HARYANA COMMUNITY FORESTRY PROJECT

VEGETATION STUDIES IN THE CATCHMENTS OF WATER HARVESTING DAMS

SUBMITTED TO

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EXECUTIVE SUMMARY

The Haryana Community Forestry Project constructed 19 water harvesting dams (WHD's) in the Shivalik foot-hill region of the sate between 2000-01 and 2006-07 adopting participatory watershed development approach. The main objective was to provide the facility of supplemental irrigation to rainfed crops thereby improving crop and mere production of resource poor farmers and tie-up their economic interest in forest protection. Since forest catchment characteristics like vegetations cover, soil and slope conditions and biotic pressure determine the water yield and rate of salutation of water storage reservoirs, it was decided to carry and vegetation studies in the catchments of five representative WHD's. The base line status of vegetation of cover before the construction of WHD's was established by laying out 10m x10m sample plots on upper, middle and lower slopes where tree and bush density, grass yield, litter accumulation, soil pH, Ec and organic carson were recorded. These observations were repealed after a lapse of 3 to 4 years after the base line during which local communities protected the forest catchments of the WHD's.

A pilot study was first carried out for Bhmanli and Brahimpur WHD's and subsequently three more sites namely

Rana/Miripur, Bhediwala/ Turon II and Nanheri were take up for base line and final survey. The catachment area of 54, 46 and 146 hectare on these three dams was divided into micro-catchments from where 27,27 and 54 sample plots were laid for the study. The base line survey was carried out in May 2005 and the find 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 base line survey have already been reported. The results of the final survey and salient changes in the vegetation and soil properties are summarized in this report.

The mean free stocking before and after the project in the forest catchment of Rana decreased from 1550 to 1540 (0.65%), Bhediwala from 789 to 700 (-10.0%) but increased from 1302 to 1420/ha (1%). The marginal decrease in Rana was due to morality of planted Khair and Bhediwala due to cloud burst which caused lot of landslides, mortality of young stock and continued grazing pressure. Though some plots in Nanheri were affected by forest fire but trees regenerated thereafter. All tree species gained diameter, height and crown cover as number of trees in lower girth classes increased in a period of 2.5 years height/cover classes decreased and number of trees in higher. The catchment of Rana and Bhediwala are dominated by but by shall 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 Nanhari. Bush density was more (Bhediwala) when tree stocking was relatively less. By and large bush cover was higher on lower hill slopes as and compared to dry and desiccating upper hill shapes.

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 Nanhari catchment, respectively. While Bhabar and Dholu grass dominated Rana forest, Dholu alone in Bhediwala and Bhabar, Dholu and Sarala in Nanheri.

The leaf litter accumulation (a combined index of vegetation cover) registered an increase 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 Nanhari.

The soil moisture content both in upper (0-15 cm) and lower (15-30cm) soil depths registered an increase in all the three hill shapes of all the three catchment. The increase was more in lower soil depth as compared to surface soil.

The overall soil pH increased in both 0-15 and 15-30 cm soil layers and Fc showed decreasing trend at all the three catchment. The overall organic carbon decreased from 0.35 to 0.21%, from

0.61 to 0.33% and from 0.48 to 0.16% at Rana Bhediwala and Nanheri catchments. The loss of soil humus with run off water appears the probable reason this trend.

The soils in Rana are heavy textured, medium in Bhediwala with high percentage of gravel 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 land slide prone area is 30% in Rana, 20% in Bhediwal and 10% in Nanheri. Four soil conservation structures have been constructed in the catchment of Rana by the HCFP, three in the catchment of Bhediwala by Kandi project but non in the catchment of Nanheri. As per the silt-loads generated, there is a need of biological and mechanical measures to further reduce the situation 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 from lands due to the facility of irrigation have reduced dependence on forests for grazing but some landless families stealthily take live stock to catchment areas.

Fe trees from sample plots were either cut for fuel wood or for feeding to goats by goat grazers. This practice has drastically reduced but not totally eliminated from forest catchments.

CONTENT

CHAPTER - 1

INTRODUCTION

The Shivaliks of north India covering 4.2 million hectare foothill areas of five states are considered as one of the few most degraded ecosystems of the country. The process of degradation triggered by poverty and resource starvation started about 170 years ago and continued unabated and defied solution. The principal land use in Shivaliks is rain fed agriculture in valleys and natural forest and pastures on young, loose friable mud hills which have weak geology and are highly prone to soil erosion. Once the protective vegetation cover is destroyed by grazing, illicit cutting and forest fires, severe soil erosion cause gullies in loose strata. The erratic distribution of monsoon rainfall lack of irrigation facilities, soil fertility depletion, severe soil erosion, small and fragmented holdings. scarcity of food fodder and fuel have made people heavily dependent on forest which were recklessly destroyed. Major part of precious rainwater ends into runoff causing downstream floods. A cycle of poverty and degradation continued with downward spiral.

The solution of this problem emerged from Sukhomajri project where rainwater harvesting from forestland by constructing a 12 m high earthen dam in 1978 stabilized rain fed agriculture through supplemented irrigation and also increased milk production because of the availability of green fodder from farm lands. This project tied

up the economic interest of the communities, which were organized as water users' cooperative with protection of forest catchments, which provided life saving water to meet multiple needs of the people. This model was replicated on a large in the Haryana state.

The Haryana Community Forestry Project (HCFP) supported by European Union having time frame of 10 years from 1998-2008 aimed to increase forest cover in the state by innovative community participation programmes. This project also proposed to construct 19 water-harvesting dams (WHD's) in the Shivalik region adopting participatory approaches of watershed development. All these water harvesting dams (WHO's) have already seen constructed between 2000-2001 and 2006-07.

By design, the HCFP has been following a very systematic approach of implementation where project strategies were designed on the basis of comprehensive studies and strong database. In pursuance of the same strategy, the HCFP first got an evaluation study of two WHO's namely Ibrahirnpur (Yamuna Nagar) and Bharouli (Panchkula) and after receiving positive recommendations, the work on other 17 WHD's was started. The project also aimed to evaluate the technical, social. economic and environmental aspects of these WHO's for which comprehensive base line surveys were carried out for each of the dam project which covers production status of command areas and socio-economic profiles of communities of the project villages.

In the design of WHO's, the water yield is estimated from the catchment area, mean annual monsoon rainfall and runoff co-efficient which is jointly influenced by number of catchment characteristics. However, the most prominent are the vegetation cover nature and properties of soils, physiography (slope, drainage, elevation difference and drainage density). The run off co-efficient values of 0.25 to 0.35 were taken which implies that 25 to 35 percent of monsoon rainfall shall be converted into runoff. The runoff actually received against the anticipated is seldom worked out because data about vegetation cover development and important watershed characteristics are seldom compiled.

