

# **SUSTAINABLE FOREST MANAGEMENT**

**WORKING PAPER SERIES**

**FOREST RESOURCE CONSERVATION  
AND DEVELOPMENT PLAN: SHIVALIK HILLS**

by

**Christopher Scott and J.R. Gupta**

**Working Paper No. 6**



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**FORD FOUNDATION  
NEW DELHI**

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DHAMALA BEAT  
SURAJPUR BLOCK  
PINJORE RANGE  
HARYANA  
17 OCTOBER 1990

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# FOREST RESOURCE CONSERVATION AND DEVELOPMENT PLAN

DHAMALA BEAT  
SURAJPUR BLOCK, PINJORE RANGE, HARYANA

17 OCTOBER 1990

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## **SUMMARY**

This document details the vegetative and physical conservation strategies that will aid forest resource regeneration in a forest beat in the Shivalik Hills. The plan comprises the technical aspects of forest micro-planning that the Haryana Forest Department (HFD) intends to implement on a beat-basis throughout the Shivaliks. Although it makes reference to the institutional and social decision-making processes that result in comprehensive forest management, this plan is intended primarily to present options for field implementation in Dhamala Beat (Surajpur Block, Pinjore Range, Haryana). Although Dhamala has received considerable investment of financial and staff resources from the HFD, it may be considered a representative beat that encompasses the various forest conditions and use patterns prevailing in the Shivalik Hills.

The plan is comprised of a forest resource inventory for Dhamala, a map indicating prioritization of forest areas for treatment, and text covering a variety of vegetative and physical conservation techniques and their site suitability. It is to be accompanied by two documents: the extension manual, "Van Upaj Se Labh Badhao, Pani ka Tez Bahav aur Mitti ka Katav Roko," which contains, in Hindi, further details of conservation options, as well as diagrams and visual aids; and the collection of field visit reports. Throughout the plan, care is taken not to distinguish conservation from development activities, i.e., physical soil and water conservation (SWC) structures from sapling plantation. Both sets of activities are means to the same end: sustainable use and management of forests.

Primary emphasis is given to the propagation of certain vegetative species rather than physical structures, which require significantly higher investment. An example of the species emphasized is *Eulaliopsis binata* ('bhabbar'), which results in financial returns to villagers organized in Hill Resource Management Societies (HRMSs) and to the HFD. Water harvesting through the construction of earthen or masonry dams is explored; however, given the current paucity of funds, such an approach is not considered to be widely replicable.

## ACKNOWLEDGEMENTS

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For technical inputs, we are indebted to the researchers of the Central Soil and Water Conservation Research and Training Institute (CSWCRTI), Chandigarh, particularly Dr. S.S. Grewal, a soil scientist, who reviewed the draft plan extensively. Mr. S.P. Mittal and the staff at the CSWCRTI Research Farm were also most helpful.

## INTRODUCTION

The need to take up micro-planning of forest and natural resources today has an urgency witnessed not only by the rapid decline in their condition, but also by the limited success of current, conventional resource management systems. In Haryana, with natural forests confined to the northern portions of the state, pressure on the resource base is extreme. In response to the ever-increasing forest resource needs for local domestic and industrial purposes, the Haryana Forest Department (HFD) is seeking to decentralize the planning process. The intended result is that resource needs and forest conservation objectives can simultaneously be met, while ensuring equitable distribution of benefits. The appropriate level for such decentralized planning is the forest beat, consisting of a maximum of several thousand hectares of forest, that is divided into "Reserved" and "Protected Forests."

Degradation has been particularly severe in the forests of the Shivalik Hills, spanning the northern extremes of Punjab and Haryana, and bordering the outer Himalaya in Uttar Pradesh and Himachal Pradesh. Timber extraction from the Shivaliks has been rampant throughout the pre- and post-Independence growth of the plains' agricultural economy in these states. Today, with timber resources severely depleted, the extraction is of fiber for the burgeoning local industrial economy. Local domestic use of resources, for fuelwood, fodder and raw material for rope, has also increased significantly with the recent dramatic increase in human and animal populations.

