

ANNEXURES

AGREEMENT BETWEEN VILLAGE RESOURCE MANAGEMENT COMMITTEE/SOCIETY AND THE HARYANA COMMUNITY FORESTRY PROJECT FOR CONSTRUCTION, OPERATION AND MAINTENANCE OF WATER HARVESTING DAM

This agreement made this ……. day of year 2…… between the Divisional Forest Officer, _____ Division Haryana Community Forestry Project (on behalf of the Haryana Community Forestry Project, Government of Haryana) on the first part and the _____ (Village) Resources Management Committee/Society of_____ community Dev. Block of_____ District. (hereinafter called VRMC/VRMS) on the several part, witnesses as follows:

That the VRMC is authorised to execute any works concerning survey, planning, execution layout of pipeline, operation and maintenance of WHD on behalf of the _____ Village community, _____ Block, _____ District.

- Co-operate with the VRMC/VRMS and the DFO in implementing the Resource Development Microplan of the village prepared by the VRMC/VRMS.

That the VRMC/VRMS shall specifically carry out the following:

- Implement the WHD Proposals approved by the village community and by the DFO in every respect.
- Appoint a Community Monitoring Team of the VRMC/VRMS, to keep regular tracking of the implementation of the WHD.
- Mobilise resource management fund of Rs. 30,000 for the WHD project for it possible maintenance.
- Open bank account for its money and keep proper minimum accounts and submit the accounts for audit by the HCFP.
- Maintain and manage the WHD's during and after the construction phase.
- Execute the extension advice rendered by the forest department with regard to protection, maintenance, management of water resources.

- The project shall engage all the unskilled labour from the village for dam construction. In case, there is no work force left, then only the outside labour shall be engaged.
- All the wage earners would be given wages at the Govt. approved rates. The workers would receive full payment of the work but voluntarily contribute in the common village fund.
- All the tractor and other machinery owners of the village engaged for dam construction shall be asked to contribute to the social fund.
- The VRMC shall prepare a list of beneficiaries and decide the area which would receive irrigation and decide the route of the pipeline.
- On the completion of the dam, the beneficiaries shall dig the trenches for laying the pipeline and refill the same and shall not charge any amount from the project.
- The VRMC shall nominate at least two persons daily to visit the dam site for supervision and ensure that the work proceeds properly as per their satisfaction. This would be done to inculcate the spirit of involvement and ownership.
- Since water for dam construction would be needed, the VRMC would allow the use of some water stored in the existing dam if any for construction of new dam.
- The VRMC would exercise maximum social pressure against grazing in the forest area in general and catchment area in particular.
- The villagers individually and jointly would provide all possible help and assistance which would be required for smooth and timely completion of the project.

That the DFO, on behalf of the Haryana Community Forestry Project, shall carry out the following:

- Train the villagers, labourers and the VRMC/VRMS, including the community monitoring team, in techniques for maintaining and operation WHD's & maintenance of accounts
- When participatory monitoring and evaluation confirms that the community is fully capable of managing the WHD's independently and establish conflict free

water sharing arrangements, hand over the WHD to the community through its VRMC/VRMS.

That the DFO (HCFP) shall continue to issue directions and render technical advice and assistance to the VRMC/VRMS regarding maintenance, management and protection of WHD and such directions shall be binding on the VRMC/VRMS.

That if the VRMC/VRMS fails to carry out any of the directions issued by the DFO (HCFP) under this agreement or any of its obligations which it is bound to discharge, the DFO (HCFP) shall carry out at his discretion any or all the works regarding protection, maintenance and management of WHD at the cost of the VRMC/VRMS/Panchayat, provided a notice of 15 days is issued to the parties.

That Project Director, Haryana Community Forestry Project shall arbitrate all disputes with regard to the operation of this agreement. His decision shall be binding on all the parties concerned.

In witness whereof, the three parties to this agreement have set and subscribed their hand seal on the dates hereinafter mentioned respectively.

Signed, sealed and delivered by the said parties on the _____ day of _____ (month), 200— (year).