Secondly, in the participatory watershed management. it IS implied that local communities would protect the forest catchments yielding runoff to the reservoirs of WHD's. As the catchments are protected against grazing, illicit cutting of trees and bushes and other biotic interferences, the condition of vegetation cover improves gradually which influence watershed hydrology. The studies of such changes upon protection are seldom attempted and this information gap trades in arbitrary assumptions. Hence the need of generating information on changes in vegetation cover complexes for better planning and designing of WHD's.

Since the characteristics of the forest catcments determine the sediment and water yields to reservoirs, hence, studies of catchments were also proposed in the project. In line with these

objectives, the base lines were established by a comprehensive catchment study conducted in 2000-01 for Bharauli and Ibrahimpur WHD's. The final vegetation survey was carried out in October-November 2005 which provided a valuable information about catchment characteristics and changes in trees, bushes and grasses in a period of 44. On the same analogy, three more catchments namely Rana/Mirpue II, Bhediwala/turon II and Nanheriwere selected for baseline survey carried out in April-May 2005. The final catchment study following the baseline methodology was conducted in October-November 2005. The TOR of this study is annexed for ready reference.

The main objective was to carry out evaluation of forest catchment areas of Rana (Mirpur II), (Turou II) and Nanheri dams for which baselines were earlier established in May 2005 and assess the changes in vegetation cover (Trees, Bushes, Grasses, Litter) and changes in some associated properties. The dams in these tree projects were constructed studies both as base line and final in these projects was awarded to the society for promotion and conservation of environment (SPACE), a Chandigarh based NGO of professionals. The results of the final study and changes observed over the baseline are presented in this report.

It is worth while to mention that the original structure and format of the baseline report. Has deliberately not been changed. Only additions, alterations and new information has been

incorporated such that this report or serve the purpose of base line for any future study on vegetation cover complexes. The logic behind this formatting of stems from the fact that due to paucity if time the baseline survey was done in April-May 2005 and final survey in October-November 2007, i.e., hardly after 2.5 years which is too short a period for discernable changes. Moreover October-November is considered the best time for vegetation surveys in forest areas. This report, therefore, presents information on changes observed over baseline in a period of 2.5 years.

CHAPTER – 2

METHODOLOGY

It was pre-decided that for the impact evaluation study of the vegetation cover in the catchment area of Rana, Bhediwala and Nanheri WHD's the same methodology and procedure shall be followed which was followed in the study of Bharauli and Ibrahimpur. This is necessary because the same sample plots shall have to be revisited to capture the cover complex changes over their base levels. The same set of observations were repeated during the final impact assessment study t-o-be carried out in October-November, 2005. In case of the catchment studies in the three WHO's namely Mirpurll, Turon II and Nanhari, base lines were established at the pre-project stage for comparison of vegetation covers at the post-project operation. This, therefore, implies that two separate reports shall be prepared one for post-project evaluation and second for base lines for three new WHO's i.e. Mirpur II, Turon II and Naniheri indicating the vegetation status at pre-project stage. The present report pertains to the post-project part of the study.

SELECTION OF WATERSHED FOR STUDY

As per the spread of 18 sites of WHO's in Panchkula, Ambala and Yaumana Nagar districts: one site at Bharauli was selected for study which could represent Banswala and Kambwala as these three sites are located in one cluster having single drainage system (see

map). The WHD at Mewas is bit isolated but could be considered with this cluster. In the next cluster of sites Mirpur, Rana (Mirpur II) and Mandappa are located which have the same drainage system out of which Rana (Mirpur II) was most representative and hence selected. In the third cluster located in Ambala district the WHD's at Turon I, Bhediwala and Dhandion are located in one drainage system and out of these Bhediwala was considered most representative. In case of Yamuna Nagar district five WHD sits at Thaska, Bhagwanpur, Nanheri, Nawangaon and Kathgarh are located in one range of hills having almost identical biophysical conditions out of which Nanheri being most representative was selected for the study. Out of two WHD sites at Ibrahimpur and Kansli, the catchment study of Ibrahimpur presents the situation of this area.

SELECTION OF TRANSECTS

In due consideration to adequate representation to the catchment area, it was decided to allocate 27, 27 and 54 sample plots of 10m x 10m each to three catchment having 55, 46 and 145 ha of forest watershed as contributing area in Rana, Bhediwala and Nanheri, respectively (see TOR annexed). In order to give representation to lower, middle and upper hill slopes having variable vegetation cover, it was decided to lay three plots in one selected transect. In order to give representation to all the aspects in a given catchment. transects were systematically laid by selecting one out of three drainage channel (creek) along which set of three plots were

laid. A care was taken that in 9. 9 and 18 transects (three plots on each transect would make 27, 27 and 54 plots) so selected almost all aspects and cover conditions were given due representation. Here a system of replication and randomization was followed to carefully avoid the chances of any bias.

OBSERVATIONS

A performa was designed to collect information from a sample plot about aspect, location on transect, soil, slope, possible influences in forms of nibbling cutting, lopping of trees etc, dropping of cattle/wild life. A complete enumeration of trees with height, girth, age cover was carried out from each sample plot. The bushes were counted and divided into height classes. The grasses were harvested from 1m x 1m plot and divided into two categories i.e. bhabar as commercial grass and forage grasses. Their green and air-dry weight was recorded. Leaf litter was careful.; collected from 1m x 1m plot and its fresh and air-dry weight was recorded. Two different set of soil samples were collected from 0-15 and 15-30 cm depth, one in moisture boxes to find out soil moisture content at two depths and other set of two samples was collected in poly bags for pH, EC and organic carbon analysis. These soil samples were processed as per standard techniques. The basic characteristics of the three watersheds were worked out using 1:15000 survey sheets and data so generated was tabulated. The comparative size, shape and

orientation of three catchments drawn from 1:15000 forest sursery survey sheets are given in with data from each catchment.

While traversing the catchment area, general observations were made about the vegetation cover distribution, biotic influences, wild life, characteristics of the drainage system, extent of soil erosion problem, sediment transport and chances of siltation of reservoir. The important characteristics of three catchmets are given in Table 2.1.

Table 2.1.1: Important watershed characteristics of three study sites.