For several natural reasons (primarily geological, climatic, and hydrological), the Shivalik ecosystem is itself fragile, and increasing the tendency towards degradation. Geologically, the Shivaliks form an outer barrier to the Himalaya, occurring as uplifted alluvial deposits from the mountains. Due to their largely unconsolidated nature, the soils are extremely erodible. In northern Haryana, the Shivalik belt (4 - 10 km in width) runs in a southeast - northwest direction, parallel to the outer Himalaya at a distance of 10 - 15 km. Generally, the Shivaliks' southwest slopes facing the plains of Haryana and Punjab are gently inclined, composed of semi-compacted alluvium of high pH and are deeply incised by 'choas' (ravines). The northeast slopes facing the outer Himalaya are steep, though less deeply incised. Soils on the northeast slopes have high clay content, and vertical cliffs occur extensively. Due to the high clay content and incidence of calcium carbonate, the soils are prone to swelling and allow little infiltration (Grewal, *et al*, p. 6). A significant proportion of precipitation is lost as runoff.

The average annual precipitation ranges from 1000 - 1200 mm, with intense cloudbursts in the three month monsoon season (July - September) accounting for 80 % of the total. Average annual pan evaporation is over 2100 mm (Grewal, *et al*, p. 3), which brings into question the rationale for constructing surface water reservoirs. Yearly maximum rainfall intensities average 98 mm/hour (15 minute duration), with 5 minute duration intensities as high as 197 mm/hour (Agnihotri, *et al*, p. XXXIII). As mentioned, runoff ratios are high, resulting in high velocity discharges in 'nalas' (gullies) and choas. Intermittent flow during the monsoons dissipates quickly through infiltration upon reaching the plains' sandy loam soils.

The Shivaliks are said to have been thickly forested a century ago. Today they support sparse, dry deciduous forest cover, with *Acacia catechu* ('khair') and *Eulaliopsis binata* ('bhabbar') predominating. Within the confines of the CSWCRTI Research Farm, vegetative cover has benefited from over three decades of enclosure. Here, vegetative density (canopy and groundcover) is virtually 100%. For further discussion of vegetative types, refer to the resource inventory section.

The causes of degradation are a complex interrelation of social and natural factors. In Haryana, the conservation effort has recently taken a new turn. In place of protecting forest resources through 'policing' local users, the HFD has initiated 'joint management' through dialogue with forest-proximate rural communities with the goal of securing their involvement in resource conservation. Various incentives, such as leases for minor forest produce (MFP) and water harvesting dams, are turned over by the HFD to local communities as the *quid pro quo* for their involvement in resource conservation (Gupta, p. 1). For over ten years, local

management of resources has been gaining momentum in the Haryana Shivaliks, specifically Pinjore and Morni Ranges. Currently there exist some sixty Hill Resource Management Societies (HRMSs) formed through the direct efforts of the HFD.

With this background, it was decided by the HFD to initiate, on a trial basis, micro-planning at the beat level. Dhamala Beat was selected for the experience held by its three HRMSs, namely, Lohgarh, Dhamala, and Sukhomajri, as well as for its proximity to Pinjore and the headquarters of the HRMS Programme of the HFD. From 18 June - 4 July 1990, an intensive resource inventory of the reserved compartments and demarcated protected forest areas in Dhamala was undertaken by the HFD field team, in dialogue with the three HRMSs to identify areas of priority for further HFD investment. Follow-up work consisting of HRMS contact, specifically interviews with village women, was undertaken from 26 - 28 July 1990. The recommendations made in this plan are based on the inventory and on the interviews.

#### **DHAMALA BEAT**

The beat is located some 5 km from Pinjore (between the Union Territory of Chandigarh and Simla, H.P.) on the Nalagarh Road (refer to attached map). The peri-urban effects of Chandigarh (35 km) and Kalka (10 km), as well as employment opportunities in industries in Surajpur (3 km) and Pinjore, are felt strongly and have a profound impact on the nature of resource use by villages in the beat.