DFO
Haryana Community Forestry Project
_____ Division

Chairperson
VRMC/VRMS
Village _____
Block _____
District _____

Witness
Sarpanch
Gram Panchayat
Village _____
Block _____
District _____

Community Participation In Water Resources Management

S.S. Grewal and S.K.Dhar

ABSTRACT : Community participation is one of the most important contributory factor in sustainable management of water resources. It implies that people join hands to influence the direction and outcome of the development initiatives. The community needs, choices, preferences and priorities are reflected in the concept and design of such programmes by involving all sections of the society in the analysis of their problems and identifying strategies to solve them. People are organised to participate in planning, implementation and maintenance of the assets. The concept of participatory management of natural resources emerged from Sukhomajri project and got replicated not only in Shiwaliks of north India but many other similar ecologically degraded agro-ecological regions of the country. Rainwater harvested from forest watersheds by constructing earthern dams resulted in quantum jump in crop and milk production and acted as catalyst to tie up the economic interest of communities with forest protection. The degree of success in sustainable management was determined by the strength of social institutions developed in the form of water user's cooperatives. Describing the emergence of community participation concept in water resource development in Shiwaliks, the technical, social and economic requirements for success have been highlighted. The issues in community participation like cost sharing, gender and equity, management of social funds and execution of works through communities are presented based on the experiences of water resources development in the World Bank supported Integrated Watershed Development Project (Hill II) and European Commission funded Haryana Community Forestry Project.

INTRODUCTION

Community participation has become the key ingredient in the recipe of rural development particularly after 73rd constitution amendment. It implies that people join hands to influence the direction and outcome of development programs and their needs, choices, preferences and priorities are reflected in the concept and design of the program. The blue print of top-down approach is replaced by participatory bottom up approach in which communities are involved in the analysis of their problems, identify strategies to solve them, participate in planning and implementation and get organized to take care of the assets created. In this voluntary process, disadvantaged groups also influence decisions that effect them

and they are enabled to organise themselves, identify their own needs and participate in the project design, implementation and evaluation (Samra, 1999). The participatory process brings the essence of the programme on the cosmic vision of the people, empower communities by giving them the ownership of programme, put focus on gender issues particularly participation of women and weaker sections and assures quick, substantial, visible and equitable flow of benefits to all sections of society. In the parlance of natural resources management, the mismanagement of common property resources, poor implementation of law and ever increasing livestock and human population caused alarming environmental and socio-economic problems defying solution (Jodha, 1986). The failure of technical solutions alone in achieving the objectives of natural resources conservation and management gradually made it clear that the poverty triggered degradation cannot be reversed without involving the local communities and adopting holistic integrated watershed development approaches (Dhar 1994 and Samra 1998). It is, therefore, felt that participatory programmes and policies are highly relevant to India and are consistent with its overall development strategy of social upliftment by reducing poverty, protection of environment by natural resources conservation and management, development of human resources and promote farm sector growth (Farrington et. al., 1999). Various facets of community participation in water resources development with particular reference to Shivaliks of north India are presented in this paper.

PARTICIPATORY WATERSHED MANAGEMENT IN SHIVALIKS

The participatory watershed management as a concept emerged in late seventies from the famous Sukhomajri project located near Kalka in the Haryana Shivaliks. It demonstrated that degraded forest watersheds can be best protected and regenerated through active involvement of local communities provided their local needs of water, food, fodder and fuelwood are appropriately integrated in the concept, design and philosophy of the project. In addition to catchment treatment with soil and water conservation measures, an earthen dam was constructed to harvest rainwater from 9.2 ha. forest watershed and conveyed through gravity fed under ground pipeline to 16 ha of rainfed farm land. Harvested runoff water from forest watershed acted as a catalyst to boost production of foodgrains and forage for livestock. People replaced their foraging cows and goats with stalfed buffaloes and themselves introduced the concept of social fencing which helped in quick regeneration of denuded forest watersheds (Grewal et. al. 1995, Mishra and Sarin, 1987). The people of Sukhomajri formed a water user's cooperative and took three historic decisions way back in 1980.

- Harvested water shall be equitably distributed amongst all the families including landless.
- Water rent shall be charged @ Rs. 2 per hour so that a social fund is created for future maintenance of the system without external support.
- Anybody taking cattle to forest area for grazing shall be fined and if he does not pay the fine, he shall not get share of water. The community may also resort to social boycott.