Watershed characteristics	**Rana**	**Bhadewala**	**Nanheri**
Catchment area (ha)	54	46	145
Runoff coefficient (value)	0.35	0.30	0.30
Expected water yield (ha-m)	18.90	13.80	43.50
Designed water yield (ha-m)	18.34	13.82	29.97
Percent of rainfall harvested	100	100	69
Mean length (m)	1200	1200	2010
Mean width (m)	450	380	725
Length/width ratio	2.7	3.2	2.8
Peripheral length (m)	3360	2740	5580
Length of main drainage line (m)	1410	1270	2151
Total fall (m)	90	110	241
Mean slope (%)	6.4	9.7	11.2
Drainage density (km/km^2(	7.6	8.2	3.1
Soil type	Silty Clay	Gravelly loam	Sandy loam
Slope in drainage line	Moderate to steep	Steep to v. steep	Very steep
Aspect	South West	West	South
Calcareous patches (%)	20	5	5
Soil erosion	Severe	Severe	Moderate
Landslide area (%)	30	20	10

CHAPTER – 3

CATCHMENT STUDIES IN RANA MIRPUR II WATERSHED

GENERAL OBSERVATIONS ABOUT THE CATCHMENT

The position of dam, water storage reservoir, self detention structures and drainage pattern is thrown in figure 1.

- The forest catchment is dominated by heavy soils like silty clay, silty clay loams with bands of sand stone. There are vertical cliffs and landslide areas devoid of any vegetation. The calcareous patches are located on hilltops where there is no grass and only patchy/sparse vegetation thrives.
- The area is dominated by Khair (*Acacia catechu*) scattered natural trees of *Acacia modesta* and introduced trees of mesquite (*Prosopis juliflora*). The natural regeneration of Khair and mesquite is common. In some pockets, Khair has been planted by the *kandi* project particularly on lower and middle slopes.
- The bushes are mainly of Lantana and Karonda while Kana is found along the main gully.
- Bhabar and forage grasses are found in lower, middle and upper slopes. Natural regeneration of Bhabar and seasonal legumes was also noted particularly on lower slopes.

- Grazing and fuel wood extraction are not very serious problems but geological strata is heterogeneous and prone to soil erosion. All along the main gully, there are Thalis relatively flat patches on both the sides, which have deposited soil over which Khair has dominated.
- There are series of dry stone check dams in creeks, many of them are functional but few have breached from sides. These structures have stabilized the gully beds and grass and mixed vegetation has come in the drainage lines.
- Though, there are steep slopes in the second and third order gullies but the main gully is having moderate slope. It was calculated from the contours that the slope in third and second order gullies is 27.0, 17.6 percent but 6.4 percent in upper areas of main gully. Only 1.3 percent slope was noted in lower 500-metre length of the main gully. This is a favourable situation as mild slope in the gully just above the dam has increased the opportunities of more water storage. There is a big flat bowl just above the reservoir, which has increased the storage capacity of this reservoir.
- In order to trap sediment above the reservoir, three check dams were constructed in the side gullies and one large size crate – wire structure was built in the main gully above the submergence area.

RESULTS OF THE STUDY

This watershed as a whole drains towards west direction but sample plots were located on different aspects (Table 3.1). The general slope is moderate to steep put in few patches the slope is very steep. The soil depth is generally shallow where rill and gully erosion is very common. The excreta of wild animals was 16 out of 27 plots. The plant damage by nibbling and branch cutting was noted in 5 out of 27 plots. Branch cutting was common along commonly used foot pal. The vegetation cover is sparse in 10, moderate in 14 and thick in 3 plots out of 27. The free species are dominated by khair both planted dark tree stock density and natural.

TREE STOCK DENSITY

The overall tree stock was 1267, 1588 and 1766 trees/ha with both planted and natural khair having 803, 1176 and 1244 trees constituting 63.4, 74.1 and 70.4 percent of total stock in upper middle and lower hill slopes (Table 3.2). The entire stock of natural khair natural trees fall in 0-15 cm girth class but planted khair trees are well distributed in lower three girth classes but majority of trees were in 15-30 cm girth. There were 33 trees/ha in upper and 11 trees/ha in lower slope having girth more than 60 cm. There were very few trees of neem (Azadirach indica) and chall (Anugoisus latifolia) and Papri. Roughly one third of total trees were of miscellaneous type i.e., 444, 333 and 467 trees/ha on upper middle and lower slopes. The majority of these miscellaneous trees were in

0-15 cm girth class. These was high mortality in younger plants but the same was compensated by new recruits of all most equal number.

The majority of natural khair trees were in 0-2 metre height class but planted khair trees variously distributed in 2-4m, 4-6m and more than 6m class but majority of other miscellaneous trees remained distributed in 0-2 and 2-4m height classes (Table 3.3).

As expected most natural khair trees were having crown cover up to $2m^2$ but planted kahir trees were distributed in lower three crown cover, classes (Table 3.4). Most of neem, and papri trees fell in crown cover class $0\text{-}2m^2$. The majority of miscellaneous trees species were also in the same cover class. The number of mesquite trees (prospis juliflora) increased and natural regeneration was noted particularly in upper bore areas.

Shrub Density

The over all shrub density of 6109, 6766 and 6787 bushes was recorded in upper, middle and lower hill slopes with Lantana, Karaunda, curry patta as predominant bushes of the area (Table 3.5). Most of these bushes have height up to 2 metres. Basuti is conspicuously absent from this catechment. About a dozen miscellaneous bush species were noted which were well distributed in almost all the plots. Data reveals that roughly 41 percent of the catchment area is covered by bushes. The sharp increase in bush density appears responsible for elimination of younger tree seedlings.

Grass Cover

Dholu and Bhabar are the two predominant grass species of this area (Table 3.6). The mean number was 24.55, 27.00 and 37.33 clums per square area of upper, middle and lower will slopes.

The overall vegetation cover complex of this watershed comprises of khair, lantana, karaunda, curry patta, bhabar and dholu plant species.

Leaf Litter Biomass

The leaf litter biomass of 27.22, 22.44 and 20.77 q/ha was recorded from upper, middle and lower hill slopes.

Grass Biomass

The mean air dry grass yield of 22.11, 96.77and 48.30 q/ha was recorded from upper middle and lower hill slopes.

Soil Properties

In the upper hill slopes, the soil texture was loamy sand but silt loam in middle and lower hill slopes. The average soil pH was 8.1, 8.3 and 8.3, Electrical conductivity as 0.18, 0.18 and 0.17 dsm^{-1}, organic carbon was 0.21, 0.21, 0.24 percent, P_2O_5 as 17.1, 18.10 and 18.20 and K_2O as 72.25, 73.14, and 75.41 kg/ha and soil moisture as 6.42, 6.91 and 6.34 percent in 0-15 cm soil depth in upper, middle and lower hill slopes. In case of 15-30 cm soil depth,

the soil texture was loamy sand in upper and silt loam in middle and lower hill slopes. The mean soil pH was 8.1, 8.4 and 8.5, Ec as 0.17, 0.17 and 0.20 dsm^{-1}, organic carbon as 0.17, 0.19 and 0.23 percent P_2O_5 as 13.7, 15.7 and 17.4 kg/ha^{-1} and K_2O as 64.36, 77.89 and 79.71 kg/ha^{-1} and soil moisture as 7.23, 8.06 and 7.51 percent in upper, middle and lower hill slopes.