Forest conditions in the beat are representative of the Shivalik region. While afforestation and soil and water conservation (SWC) have been undertaken in Dhamala in the past, the current effort seeks to address local residents' needs, in addition to the forest conservation objective of the HFD, by following up on the joint management strategy.

Dhamala is comprised of two Reserved Forest (RF) compartments and a strip of Demarcated Protected (DP) forest. It is adjacent to protected forests in Surajpur and Prempura Beats, and those in the Union Territory (UT) of Chandigarh. The total forest area in Dhamala is 505.7 hectares (1254 acres) as follows:

<u>Compartment</u>	<u>Area (ha)</u>
C-3	233.5
C-4	209.3
DP-253	<u>62.9</u>
Total	505.7

Adjacent to C-3 is Lohgarh village, with an HRMS formed in 1983. C-4 lies contiguous to two villages, Dhamala and Sukhomajri, with HRMSs formed in 1983 and 1980 respectively.

The primary caste groups in the three villages are Gujjars, Jats, Banjaras, and Harijans. Obviously, some communities have greater reliance on MFPs, though an effort has been made to include all groups in the HRMS. Where certain groups within the HRMS clearly dominate others, priority for leasing has been given to forest dependent communities. Guidelines for community contact and group formation are currently being formalized by the HFD; they are complementary to the guidelines presented in this plan.

A brief background of previous efforts at natural resource conservation in Dhamala Beat is in order. Since 1978 the beat, and specifically Sukhomajri village, have received considerable external conservation assistance, owing to Sukhomajri's location in the upper reaches of Chandigarh's Sukhna Lake catchment. Sedimentation rates in the lake were alarmingly high and efforts were made to bring the whole catchment under SWC treatment, an initiative first made by the Central Soil and Water Conservation Research and Training Institute (CSWCRTI), Chandigarh. Significant follow-up effort was made by the HFD in collaboration with villagers in the catchment area. Reports on the success of this venture indicate that erosion rates from the catchment are down from 900 to 30 tons/hectare/year (Bansal, *et al*, p. 3).

Water harvesting dams were also constructed in the villages for supplemental irrigation (4 in Sukhomajri, and 2 each in Dhamala and Lohgarh). Perhaps more significant is the fact that villagers have, of their own accord, largely converted to stall feeding of animals, and instituted a system of 'social fencing' to protect the catchments of the small dams. Subsequently, social fencing was extended to the Sukhna catchment.

An interesting hydrological feature of the settlement pattern in the beat is that while private agricultural land and village common property lie outside the Sukhna catchment, i.e., to the northeast in the Jhajra River catchment, the RF and DP straddle the watershed divide between the two catchments. That is, the small dams built by the HFD and CSWCRTI for sediment control and water harvesting for minor irrigation do not lie in the Sukhna catchment. The various watercourses (nalas and choas) feeding the lake have been treated primarily with physical conservation measures, but not as intensively as the small dams' catchments. What has actually happened is that provision of supplemental irrigation and increased MFP yields in the Jhajra catchment have significantly reduced biotic interference in the Sukhna catchment.

The HFD's joint management strategy further provides for MFP leases to be sold to HRMSs at the average of the past three years'

price obtained from private contractors in open auction. HRMS members then decide collectively what each household will pay for a year's harvesting rights ('dati') over MFP in the RF and DP, which lie mostly in the Sukhna catchment. The conservation incentive is built into the lease: HRMS members protect the RF and DP in order to maximize their returns.