The issues of equity, ownership and sustainability were inbuilt in these decisions taken by the elderly wisemen of Sukhomajri (Sarin 1996). The Sukhomajri message was clear that the forest development is possible when direct, visible benefits flow to the people and they resolve to protect the forest watersheds (Chopra & Kadekodi 1991, Mishra 1991). The social, economic and ecological benefits of participatory watershed management promoted large scale replication of the model with financial assistance from local and central governments and foreign funding agencies.

The participatory watershed development approaches, adopted in most projects operated in Shivaliks, are primarily aimed at poverty alleviation, empowerment of poor, women, landless and small farmers. The focus remained on reducing regional imbalance in economic development, which was created due to lack of irrigation and infrastructure in hilly areas. The issue of equity in broader sense is addressed as efforts are being made for socio-economic development of this rainfed and backward but ecologically important region (Sarin, 1995).

There has been a mix of successes and failures depending upon the extent of benefits which could be generated, commitment of social institutions built around the interventions, effectiveness of social fencing and attention to ownership and equity related issues. Where social institutions remained weak and ineffective, projects failed to deliver. The main reasons of failure were analyzed as under:

- People not involved/consulted from day one and then on at every stage.
- People were not motivated and organized to own the assets.
- Programs were not tailored to the needs of people.
- Flow of direct and visible benefits to the community not ensured.
- Projects not handed over in perfect operational conditions.
- Mechanism for generation of social fund for maintenance not developed.
- Internal caste/religion based conflicts in the society.
- Lack of transparency.

Inadequate attention to the above alienated the communities from the project interventions and they did not own the assets created. Owing to lack of maintenance and after care, soil conservation structures breached, plantations were grazed and the process of decay started very quickly. The golden rule "hand over the stick and slowly withdraw based on the maturity level of social institutions" was not followed.

There is a long list of watershed development projects like Sukhomajri, Nada, Bunga, Relmajra, Takarla, Nangal where development of vision, ownership for operations and maintenance and flow of benefits have definitely occurred. However, gender concerns and equity, empowerment of women, flow of substantial benefits to landless and weaker sections remained sub-optimal. Even in Sukhomajri, women have not been attending meetings for long time and there were no attempts to decrease their workload. The participatory appraisal of Bunga project showed increased workload of women consequent upon flow of benefits through crop and milk production (Arya and Samra, 1995).

COMMUNITY PARTICIPATION IN WATER RESOURCES DEVELOPMENT

A critical review of five decades of water resources development in India would indicate the need of such works rather at an accelerated pace for sustainable economic and ecological development. Water is becoming more and more important as its fast increasing scarcity has become a cause of serious concern. The available ground water resources are not only depleting fast but also getting polluted and are unfit for human consumption. In the sub-tropical and semi-arid monsoonic type of climate under which major parts of India are covered, about 80% of rainfall is received in three monsoon months and the remaining nine months are almost dry. Harvesting of surplus monsoon rainwater and its efficient use during moisture stress period has demonstrated the technical feasibility, economic viability and social acceptability of the technology in most rain-fed areas of India.

The Indian Council of Agriculture Research (ICAR) did pioneering work in operational research mode in projects like Sukhomajri and Facot and the success of water harvesting initiatives lead to large scale replication of this technology through national watershed projects. The initiatives of ICAR particularly through CS&WCR&TI Dehradun and CRIDA Hyderabad provided great push to the water resources development programs. The main support was provided through demonstration, data generation, documentation and dissemination of information.

It was observed that maximum community participation is obtained in water harvesting innovations.

The holding of this very national conference on Resource Conserving Technologies for Social Development attempts to achieve the objectives of sharing information, experiences, constraints and awareness generation.

The rain-fed area, about 90 million hectares in India, requires serious efforts towards harnessing renewable rainwater resources by various ways and means. It is suggested that:

- The highest priority should be given to the development of thousands of small water harvesting structures/ devices so that stored water is applied at critical stage of crop growth to avoid crop failures. The benefits of supplemental/minimal irrigation in terms of increasing/stabilising crop production and better utilization of profile stored moisture are well documented by several studies (Grewal et.al 1995).
- Efforts must be made to store maximum amount of rainwater where it falls (in-situ conservation) both in farm and forest lands.
- The old ponds and water storage reservoirs should be renovated and rehabilitated.
- In case of cities and towns roof-water harvesting should be popularised.
- Pollution of water, contamination, water born diseases must receive attention.