CHAPTER – 4

CATCHMENT STUDIES IN BHEDIWALA

General Observations About the Catchment of Bhediwala WHD

- This catchment is full of coarse particles like round bhajri and boulders in whole area even on vertical cliffs. The drainage lines have steep slopes and gully beds are filled with large size gravels, which are getting pushed to the main Nala. This is the reason that in whole of the revervoir area, there is about a metre thick layer of stones below which heavy soil is imbedded. The soils are gravelly medium textured sandy loam and loams. One does not find patches of heavy silty clay soils in the catchment.
- There were 4 drop structures in the lower part of catchment each having drop varying from 2 to 3 metres. These were constructed by the Kandi Project and all had silted right up to the top. At the time of dam construction, two structures came in submergence area. Two just on the periphery of reservoir and one for silted. However, above each structure, there is good moisture in the deposited debris and as a result mix vegetation has come up in the bed, which is further arresting sediment. One strong masonry dam of 4m height is located in one of the main gully and is also fully silted.

- The lower area all around the reservoir was planted to Khair during the last 2 years. The survival is good and the entire area is likely to be full with Khair in the next few years. The upper areas support large number of fully grown chall trees.
- At places creepers (glow) have spread over the chall trees and lot of leaf litter is being produced by the creepers.
- About 20% area is covered with vertical cliffs, which are stable. There is no flat land in the entire catchment.
- As such, there is no vegetation in the Nala bed because of steep slope and high velocity of over flowing water.
- There is sufficient stock of trees and bushes but grazing continues. We noted 15-20 cows grazing in the catchment almost daily. This is supported by their excreta also.
- There is no wetness in gullies nor any springs. The very name Suka Nala shows that the bed is dry.
- No recent forest fire was noted.
- Longoor in large number, wild goat and lumbri were seen in the area. This was also confirmed the droppings and pug manes near the water body.
- A cloud burst occurred on 03/08/07 which caused extensive damage and caused land slides. Large size trees on banks were uprooted. The stones and land flow to lower areas in the heavy storm not only filled the reservoir but spillway functioned and its lands portion was damaged.

- There is not much infestation of Lantana in his catchment but Karonda is most abundant.
- The loping, cutting and nibbling is very common in areas close to the village which shows pressure of fuel wood extraction. Grazing was a problem for 3 to 4 months but in rest of the period, the livestock was taken to riverbeds for grazing. Cattle migration was common in this village. But after dam construction, cattle migration has been reduced considerably and this is leading to grazing pressure in areas close to the reservoir.
- About 90 percent area is fairly well covered with vegetation and there is leaf litter on the ground. The gullies were more or less stable but the cloud burst of August 2007 destabilize the entire area. The chances of siltation of the reservoir were low, but one heavy storm pushed lot of sediment closer to the water body which ultimately would go to the submergence area.

RESULTS OF THE STUDY

This forest watershed as a whole drains from east to west but sample plots are located on different aspects. Out of 27 sample plots, nineteen were located on steep, six on moderate and two on very steep slope (Table 4.1). The soil depth in all the plots was shallow as most of topsoil was washed due to severe soil erosion. Where the slope was moderate, sheet and rill erosion was more common. On steep slopes, rill and gully erosion was prevalent and on very steep

slopes, the whole area is converted into deep gullies. The indications of grazing were visible in 50% of the sample plots. The excreta of wild animals or pug marks were observed in 22 plots out of 27. Damage to plants by nibbling, and branch cutting was observed in 8 plots. The vegetative growth was spare in 11 and moderate in 16 plots. There was some khair plantation work carried out during 2004 in areas close to the reservoir and those saplings here picked up good growth.

Tree Stock Density

The overall tree stock of 700, 766 and 633 trees/ha was recorded out of which 433, 245 and 266 trees/ha were of kahir forming and 61.9, 32.0 and 42.0 percent trees of khair in upper, middle and lower slopes (Table 4.2). The majority of khair trees were planted and very few established through natural regeneration. The entire stock of khair trees was in 0-15 cm girth class. There were very few neem and papri trees and almost all of them were in 0-15cm girth class. Chall trees were noted in some plots, which also constituted of few fully nature trees have girth above focus. The majority of miscellaneous tree species were also in 0-15cm girth class, but few trees were also of higher girth classes. Younger seedlings of khair and miscellaneous species recorded high mortality.

The entire stock of planted and natural khair trees were in 0-2 meter high class (Table 4.3). So was the case of papri and neem trees but chall trees were present in some plots had medium height. Few

trees of chall and some miscellaneous trees species crossed six-meter height. Few large size trees of Bohr are present in the catchment.

The majority of trees recorded in the sample plots had crown cover of 0-2m^2 (Table 4.4). Only few trees of chall and few of miscellaneous type trees had crown cover varying from 2 to 6m^2. As such, trees species have provided ground cover varying from 10 to 15 percent of the total area.

Shrub Density

Bhediwala catchment is having almost half the number of trees as compared to Rana watershed but have more than double the number of bushes. The Lantana infestation is much less in the catchment. Almost half of the number of bushes are of Karaunda which were almost uniformly distributed in all the three slope classes. Their numerical strength was 5466, 4655 and 5878 bushes/ha in upper, middle and lower hill. The stock of curry patta was, however, 2011 bushes/ha in upper, 3055 bushes/ha in middle and 3755 bushes/ha in lower hill slope. Similar was the trend in the distribution of Basuti which were 66, 366 and 1044 bushes/ha in upper, middle and lower hill slopes. The bush dominance was much more on lower slopes which are more moisture. There was a good mix of miscellaneous types of bushes which were well represented on all the three slope classes. The majority of bushes of all types was in 0-1 m height class. Bushes like Karaunda, Curry Patta and miscellaneous types had sizeable number in 1-2 and above 2m heigh

classes also. The overall bush density increased from 8577 to 11032 in upper, 8977 to 10865 in middle and 11580 to 14777 bushes/ha. Upper, middle and lower slopes thus registering an increase of 28.6, 21.0 and 27.6% respectively.