The condition of forests in the RF and DP in Dhamala beat reflects differing histories of exploitation by contractors and villagers, differing current use patterns and a variety of physical factors including soil type, slope and aspect. Generally, it is true that C-3 and the DP-253 adjoining Lohgarh (refer to the map) support better vegetative cover, and exhibit fewer signs of erosion. In C-4, the degradation of forest cover becomes more severe toward Sukhomajri village in a northwest direction from Dhamala. The Sukhna catchment in C-4 adjoining Sukhomajri shows the severest symptoms of erosion, with steep clay slopes devoid of any vegetative cover. At the watershed divide between the Jhajra and Sukhna catchments, vertical cliffs of unconsolidated soil are perched precipitously over the watercourses. It is evident that in intense rain, these collapse, dropping their debris into the Sukhna catchment, and taking with them portions of the agricultural fields of Sukhomajri. Though the loss of agricultural land has been halted to a large extent, some areas of Sukhomajri are still in danger.

## **OBJECTIVES OF THE DHAMALA BEAT PLAN**

The preparation of plans at the beat level has multiple objectives. For joint management to be a viable strategy, the particular and shared needs of both the HRMSs and the HFD must be addressed. Micro-planning, therefore, must be based on the following objectives:

- 1) Improved MFP yields. As HRMSs are primarily interested in grasses for fodder and fiber, whether for domestic use or for sale, an important component of the planning process is to secure HRMS input regarding the sub-compartment yields of grasses, and adequate measures to increase MFP production.
- 2) Forest conservation. Conservation includes a range of options, including various afforestation and SWC measures, as well as HRMS management of forest exploitation.
- 3) Equitable distribution of benefits. For the continued success of joint management, it is necessary to secure a high degree of participation from all HRMS members. Thus, equitable distribution of profits within the society (from sale of MFPs, fishing rights to contractors, etc.) must be ensured.

## RESOURCE INVENTORY

The discussion of resource conditions and potential for conservation is done on the basis of the HFD's division of the beat into compartments and demarcated protected forests. In order to identify the locations of choas named in the following descriptions refer to the attached map.

### Compartment C-3

Vegetative and soil conditions in the compartment are basically sound. Tree species include *Acacia catechu* ('khair'), *Dalbergia sisoo* ('shisham'), *Lania coromandelica* ('jingan'), *Acacia modesta* ('phulai'), *A. nilotica* ('kikar'), *A. leucophloea* ('reru'), *Anugosis latifolia* ('chhal'), *Prosopis juliflora* ('mascat'), *Bauhinia variegata* ('kachnar'), *Azadirachta indica* ('neem') and numerous others. The southwest aspect supports better vegetation, due in part to more gentle slopes. Large areas of heterogeneous species composition occur, as in the Ladiwala Choa catchment.

Numerous shrubs form an intermediate cover under the upper canopy: *Didonia* ('mendar'), 'karonda,' *Moria cunigii* ('curry patha'), *Agave* ('ramban'), *Euphorbia* ('thur'), *Ipomia* ('aankh') and *Lantana* ('buti') are notable. The latter is a terrible scourge: being a pioneer species, it chokes out other, more valuable, native species. *Lantana* occurs in profusion on the Jhajra catchment side (northeast), particularly toward Surajpur, as in the DP above the railway bridge.

Grasses play an important conservation function in providing groundcover under the canopy of trees and shrubs. Grass species in evidence in C-3 include *Eulaliopsis binata* ('bhabbar'), *Chrysopogon fulvus* ('dholu'), *Heteropogon contortus* ('sarala'), 'gesain', 'churi', *Sacharum manja* ('jhoond'), and 'khahand'. *Vetiveria* ('khus') is not in evidence. Extensive areas of bhabbar have been planted by the HFD, particularly on the ridges above the Chokyad and Ghatiwala Choas. While bhabbar is economically the most important species, other grasses are in demand by HRMS members as fodder, fiber, or for thatch. It is evident that the improved MFP yield, conservation, and equity objectives mentioned above can be met by propagating a combination of trees, shrubs, and grasses.

A note on soil conditions in C-3. The highly erodible hills are formed of layered, unconsolidated alluvium, dominated by compacted sand parent material giving rise to sandy loams. Interspersed in layers are clays of high bulk density, with high pH and calcium carbonate conditions favorable to the formation of hardpans (Grewal, *et al*, p. 6).