The message of the Prime Minister is clear *" khet ka pani khet mein,gaon ka pani gaon mein'.* The year 2003 was declared as International year of fresh water to highlight the impeding threat of fresh water scarcity and the need of water conservation and management.

PRE REQUISITES FOR EFFECTIVE COMMUNITY PARTICIPATION

The community participation cannot be viewed in isolation. There are several driving and motivational forces, which promote community participation. Though the spectrum is wide but few encompassing technical, social and economic aspects are highlighted.

TECHNICAL ASPECTS

Efficiently executed works of good quality and high standard help in generating goodwill and respect for the project staff in the minds of the beneficiaries. Quite often field staff need help and guidance in technical matters, as there was no single reference source to which field staff could refer for planning and design of

water harvesting dams (WHD). It was in this context that a field manual on WHDs was prepared by the Haryana Community Forestry Project (HCFP), which outlined the entire methodology to be adopted in planning, designing, preparing cost estimates, construction, maintenance, community participation, formation of local institutions and their roles and responsibilities. The copies of the manual were made available to all field units, which helped in quick processing of plans and cost estimates and also improved the quality of work. The executed works in perfect running condition and after full demonstration, are handed over to the community executives for further operation and maintenance. Suitable measures are taken against siltation of storage reservoirs. There is a need to improve the design of water harvesting structures and to make them more cost effective by using local materials.

SOCIAL ASPECTS

Formation of Village Resource Management Committees (VRMC)

Strong dialogue with the community, assessing their needs and perceptions, level of commitment and formation of VRMCs, a local village level institution, is a pre-requisite for any natural resources project. Besides other things, it must be made clear that water harvesting would form part of the village development plan and the villagers have to actively participate in planning, execution and be responsible for the maintenance and operation of water harvesting structures. Every household becomes member of the general house by paying membership fee. The general house then elects the executive, where women and scheduled castes are given representation. The participatory rural appraisal techniques are employed to prepare the development plan.

Cost Sharing

In order to ensure effective participation and develop a sense of ownership, VRMCs are asked to generate a social fund through local collections and meet the cost of digging and refilling the water conveyance pipeline from this fund. The VRMCs would sell water and generate funds for maintenance. The scope and extent of cost sharing by rural communities in watershed development projects was discussed by Grewal et.al., 2003 ‘a’ and ‘b’.The arguments for and against cost sharing have been presented. The enlightened farmers of Shiwalik hills argue that benefits of green revolution were appropriated by the farmers of irrigated plains, who never directly contributed for the construction of Dams like Bhakhra

and its canal system. When small earthen dams are made for poor hill farmers, they are asked to share part of cost. This is not fair, argue many farmers.

However, an equally strong case in favour of cost sharing is made on the strength of the following:

- Farmers willingness to bear a part of cost is an indication that he recognises the benefits of the chosen treatment.
- This filters out non-productive activities common in top-down approach.
- Farmers tend to buy a share in decision making through their contributions.
- It shows that institutional development has taken place and there is some capacity to maintain the executed works.
- It suggests that wider consultations have been held with the community.
- Collection of contribution entails an element of transparency in the process.
- The farmers tend to become more concerned about the correctness of expenses.
- Communities demand better service from the service providers.
- Contributions inculcate a sense of belonging/ownership, which is necessary for sustained management.
- These contributions constitute a corpus fund to be used for future maintenance.

The contributions are generally in the form of labour or some local material like stones and sand or cartage of material to work site. Such contributions generally constitute a small fraction of the total project cost. The Govt. of India Ministry of Agriculture guidelines provide for 10 percent contribution in individual and 5 percent in common development works. One percent of approved cost is earmarked for corpus fund to be matched by the contribution from the community and partly from the state government.

Employment Generation

All the labour in the construction work is engaged from the village and VRMCs may decide who would work. Preference is given to poor, landless and scheduled castes. As the facility of irrigation water is made available, farmers get activated to level the land, add more manure, resort to cultivation of vegetable, barseem and other high value crops which generate additional employment for land owners and landless. As green fodder availability improves, better quality milch animal are kept by replacing low yielding cows. This increases employment in livestock related activities, particularly for women, both with land owners and landless. Migration with livestock reduces as better employment opportunities become

available in project villages. We observed the increase in number of shops in such villages and owners are usually landless and schedule castes.