Grass Cover

The grass cover was devastated by the grazing cattle during base line survey. Dholu was the only grass which was holding the ground. The catchment remained assessable to restore from August to October 2007 as water body covered all routes to the upper areas. As a result the mean number of grass clumps increased 5.33 to 9.44, 4.79 to 8.33 and from 4.88 to 8.44 per square metre and registered on increase of 77, 75, 73% in a span of 2.5 years, in upper, middle and lower full slopes (Table 4.6).

Leaf Litter Biomass

The mean leaf litter biomass was 13.44, 21.00 and 19.89 q/ha in upper, middle and lower slopes of the watershed. There were creepers in some plots which could not be counter because of larger spread across several plots, but such creepers contributed to litter biomass.

Grass Biomass

The mean air dry grass yield was 23.91, 24.80 and 22.70 q/ha on upper, middle and lower slopes of the catchment.

Soil Properties

The predominant texture of soil is sandy loam in the entire catchment with mixture of gravels and pebbles. In the 0-15 cm surface layer of the soil, the soil pH was 7.6, 7.6 AND 7.6; Ec of 0.17, 0.17 and 0.17 dsm^{-1}, organic carbon as 0.29, 0.36 and 0.36% phosphorous (P_2O_5kg/ha) as 20.8, 25.4, and 25.6 kg/hr Potash (K_2O kg/hr) as 82.57, 113.70 and 103.78 kg/ha and soil moisutre as 6.5, 6.7 and 7.0% in upper, middle and lower slopes. In case of 15-30 cm soil depth the mean soil pH was 7.7, 7.8 and 7.7; Ec as 0.17, 0.16 and 0.17 dsm^{-1}, organic carbon 0.31, 0.33 and 0.32% phosphorous as 25.4, 23.7 and 24.7 kg/ha, and potash as 71.38, 78.10 and 96.92 kg/ha and soil moisture as 6.9, 7.1 and 7.3% in upper, middle and lower hill slopes. The soil moisture levels were much higher during the final survey done in October-November 2007 as compared to soil moisture level of base year when sampling was done in May-June 2005. The difference is because of low temperature conditions during the period of final study.

CHAPTER – 5

CATCHMENT STUDIES IN NANHERI WATERSHED

GENERAL OBSERVATIONS ABOUT THE CATCHMENT

The position of earth dam, water storage research and catchments area is shown is Figures.

- The nanheri WHD is located just on the border of Haryana and Himachal Pradesh. The dam body is in Haryana but major part of the storage reservoir and whole of forest catchment falls in the area of Himachal Pradesh. No soil conservation works were done in the catchment area and only one-hectare earth borrow area close to the dam was planted to Khair.
- Whole of the catchment area was reasonably covered with trees and bushes but forest fires have been common as most ground vegetation was resprouted from burnt up clumps. The trees did not have straight bole but most trees were twisted and tilted, mainly due to forest fires and lopping for leaf fodder.
- The lower one-third area of slopes mostly located along the main gully was full with Kana (*Saccharum munja*), which provided good protection against soil erosion. The landslips at two places were noted where the entire hill slope had slided down and vegetation had again come over the slided portion. Kana was dominated the land slip areas.

- As such there was no apparent signs of active soil erosion except 5 per cent area where heavy pink shales were seen exposed and this area was bare and yielding sediment.
- The entire length of main nala was full of rocks and large sie stones in which natural rock structures were formed which were holding the bed and not allowing to scour. The banks of nala were also consolidated and not much stream bank erosion was noticed except few critical areas. In the lower one-third length of Nala, Bhabar and Kana was coming up in the bed where deposition had taken place or site was bit moist.
- At several places small pools of water were noted in the Nala bed, thus showing the presence of springs, in upper areas.
- Soils in general are light in pockets and medium in most of the area. The soil quality for indicated vegetation is good as supported by termite mounds and burrows but forest fires negate the effects of vegetation cover development. The trees were only 5-7 metres in height and big trees were noticed only on relatively in accessible upper slopes. Chall an important fodder tree dominated the landscape and was heavily lopped.
- There were no signs of any livestock entering the area from upper Himachal side mainly because there is no habitation and steep slopes cover the outer fringes of the watershed.

RESULTS OF THE STUDY

The drainage system of this watershed as a whole drain towards true south but sample plots were located on different aspects. Most of the sample plots were located on steep and very steep slopes but few plots had fallen on moderating sloping piedmonts (Table 5.1). Due to rocky strata of hill slopes, the soil depth is generally shallow. Where sub-stratum is hard, the gully formation was not possible and hence only sheet and rill erosion was noticed. But in some pockets, hills are composed of loose and friable soil material where rill and gully erosion is prevalent. The indications of grazing were evident in all the plots. At the time of baseline survey but during the final study in 24 plots out of 54, no sign apparent grazing in final. Excreta of wild animals were seen in some plots but not all. The damage to the plants in the form of nibbling and branch cutting was partial in all the plots earlier but in final study no such signs were noted in 9 plots out of 54. In the remaining plots free lopping was noted.

Tree Stock Density

The mean tree stock density was 1294, 1189 and 1422 trees/ha in upper, middle and lower hill slopes of Nanheri forest watershed which changed to 1433, 1272 and 1556 trees/ha respectively thus registering an increase of 10.7, 7.0 and 9.4% respectively. Chall continued as the most common tree species respectively. While papli was totally absent, need also formed

relatively small function of the free store. Khair both natural and planted combined together formed 14.0, 15.3 and 13.9% of total tree stock on upper, middle and lower hill slopes. The miscellaneous tree species formed 32.2, 42.4 and 62.4 percent of total stock on respective slopes thus indicating that miscellaneous trees occupied the lower slopes where numerical strength of chall was relatively low. In case of all other tree species, the majority of trees were in 0-15cm girth class but in case of Chall, the trees were well distributed in 0-15, 15-30 and 30-60cm girth classes on all the three hill slopes (Table 5.3). The miscellaneous tree species were also distributed in various girth classes on all the three slopes.

As expected chall trees are well distributed in all the height classes. So was the case with miscellaneous tree species though maximum number of trees were in 0-2m height class. Most of the natural Khari was in 0-2m height class but planted Khair frees were distributed in all height classes.

The crown classification is almost identical to height class distribution i.e., maximum trees in 0-2m^2 class followed by 2-4m^2 class and very few in higher classes.

Shrub Density

The mean shrub density was 3650, 4355 and 4866 plants/ha which dramatically increased to 5921, 2991 and 6119/ha on upper, middle and lower hill slopes respectively (Table 5.5). Karaunda remained the most dominant bush having 53.2, 47.4 and 54.4

percent of total shrub population in upper, middle and lower hill slopes respectively. While Basuti and Curry Patta were totally absent, the Lantana and Kuri population was also very small. The miscellaneous shrub species accounted for 20.8, 29.4 and 25.0 percent of total shrub population on upper, middle and lower slopes. Most shrubs of Karaunda, Kuri and miscellaneous species were well distributed in 1-2 and 72m height classed but the number remained highest in 0-1m height class. Forest fires do not eliminate the bushes but their height classes may keep on varying because of burning.