The top ridges of the catchments are composed of vertical sand and clay cliffs, below which fallen debris has accumulated.

Expansive, exposed, steep slopes are the source of considerable runoff, and show signs of rill and gully erosion. As a general rule, the catchments of the two Lohgarh earthen dams show more advanced erosion than the adjoining areas of C-3 in the Sukhna catchment. This will be dealt with in greater detail in the DP-253 inventory below.

#### Compartment C-4

While vegetative density in C-4 is considerably lower than in C-3, the variety of tree species is roughly the same. C-4 supports more homogeneous stands of tree cover, as for example, a large area of chhal with grass and shrub understory, above the Tooti Dhang on the ridge dividing the Ogawala and Maajalwala Choas. This area, generically called 'thapar' in local parlance, is on a gentle slope with southwest aspect. The parent material is a sand-gravel conglomerate, though with significant amounts of organic matter and high rates of infiltration, the soil is fertile with depths perhaps 30 - 100 cm. HFD has undertaken trenching and stone gully plugging in support of khair on the boundaries of this chhal thapar. 5 - 8 years after plantation, some khair have achieved 40 cm girth.

Further north from this area are the two deeply incised valleys of the Dhamalawala and Badawala (or Majriwala) Choas. These support little vegetation of any kind, except in isolated pockets. For example, behind the masonry checkdam at the confluence of these two choas, the stream beds themselves are lined with shisham, which grows well in moist conditions. The surface gradient is extremely low at this point, owing to the complete sedimentation of the 3 m high structure.

Soil characteristics are much the same as in C-3, though clays predominate in the two choas. From a distance, soil layering is quite noticeable, with red, yellow, brown, and gray indicating different degrees of oxidization of minerals through weathering. The long, exposed slopes (100 m depth) have been planted with *Agave*, with some success. There appears little remedy for erosion on a massive scale in areas such as the Majriwala Choa, except to regulate grazing and excessive cutting of grasses by HRMS members on steep slopes. The lower, more gentle slopes have been planted with bhabbar quite successfully. These should be exploited more fully by HRMS members, leaving the highly degraded areas to regenerate naturally.

#### Demarcated Protected Forest DP-253

The southern extremity of the DP-253 adjoining Surajpur supports an excellent variety of tree, shrub and grass cover. Khair, mendar, and various grasses including bhabbar predominate.

The settlement of Lohgarh village is such that the DP is quite some distance, and firewood and fodder needs can largely be met from private and panchayat resources.

Erosion in the southern DP is less advanced than in the DP adjoining Dhamala and Sukhomajri in particular, due to the lower elevations of the southern ridges. As one proceeds in a northerly direction, vegetative conditions and erosion problems in the DP deteriorate. On the northeastern aspect of the Shivaliks, i.e., in the Jhajra catchment, slopes are precipitous, the matrix less consolidated, and the area overgrazed, leading to the most severe erosion in the beat.

All of the eight earthen dams in Dhamala Beat (4 Sukhomajri, 2 Dhamala, 2 Lohgarh) lie in the Jhajra catchment, inside or on the boundary of the DP. Additionally, a large portion of the catchments of the dams is in the DP. Thus, the most important yield of the DP, one can even call it an MFP, is water. As discussed in the introduction, the provision of water for supplemental irrigation is of critical importance to the success of joint management in such areas. Its continued supply to villagers must be given top priority in the forest management plan.

The strategy of providing benefits to HRMSs in return for their involvement in forest conservation is reflected in the establishment of priorities for the Dhamala plan, as outlined in a subsequent section.

## **TECHNIQUES**

Soil and water conservation measures are seldom successful if used in isolation. It is more effective to consider SWC as a comprehensive system, comprising a range of conservation techniques. The options to be adopted in Dhamala may be classified by their primary component as vegetative, physical, or preventive. Ideally, the system to be implemented must integrate these three. For the purposes of this plan, they will be discussed separately, and various techniques enumerated under each.