Social Fencing

The protection of forests against grazing, illicit cutting and forest fires was a big challenge. The water harvesting projects created awareness in the society and motivated them to protect the vegetation cover to induce sediment free flow of water to the storage reservoirs and ponds. The village community in general is restrained from taking livestock for grazing in the forest land and the VRMC executive exerts social pressure to impose effective closure. This improves vegetation cover and minimises risk of siltation.

ECONOMIC ASPECTS

The community participation is strongly related to flow of benefits from the water resource development programme in terms of increase in crop and milk production. The flow of benefits from one typical water harvesting project of HCFP at village Bharauli in Raipur Rani of Panchkula district are presented.

Increase in crop production and net returns

In the 96.46 ha. of the command area of Bharuali WHD, the wheat crop yield increased from 18.35 to 30.80 $q.ha^{-1}$, wheat straw for livestock from 1225 to 1875 quintals and net income from just Rs. 43245 to Rs. 204104 in a period of one year due to the availability of irrigation water from the water harvesting dam. The area under onion crop increased from 1.61 to 2.08 ha., crop yield from 229.7 to 295.5 $q.ha^{1}$ and net returns from Rs. 60569 to Rs. 97022 in the same period. In case of radish seed production, the area increased from 13.08 to 15.68 ha., yield from 5.33 to 7.50 $q.ha^{-1}$, total production from 69.72 to 117.6 quintals and net returns from Rs. 11721 to Rs. 69196. The real miracle happened in case of cauliflower seed production where area increased from 0.25 to 2.40 ha, crop yield from 4.16 to 4.93 $q.ha^{-1}$, production from 1.04 to 11.83 quintals and net return from Rs. 7731 to 98010 between 2001-02 and 2002-03. A similar trend was noted in carrot seed production. Bharauli farmers got assured price in case of vegetable seed production as they entered into contract farming with a firm that supplied seed material and purchased produce at pre-decided rates. Similarly, the production of barseem as green forage increased from 358 to 888 quintals. Some fallow land was levelled and brought under the plough. The overall net income from Rabi crop raised over an area of 84.5 ha. jumped from Rs. 127820 to Rs. 631046 in the first year and got stabilised at this level during the second year.

The net return from maize crop increased almost three times. The area under forage crops also increased from 17.5 to 21.6 ha. The net return from Kharif crops

rose from Rs. 108115 to 307700. It was possible to have a third crop of summer fodder for the first time over an area of 2.85 ha. The overall net return form the command area increased from Rs. 2.36 to 9.73 lakh in one year. The interest in land development increased and so did on-farm employment opportunities for landowners and landless.

Increase in milk production

Livestock is an important asset of the local community, but scarcity of forage was restricting milk production. The availability of green forage helped in increasing the milk yield of cows from 1.8 to 2.21 and that of buffaloes from 2.55 to 3.65 litres/day and overall production from 669 to 837 litres/day. Buffalo, the most favoured milch animal, is reared by all households including landless and constitute about 68 percent of the total livestock. Though the number of buffaloes decreased from 233 to 207 (as a few families shifted their buffalo to a nearby town), the number of young she-buffaloes registered an increase from 117 to 186. Many families reported that mortality rate of offsprings has reduced with better feed and aftercare.

Cost-benefit analysis

The cost-benefit analysis of WHD Bharuali, taking a period of 7 years with 3 years actual and 4 years projected data, revealed a BC ratio of 1.22:1 and internal rate of return of 14%. The break-even curves showed that the cumulative cost and cumulative income are levelled off in a period of 4 years, thus showing that investments made are recoverable from increased production in a period of 4 years.

GENDER AND EQUITY

Most water resource development projects ensured quick and substantial flow of benefits. However, gender and equity issues were not well addressed. Conscious of the above realities, the HCFP attempted to address gender and equity concerns. The highlights are:

- In the VRMC's, the position of vice president and 30% seats in executive were reserved for women. Scheduled castes were given one seat as office bearers.
- Women link workers were engaged from the villages to improve participation of women.
- In all the meetings, women were invited, given respect and their views were solicited.