Grass Cover

There were 26.0, 27.0 and 30.9 number of grass clumps/m^2 area out of which Bhabar and Dholu constituted 40.9 and 33.1; 42.7 and 32.7; 39.9 and 33.0 percent on upper, middle and lower hill slopes (Table 5.6). Bhabar and Dholu were, therefore, most dominant grasses in this catchment. The number of Dub, Khabal and other miscellaneous grasses was relatively very small. However, sarala grass which was in very small number earlier registered a phenomenal increase on all the three hill slopes. It appears that small decrease in the proposition of Bhabar and Dub grass has been compensated by Sarala grass. Incidentally, light canopy of chall and its extensive lopping during winter allows sufficient light on forest flow, which promotes adequate grass growth in the under storey. The dominance of light crow karonde bush which dominate this

catchment his also synergic effect on grasses because its thorny branches tend to keep away the grazing animal.

Leaf Litter Biomass

The mean leaf litter biomass was 13.53, 11.72 and 10.33 q/ha in upper, middle and lower hill slopes. Which increased to 17.5, 17.36 and 19.72 q/ha respectively. The litter biomass in this catchment was lowest as compared to Rana and Bhediwala watersheds perhaps because of forest fire which occurred two years before the baseline. However, there was significant increase in the leaf litter biomass on all the hill slopes.

Grass Biomass

The mean air dry grass biomass yield of 51.02, 38.51 and 49.52 q/ha recorded from upper, middle and lower hill slopes during base line increased to 65.42, 60.0 and 61.97 q/ha during final study (Table). The availability of 4- 5 tonnes of grass per hectare in the dry month of May 2005 provided a good indication that grass biomass yield would be two to three times in the month of October/November. But actually the grass yield in final study did not improve that much because the grasses are not fully harvested by cut and carry system. The grazing is restricted to only selected projects. The decrease in the need of forest grasses due to increase of farm production, forges appeared responsible for this trend.

Soil Properties

The soil texture was sandy loam in most plots with loam in few. In the 0-15 cm soil profile, the mean soil pH was 7.7, 8.0 and 7.8 the Ec was 0.16, 0.19 and 0.16 dsm^{-1}, the organic carbon was 0.16, 0.17 and 0.16 percent (P_2O_5) available phosphorous as 14.6, 14.4 and 14.6 kg/he and available potash (K_2O) as 71.69, 90.37 and 79.80 kg/ha and soil moisture as 6.63, 7.32 and 7.39 percent recorded in upper, middle and lower hill slopes (Table 5.7).

In the 15-30cm soil layer the mean soil pH of 7.9, 7.6 and 7.9 Ec of 0.17, 0.17 and 0.19 dsm^{-1} organic carbon as 0.13, 0.18 and 0.18 available phosphorous (P_2O_5) as 12.8, 16.2 and 15.2 kg/ha available potash (K_2O) as 59.51, 72.58 and 63.77 kg/ha, soil moisture as 7.14, 7.66 and 8.47 percent were recorded in upper, and lower hill slopes.

CHAPTER – 6

SUMMARY OF RESULTS

The Haryana Community Forestry Project has constructed 17 water harvesting dams (WHD's) in the Shivalik region covering foothill areas of Panchkula, Ambala and Yamuna Nagar districts. Since characteristics of the catchment areas and vegetation cover determines the water yield and sediment loads to the reservoirs of WHD's, it was decided to genera i.e. base lien information on vegetation cover status of three typical catchments feeding the reservoirs of WHD's. The baseline study was conducted by SPACE (Society for Promotion and Conservation of Environment) a Chandigarh based consortiums of professionals in the month of May and June 2005 in the catchment of Rana/Mirpur – II, Bhediwala, Turon – II and Nanheri watersheds. The changes in the vegetation status were monitored by repeating the same study in October-November 2007. The catchment areas were systematically divided into segments and transects were laid in 9 segments each of Rana and Bhediwala and 18 in case of Nanheri. In each transect sample plots of 10m x 10m size were laid on lower, middle and upper hill slopes. The enumeration of trees and bushes was made from $100m^2$ plots but grass cover, yield, litter accumulation were recorded from $1m^2$ area. Soil samples were also taken from 0-15 ad 15-30cm depth for soil moisture, pH, EC and organic carbon status. Some set of plots and observations were repeats in the final study. General

observations about the catchment characteristics were also made during both the studies.

The summary of salient changes in vegetation cover have been in Table 6.1.

Table 6.1: A comparison of biometrical parameters of three slope classes in three typical forest catchments in Haryana Shiwalik

Biomaterical parameters	Name of catchments	Baseline Slope Class			Current Slope Class			Overall Mean		
		Upper	Middle	Lower	Upper	Middle	Lower	B	C	±%
Tree Stock (No/ha)	Rana	1300	1610	1740	1267	1588	1766	1550	1540	-0.65
	Bhediwala	811	933	589	700	766	633	778	700	-10.0
	Nanheri	1294	1189	1422	1433 10.70%	1272 -7.00%	1556 9.40%	1302	1420	+9.1
Shrub Density (No/ha)	Rana	2988	3222	4022	6109	6766	6787	3411	6554	+92.1
	Bhediwala	8577	8977	11580	1032	10865	14777	9711	12225	+25.9
	Nanheri	3650	4355	4866	5921	5991	6119	4290	6010	+40.1
Grass Clumps (No/m^2)	Rana	18.00	18.33	22.11	24.55	27.80	37.33	1948	29.89	+53.4
	Bhediwala	5.33	4.77	4.88	9.44	8.33	8.44	4.99	8.74	+75.2
	Nanheri	16.05	18.94	22.05	26.00	27.04	30.94	19.01	27.99	+47.0
Leaf Litter Biomass (q/ha)	Rana	27.22	22.44	20.77	29.05	30.66	27.61	23.48	29.11	+24.0
	Bhediwala	10.11	21.00	14.33	11.60	23.10	17.60	15.15	17.43	+15.0
	Nanheri	13.53	11.72	10.33	17.53	17.36	19.72	11.86	18.20	+53.5
Air Dry Grass Biomass (q/ha)	Rana	22.11	96.77	48.3	28.11	117.56	59.20	55.72	68.29	+22.6
	Bhediwala	23.91	24.8	22.7	26.6	28.30	21.3	23.54	27.40	+16.4
	Nanheri	51.02	38.51	49.52	65.42	60	61.97	46.35	62.46	+34.8
Soil Moisture of 0-15cm depth	Rana	5.4	5.7	4.7	6.4	6.9	6.3	5.3	6.5	+22.6
	Bhediwala	5.1	5.4	5	6.5	6.7	7	5.2	6.7	+28.8
	Nanheri	5.5	6.1	5.1	6.6	7.3	7.4	5.6	7.1	+26.8
15-30 cm depth	Rana	4.8	4.8	4.1	7.2	8.1	7.5	4.6	7.6	+65.2
	Bhediwala	4.6	4.7	4.5	6.9	7.1	7.3	4.6	7.1	+54.3
	Nanheri	5	5.3	7.6	7.1	7.7	8.5	5.9	7.8	32.2