### VEGETATIVE

#### Bhabbar

The thick roots and tufts of bhabbar grass play an important conservation function by stabilizing steep slopes and catching sediment and runoff. On slopes above 50 degrees, bhabbar is to be propagated by planting slips along the contour at a spacing of no less than 50 cm, with the minimum possible disturbance to the soil profile. On slopes of 30 - 50 degrees it may be supported by

contour trenches or contour bunds (see physical measures). In such cases, it is to be planted at 30 cm spacing, as moisture competition among adjoining tufts will be reduced. Bhabbar does quite well interplanted with khair, or other tree species with a light shade canopy. A tree/shrub/grass combination is the optimal conservation/production system.

Chopra has estimated that bhabbar yield in forest compartments under joint management may be as high as 10.62 quintals (1.062 tons) per hectare [10 quintals = 1 ton]. Given the economic value of bhabbar, and the prospects for value addition through the production of rope ('baan') by hand or machine, it is to be propagated extensively in C-3 and C-4. HRMS societies in all three villages have expressed interest in further bhabbar planting.

#### Other Grasses

Of the various grasses besides bhabbar listed in the inventory, churi has potential as a pioneer species for propagation on steep slopes. Its seed is to be dibbled at a depth of no less than 2 cm, with precaution to avoid excessively disturbing the soil surface. Churi yield is minimal on poor soils; however, it could be used as a protective barrier above plantation of bhabbar.

Sarala and dholu are the fodder grasses preferred by women who have primary responsibility for the care and feeding of cattle. The propagation of sarala and dholu needs further investigation.

Gesain and jhoond favor higher moisture and can be used to treat unstable nala banks. Evidence of the success of jhoond in stabilizing gullies may be found throughout the agricultural fields of the villages in Dhamala Beat. Jhoond may be used for thatch, though it also has a market as raw material in the paper mills.

Kahand also appears to feature in local resource extraction. Moist, it can be used as cut fodder, or it can be planted in panchayat and village common land buffering the DP where cattle are taken to graze early in the rains before field crops germinate. Procedures for the propagation of kahand as well as the other grass species mentioned need to be formalized so they can be used by HRMSs to full advantage.

#### Khair

In an effort to control mass wasting, i.e., the collapse of vertical cliffs, a deep rooted tree that grows well in conditions of low moisture is required. From the inventory, it is apparent that khair is suitable for the stabilization of cliff edges. Pits are to be dug 45 x 45 x 45 cm in size, a minimum of 1 m behind the cliff edge, at a spacing of 3 m. On cliff edges, no trenches are to be dug, as soil saturation may accelerate mass wasting. On slopes up

to 50 degrees, khair may be aided by staggered contour trenches (single or double; see description under physical measures, below). Khair is to be interplanted with grasses to provide a canopy and groundcover protection to the erodible soils.

Since mature khair is exclusively a source of revenue for the HFD, but of little benefit to villagers (as such termed a 'forest species'), concentrating the sapling plantation solely on khair will result in ambivalence, perhaps hostility, on the part of HRMS members. However, as it is ultimately suitable to current agro-ecological conditions in the Shivaliks and is an excellent source of HFD revenue, it may be propagated in areas of C-3, C-4, and the DP where the moisture regime is poor.

### Shisham

Another 'forest species' that has the proven ability to stabilize choas and nalas is *Dalbergia sisoo*. It has strong preference for sandy loam soils with good moisture, and grows quickly. Behind previously constructed checkdams where some sediment has accumulated, it should be planted in 45 x 45 x 45 cm pits, at a spacing of 3 m. With low survival rates, plant density will be reduced over time.

Returns from shisham to the HRMSs will be minimal, except as a relatively insignificant source of kindling. The HFD can, however, realize significant returns through the sale of shisham timber upon maturation.