- In most project functions, women outnumber men and they freely convey their views. They are gradually opening up and hesitations are fading away.
- Migration of men with livestock used to put lot of inconvenience to women. This has been totally eliminated after the project.
- Earlier, large number of women used to go to the forest for fodder and fuelwood collection inviting wrath of forest officials.
- Women now spend more time on their farms helping men in cultivation operations. Most bring green fodder from fields rather than forest.
- As open grazing is getting replaced by stall feeding, livestock care now consumes more time.
- All landless families keep livestock, get some land on rent and raise their own fodder crop.
- Earlier landless used to buy wheat straw, from outside like other villagers. Now it is available right in the village. Quite often they give manure and take wheat/maize straw adopting barter system.
- In addition to gainful employment on dam construction, most of landless are in demand as farm labourers. Earlier, many used to go to nearby towns for work but now sufficient work is available at the farms of the village.

Farmington *et.al.* 1999 provided an exhaustive review of participatory watershed development in India and made recommendations on poverty and gender for a new generation of watershed projects. The HCFP has taken due precaution and steps to address the ownership, equity and gender concerns as indicated below for Bharauli project:

- Dam was made after following complete social development process. After long discussions and PRA a demand driven and need based, microplan was prepared.
- Communities generated a social fund of Rs. 55000/- before the system was made operational.
- The digging and filling of pipeline was carried out by the VRMC.
- Water is shared by all households. Landless are also given share of water.
- Reservoir water was democratically auctioned for Rs. 18000 in first, Rs 35000 in second and Rs.35600 during third year to persons of Bharauli with commitment to pay 50% in advance, charge water rent @ Rs. 10/hr and maintain the system during the tenure of the contract.
- Society is registered and account opened in a Bank.

- Auction of stones from river bed of the Panchayat land stopped by the Panchayat.
- Social fencing is enforced by the VRMC.

The same procedure and strategy was followed with successful results in village Mirpur, Kaimbwala and other 12 dam project villages. The impact assessment studies indicated that the water harvesting projects initiated by HCFP in Haryana Shivaliks have definitely increased flow of benefits to the community as a whole, reduced risk of floods and droughts and regenerated denuded forest catchments. Such a progress could be rated as highly satisfactory. The VRMC's were provided an opportunity to own, manage and maintain the assets. The assessment of their performance could be rated as “satisfactory ". However, satisfactory results could not be achieved on gender and equity front. In fact this in itself is a full time job and lot more needs to be done. The changes are sweeping across project villages and signs are positive. The lessons of experiences are being incorporated in the new projects after detailed deliberations.

REHABILITATION OF VILLAGE PONDS

The village ponds were built to harvest and store rainwater to meet variety of village needs. These ponds were renovated by community efforts. Consequent upon tap water supply and installation of hand pumps, the ‘*Johads*’ gradually became redundant and now are in a state of neglect and disuse. The village institutions that used to organise desilting through voluntary labour and guard the ‘*Johads*’ against pollution have collapsed and these ‘*Johads*’ have become garbage dumps and breeding grounds for mosquitoes. A baseline study carried out by the HCFP identified the degradation of ‘*Johads’* as one of the most serious environmental problem in the project villages. The HCFP obtained the services of an NGO-named Action for Food Production to prepare a participatory action plan for rehabilitation of 18 ‘*Johads*’ in Hisar, Fatehabad and Sirsa districts. So far, 11 ‘*Johads*’ have been desilted, renovated and rehabilitated. The highlights of community participation are:

- All families of the village contributed @ Rs. 10 each as membership fee to become members of Johad management committee.
- Through voluntary efforts organised by this committee, villagers laid a pipeline from the nearest source of canal to bring water to fill the ‘*Johads*’.
- Since project provided limited funds for this purpose, any additional work felt necessary was done by the community.

- All around the '*Johads'*, plantation of indigenous tree species was carried out by the people and project supplied the saplings.

  The rural communities are satisfied with this project intervention and are taking responsibility for the maintenance of the renovated '*Johads*'.