Tree Stocking

The tree stocking at base line varied from a minimum of 811 to maximum of 1740/ha on the hill slope of these catchments. The maximum tree stock (1300 to 1740/ha) was noted in Rana and lowest in Bhediwala when Nanheri was in between these two. Generally tree stock was more in lower, followed by middle and upper hill slopes except in Bhediwala where lower grazing pressure is high. In a period of 2.5 years, the tree stocking increased by 7.0 to 10.7 in case of Nanheri. Forest fire in some plots caused mortality of young stock but new recruits compensated the loss. This increase came from new recruits in miscellaneous tree species. However, some reduction in tree stock was noted in upper, middle classes of Bhediwala due to mortality younger held on. In case of Rana and stock all remaining the same.

Shrub Density

At the base line survey the shrub density varied from a low of 2988 to 11580/ha on segments of hill slopes. The maximum shrub density (8577 to 11580/ha) was recorded in Bhediwala followed by Nanheri (3650-4866/ha) and lowest in Rana (2988 to 4022/ha). The shrub density was maximum in lower and minimum in upper catchment obviously because of better moisture conditions. An inverse relationship existed between trees and bushes. The bush density dramatically increased on all the three slopes and in all the three villages.

Grass Stocking

During baseline the grass clumps varied from a minimum of 4.77 to a maximum of 22.11/m^2 on the segments of hill slopes. While the grass stock was almost similar in Rana and Nanheri, it was conspicuously low in Bhediwala due to high grazing pressure. Grasses were almost equally distributed on hill slopes with small preference for lower moist hill slopes as compared to drier top slopes. During the final survey a significant increase in grass clumps was observed on all slopes and all the villages. This was mainly because of domestic reduction in grazing pressure.

Litter Accumulation

Leaf litter is been burning due to forest fires and as such does not follow any pattern. The overall accumulation varied from a low of 10.11 to high 27.22 q/ha on various hill slopes. The accumulation was maximum in Rana because of higher number of leaf shedding khair trees, and lowest in Nanheri due to higher incidence and lopping of foliage of chall trees on the basis of final survey it was noted that leaf litter accumulation increase significantly in nanheri where lopping of chall trees for fodder was considerably reduced due to the availability of farm produced green fodders. In case of Bhediwala small increase was noted because lot of leaf litter was washed down due to a cloud bust event, which generated heavy erosion of top soil including the humans and litter. The litter becomes also increased in case of Rana. Taking average of about 2%

N, 0.15% P and 1.3% K in leaf litter, one can estimate the accumulation of nutrients on the forest floor.

Grass Biomass

The air – dry grass biomass yield at initial level varied from a low of 22.11 to a high of 96.7 q/ha on various hill slopes. The grass yield was lowest in Bhediwala, reasonably good (38.51 to 51.02 q/ha) in Nanheri. The mid-hill slopes of Rana especially recorded higher yield of grass. The grass yield was better as some rainfall storms were received about a month before the baseline study. During the final study an increase in grass yield was recorded on all the slopes and in all the three catchment. But such an increase was quite substantial in Nanheri. Six tonnes of air dry grass yield could be produced mainly be caused of this canopy of chall trees and reduction in grazing pressure.

Soil Properties : Soil moisture in 0-15 cm soil depth varied in a narrow range of 4.7 to 6.1% between slopes and catchments at the time of baseline. There was reasonably good moisture at 0-15cm soil depth during final survey which ranged between 6.3 to 7.4%. This increase is mainly because of better climate during the final study. Similarly, soil moisture in 15-30 cm soil depth range between 4.1 to 7.6% during baseline and the same increased to the range of 6.9 to 8.5% during the final study.

Soil pH: As such, soil in Rana/Mirpur II is relatively more as compared to Bhediwala and Nanheri due to heavy textured soil.

The mean soil pH increased from 8.05 to 8.28 in Rana, from 7.30 to 7.67 in Bhediwala and from 7.57 to 7.70 during the period of 2.5 year (Table 6.3). The reduction in soluble salts concentration as given by Ec values appears responsible for some increase in soil pH.

EC: Conversely mean Ec values generally decreased from 0.22 to 0.18, from 0.26 to 0.17 and from 0.26 to 0.17 d_5m^{-1} in Rana, Bhediwla and Nanheri respectively. During and baseline period of May – June 2005, generally the salts come to the soil surface with capillary rise water and subsequent by get deposited in surface soil after evaporation of water. These salts are then washed down by rains during monsoon. The current level soil sampling done after monsoon 2007, therefore showed lesser salt concentration over base level.

Organic Carbon : This is noted with concern that mean soil organic carbon decreased from 0.35 to 0.21% in Rana, from 0.61 to 0.33% in Bhediwala and from 0.48 to 0.16% in Nanheri respectively. The washing down of surface deposited humus with run off water appears responsible for this loss.

Phosphorus: The soil analysis for soil phosphorus was not done during base year but the same was done during post project

period the overall $P_2{}^0{}_5$ level was 16.7, 24.0 and 14.9 kg/ha which comes in medium range of retailing.

Potash: The mean soil K_2O was 77.08, 90.93 and 72.82 kg/ha. The soil of Behdiwala are richer in available macro-nutrients as compared to the soils of Rana and Nanheri.

General Observation

The catchment area and resultant water storage is almost three times in Nanheri as compared to Rana and Bhediwala. The mean slope in the main gully is more in nanheri but due to presence of rocky strata, the drainage density is low (3.1 km/km^2) as compared to 7.6 in Rana and 8.2 in Bhediwala.

The soils in Rana are very heavy in texture (silty clay) but medium in Bhediwala with high presence of gravels. The soils in Nanheri are relatively light textured sandy loams.

In the main drainage line, the slope is very steep in nanheri, steep to very steep in Bhediwala and moderate to steep in Rana. The land side prone area in maximum (30%) in Rana, moderate (10%) in Nanheri and in between (20%) in Bhediwala.