### Bamboo

Various species of bamboo are to be raised in HFD and Kisan nurseries for propagation in the DP. The species of greatest suitability and utility appears to be *Dendrocalmus strictus*. Once it forms tufts, *Dendrocalmus* has excellent SWC properties. It grows best in nala bottoms, drawing on available soil moisture, where it also serves a conservation function. In the Shivaliks and Outer Himalayas area, however, it occurs naturally on medium slopes (up to 50 degrees), with roots that penetrate the hardest soil. Bamboo is to be planted in pits 45 x 45 x 45 cm in size, at a spacing of 3 m on mild slopes (upto 25 degrees) or 5 m on medium slopes (25 - 50 degrees). Layout of pits should be staggered down the slope.

As bamboo is considered an MFP by the HFD, HRMSs in beats other than Dhamala have taken leases for its harvest. The uses of bamboo are manifold, from building construction to use in agricultural implements.

### Agave

In the areas it was intended to treat, i.e., severely eroded

slopes over 50 degrees, *Agave* has had limited success. It is neither a source of fodder nor fuelwood for villagers. Consequently, *Agave* planting must be restricted to those areas where no other species will grow. It is propagated from slips, preferably from well-matured, healthy stock, as that from Parwanoo.

#### Other Shrubs

In conjunction with *Agave*, other shrubs that do well on slopes, i.e., mendar or karonda, may be planted to benefit from the soil and moisture holding capacity of *Agave*. Both mendar and karonda have some utility for HRMS members.

#### Brush/Live Checkdams

An inexpensive though temporary solution to the problem of gullying is the installation of brushwood checkdams, preferably of densely branching thorny species that will trap organic matter in surface runoff. Once deposited, this material forms the fertile base for the growth of live checkdams. Initially, karonda is to be used as the brushwood. Alternately, *Acacia modesta* (phulai) or *A. leucophloea* (reru) would serve this purpose well. These are cut in 1 m diameter (width) thickets, and lodged against stakes embedded in the nala bed. Stakes of a sprouting species, such as *Lania coromandelica* (jhingan), are preferable. Spacing of checkdams down the nala bed is to be every 10 - 20 m, just above locations where the slope of the bed abruptly steepens. Bamboo or other suitable species that grow well in moist conditions may be planted in the sediment deposited, to form a live checkdam.

### PHYSICAL

#### Staggered Contour Trenches

The primary function of the trench is to reduce runoff and trap the silt carried down from the micro-catchment above. For this reason, the trenches are staggered along the contour, i.e., so that one trench does not interfere in the micro-catchment of the trench below. The double trench is used for particularly dessicated soils, where the upper trench acts as a reservoir, the lower as a pit for the sapling.

A word of caution is in order regarding the application of trenches to erodible, sloping soils in the Shivaliks. The movement of large quantities of soil from their undisturbed position to the surface may, in fact, result in higher rates of erosion, even in the long run. It is recommended that trenches be dug only on slopes less than 30 degrees, as the establishment of vegetative cover on the excavated soil is virtually impossible by the time the first erosive precipitation occurs.

## Contour Bunds

Embankments of compacted earth aligned with the contour, or graded with a gentle slope, act as barriers to excessive sheet erosion, and cause sedimentation of eroded soil from the micro-catchment above. The ideal height and spacing of the bund depend on the soil in question, on the vegetative system it supports and on the severity of erosion on the slope. Typically, bunds are 15 - 30 cm in height, with a tapered, trapezoidal cross-section, spaced a minimum of 5 m below the previous bund. It is of critical importance that the bunds be provided with compacted earthen tie ridges extending perpendicularly upslope from the bund every 5 - 10 m along the bund. Tie ridges separate smaller volumes of impounded water behind the bund. Should the bund fail, only the water between two tie ridges will be lost. Contour bunds are suitable only for slopes lower than 30 degrees, for similar reasons as cautioned with the trenches.

It must be recalled that for bund construction, water is recommended to aid compaction of bunds in soils with high silt and sand content. This requirement limits the application of contour bunds in Dhamala to the catchments of the dams. However, when well implemented, bunds can be cost-effective, as they are capable of greatly increasing the yields of bhabbar and other grasses, which may be planted directly on and behind the bund.