MANAGEMENT OF SOCIAL FUND

Regular collection of water rent by the VRMCs or Water Users Association (WUA) has always been a problem. Even at Sukhomajri, Nada, Bunga and several other successful projects, the problem of collecting water rent persisted. Many beneficiaries wanted water on credit and frequently defaulted. Whenever executives were changed, the new executives wanted that previous accounts are settled by recovering arrears of water rent. But it never happened. There was no mechanism to extract water rent by force. The accounts of the societies were never audited. The cases of exaggerated billing, unauthorised expenditure on unrelated items, delay in depositing cash in bank accounts and misappropriation frequently came to notice. Regular meetings were not held to settle the issues. The visits of project staff are reduced as they move to new project location. The office bearers of WUA are neither much educated nor well trained in account keeping. No rumenerations are paid for such voluntary jobs. Serious thinking is required to improve the financial management by social institutions.

The communities themselves devised a way out to solve the problem to some extent. A system of auction of reservoirs every year to a local contractor of the village was devised. The contractor pays part of auction money in advance and balance in installments. He collects the water rent at a rate approved by the VRMCs. Many VRMC's laid conditions of contract specifying period of lease, limits of rent, payment schedule and maintenance during contract period. Problems related to transparency still persist and appropriate solutions are still not visible. In the state of Uttaranchal, the World Bank has just agreed to fund a watershed development project, which shall be executed through village panchayats.

Execution of works through social institutions

In the second phase (1995-2005) of Integrated Watershed Development Project (IWDP II) funded by the World Bank in five states of north India, a provision was made to empower the social institutions to such an extent that they may be able to execute common works in forestry, soil and water conservation and rural infrastructure sectors. The Village Development Committees (VDC) acted as local contractors and savings made in this venture were credited to their social fund. The condition of calling tenders was waived off to facilitate VDC's to

undertake works in their own village. The sites for soil and water conservation works including water harvesting dams/ponds/base flow harvesting/ check dams are decided by joint inspection by technical officers and community representatives. The plans and estimates were prepared by project staff but execution under the supervision of staff is carried out by the VDC's. Some advance payment is made to start the work. The payments to VDC's are made on the basis of actual measurements recorded by the staff. It is good that involvement of the social institution in execution helps to enrich the social fund and chances of future maintenance improve. However, some VDC's tend to show more expenditure than actually incurred, delay the works as they want to do it during spare time and thus tend to compromise the quality to increase their savings. Some VDC's sub-let the works to small local groups to avoid devoting time and energy and, therefore, ignore responsibility. A clear picture is yet to emerge. There are conflicting views about the practicability of this procedure.

ROLE FOR SOCIOLOGISTS AND NGO's IN COMMUNITY PARTICIPATION

As the strategy for community participation and local governance gained strength, the funding and implementation agencies put on board the services of sociologists in the programmes. For example in case of IWDP (hills) the project management was shifted from water to rural development sector in the World Bank office in New Delhi. In the project states social development co-ordinators and women facilitators, having sociology as the main educational qualification, were recruited. Special consultancy services were offered to sociologists to strengthen the community participation work. Several workshops, study tours, training courses were organised by the sociologists for the technical staff to bring change in their mind-set and motivate them to absorb the changes sweeping the country in favour of community participation. The need of NGO's is well recognised, to work as an interphase between government departments and the people and help in community organisation. A commendable work in water resources development has been done by several NGO's. Yet conflicts frequently reported between NGO's and Govt. departments at the local level need to be amicably resolved as the root cause in most cases appears to be related to ego and personality clashes.

In conclusion it is stated that community participation is necessary for sustainable management of water resources developed at scattered locations in remote rural areas. The participatory process is being developed and refined by gaining practical experiences through a variety of projects. The mindset of staff is changing in favour of participation. The benefits of

water resources development have percolated to small farmers and additional employment opportunities have been created. The cost sharing is gradually being accepted as a project requirement. However, much could not be done on improving equity. Benefits of income generating activities remained limited to only selected families. Football/candle/namkeen making are not related to watershed generated products. The concept of agro-industrial watersheds is still missing. The scope is better in dairy, vegetable seed production and value addition wherever possible. Further strengthening of social institutions is needed by developing institutional framework at block, district and state level. The linkages with Panchyati Raj institutions need to be carefully worked out.

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