The catchments of Rana and Bhediwala were dominated by Khair but by Chall trees in nanheri which have been repeatedly burnt.

The soil conservation structures have been constructed in the drainage lines of Rana by the project and by the forest and Kandi project, and in Bhediwala by the kandi project. But no such

structures exist in the catchment of Nanheri because the catchment area falls in Himachal Pradesh.

The grazing pressure is high in Bhediwala but moderate in and slight in Nanheri. Some specific observations about each of the three catchment are given as under.

Rana/Mirpur II

- The catchment areas of Banswala, Kaimwala Bharanli, Mirpur I and Mirpur II and Mandapa forms part of a cluster almost same landscape characterize by erosion prone, highly dissected, heterogenous, landslides infested low hill slopes vertical cliffs and bands of sandstone and shale Mirpur I and Ii catchment lie parallel and drain towards south into main khad. The drainage density of cliffs. The problem of soil erosion is extremely high in Khair dominated catchment comprising of calcareous and heavy textured soils.
- Besides inherent erosion prone nature of soils, the grazing pressure particularly of cows and goats was very high. Only favourable features were good dam sites, lot of run off, low seepage and possibility of gravity flow of harvested water.
- Mirpur II WHD was constructed 2 years (2004-05) after Mirpur I (2002-03) and some control over grazing was exercised. Though three cement stone masonry check dams on three side gullies and one 3.5m high crate wire structure in main were constructed simultaneously with dam construction but these

were silted to capacity in the very first year. One of the CSMCD and the main crate wisa structure leaked from one side during second year of operation (2006-07). Unless repaired, these two would be further damaged and silt deposited above them would travel to the main reservoir. There is a clear need of soil conservation measures in the catchment area.

- Khair remains the most dominant tree species of the area and planted khair in 15-30 cm and 30-60 cm grith classes was present in large numbers on all slope classes. But some khair trees were found dead/removed from sample plots indicating the continuing incidence of fuel wood extraction.
- Tough considerably reduced, but grazing still continues. Branches of many trees particularly of khair were cut to feed the goats. VRMC has not been able to contain the menace of grazing and fuel wood extraction.

Bhediwala

- In the lower areas of this catchment, grazing pressure was high before dam construction. There were few permanent pool of water which attracted more animal to this area. After dam construction, the easy passage to upper areas was blocked and footpaths on side slopes were submerged and water and as a result grazing was reduced but only upto October end. As the water level of reservoir lowers down some foot paths become operational and grazing again starts.

- In the inaccessible areas close to the periphery of reservoir, dense vegetation cover has started developing because of improved moisture regime. Thick vegetation has come even in cracks entering the reservoir from surrounding slopes. This is a positive sign of quick cover development.
- In lower areas, khair plantation was done in 2004-05. During May-June of 2005, lot of mortality of this khair was noted. But in the areas where moisture conditions were better, the survival was good. Those surviving plan have now flourished very well and pockets of good khair plantation in valley bottoms have developed.
- In this catchment, large size chall trees are scattered all over, which are lopped in winter for fodder. Large size papri trees though lesser in number are also present and lopped for leaf fodder.
- Cement stone masonry check dams which were constructed by Kandi project in 2004-05 have silked but are fully functional and vegetation has started developing on the silted area.
- Few khair trees close to the village were seen removed. Some branch cutting was noted for feeding goats.
- The torrential rain shower of August 2007 has produced lot of debris which has moved fast towards the reservoir. Fallen trees in the Nala have hold back lot debris which on decay of trees and branches would move to the reservoir. This mass

movement of debris must be checked by crate-wire structures otherwise the reservoir would be silted up quite fast.

- There are many peaks in this catchment which have no trees and bushes but only well sodded grass cover.
- In order to prolong the life of the reservoir, live stock grazing should be eliminated and few crate-wire structures be constructed to hold back the debris. Fortunately large size stones are available in the main drainage times.
- The process of community participation which was initiated earlier has slowed down as the closing time of the project is approaching. The need interaction with the people and to motivate them for catchment protection so as to keep the irrigation system functional must be continued.

Nanheri

- The clean blue water is the Nanheri reservoir indicates lesser soil erosion in the catchment. This is mainly because of rocky strata in upper drainage lines. Soil erosion is prevalent only in a small pocket of exposed silty clay soil and rest of the slopes are relatively will protected.
- Grazing was a serious problem in the catchment but the same has been considerably reduced after dam construction. Not only that the main passage to the hills have been blocked by the dam and reservoir but the area below the dam has come under crops where free grazing animal movement is not

allowed by the farmers. Infact, entry from one side has been closed because erst while uncultivated private land has been leveled and brought under irrigated crops. On the other side, community plantation has been raises. Some animal do go for grazing and it was reported that one man from nanheri has take the catchment grass on lease and he is taking his own animal for grazing. Excreta of goats and cows was seen on pootpath confirming animal grazing.

- While the upper areas are dominated by chall and dholu, bhabar and sarala grass, the lower areas are covered by miscellaneous trees of low height, bushes and saccharum munja. While lantana infestation is much less and karonda is predominant plant among shrubs.
- Moring in the area, we noted that vertical cliffs on slopes or upper area were either stable with black moss cover or even of some small slides occurred the soil was hold back by Bhabar, Dholy and Kana. However, the slides/bank erosion caused by water flow in the meandering main drainage line remain a problem in some area. The sediment thus produced straight way moved in the reservoir.
- There were clear signs of recovery or change from degradation to rehabilitation as indicated by more wetness, more sand deposition in bed thus holding back stone movement and

promoting vegetation in the nala bed. The drainage lines appears to be shrinking in width due to deposition of sand.

- No check dam was constructed in the catchment to retain silt mainly because the catchment was located in the Himachal Pradesh. In case some soil conservation works be done, the chances of siltation of the reservoir would be greatly reduced .
- Forest fires remains an unsolved problem. While grasses and bushes particularly karonda responds with first rain but main damage occurs to younger tree store. This is the reason that tree stock density is restricted and bush density goes up when otherwise protection is provided. This is what has precisely happened in Nanheri catchment.
- While the problem of forage is greatly solved consequent upon introduction of inigation in command areas of WHD's. But the problem of fuel wood persist particularly in exterior villages like nanheri. Though more fodder brings more stall fed buffalo and inturn cow dung availability improves; part of which is used as manure and part for cow dung cakes. Yet, dependence on forest for fuel wood persist. This is the reason we found tree cutting both bole and branches inspite of the promises the VRMC and the people made not to cut the tree in the catchment area. The removal of dead disease and dry wood may not cause problem but cutting of green trees must be discouraged.