In laying out the bunds, it is important that the contour be precisely followed. Field teams can make quick work of this with a level tube, spirit level or A frame.

## Gully plugs

Gully plugging is a cost-effective soil conservation measure only where erosion rates are low. Due to the high maintenance costs when silted in, gully plugs should only be implemented after vegetative measures have been implemented on higher slopes. In many cases, the primary purpose of constructing gully plugs is to reduce the velocity of runoff, and thereby reduce further erosion downstream. Made where stone is available nearby, gully plugs must be constructed by competent masons. The effects of stone washing down a steep gully are disastrous. Similar to the brush checkdams, gully plugs are to be spaced every 10 - 20 m along the nala bed, just above locations where the slope of the bed abruptly steepens.

For steep nalas, a stone apron must be provided to absorb the impact of water flowing over the gully plug, thus preventing further erosion. Apron layout for gully plugs is similar to apron layout for checkdams; see below.

### Checkdams

Typically larger in size than gully plugs, checkdams are perhaps the most expensive option in the package. Consequently, where SWC is perceived by HRMS members to be the HFD's responsibility, this may be their first preference. Built of stone, and often reinforced with gabion wire, a single stone masonry structure may cost Rs. 50,000. Where rates of sedimentation are high and the life of structures correspondingly low, it is advisable to seek vegetative solutions.

A foundation at least one-third as deep as the structure is tall must be dug in soft soils, or down to solid rock where the soil profile of the nala bed does not permit such deep excavation. The foundations for the apron and checkdam are to be excavated simultaneously. The length of the apron is recommended to be at least one and a half times the height of the checkdam. Where flows of high velocity and discharge occur, the masonry in the checkdam must be of dressed stone with lime or cement mortar. Lower discharge nalas may be treated with checkdams of dry stone masonry (rough dressed to reduce voids) or gabion wire.

### Earthen Dams

Dams as large as those constructed in the three villages in Dhamala are technically minor irrigation dams, not SWC measures, with the exception of Sukhomajri's oldest earthen dam, SM-1. Consequently, they are not included in this package of SWC options. Although they play a potentially important role in the exchange of benefits to villagers for their cooperation in watershed protection, water-harvesting dams (whether earthen or masonry) should not be included with SWC options for several reasons. First, the level of investment required to replicate the number of dams built in Dhamala in every beat in Pinjore and Morni Ranges greatly exceeds the financial resources of the HFD. Second, the dam's main SWC function, i.e., sediment collection, does not integrate with a systems approach that emphasizes source reduction of erosion. This is not to say that earthen dams should not be constructed; it is recommended that they be implemented sparingly, in cases where the potential for irrigation is high and its benefits can be shared equitably.

### PREVENTIVE

A management option that successfully prevents soil erosion confirms the adage: "Ilaaj se parhej accha (An ounce of prevention is worth a pound of cure)". Given the relationship between forest use and degradation in Dhamala, any comprehensive plan for forest conservation must evolve a system of management that accounts for locally prevailing use and management patterns. That is, open

grazing and unrestricted fuelwood collection could be replaced, wherever possible, with stall-feeding and limited collection of fuel on the part of the local HRMS in exchange for the HFD undertaking fodder and fuelwood species propagation in the DP.

The women's group interviews made clear that the forest provides fuel and fodder needs in all three villages. A sensible management plan might first rank the relative priority of these resources during different seasons. Subsequently, resource use might be stipulated in accordance with the regenerative capacity of a particular area of RF or DP. It is evident that with the increase in the number of stall fed milch cattle, fodder needs in the three villages eclipse fuelwood needs for much of the year, particularly when field-grown fodder is unavailable. During May and June, the combined fodder available from the forest and the villages is insufficient, and maize and sorghum straw must be purchased. The potential to meet greater portions of the total fodder demand from forest resources in exchange for HRMS-managed exploitation appears to be great.

Preventive management practices have emerged in response to the HFD efforts in the three villages. Social fencing evolved in Sukhomajri after the early initiatives of the CSWCRTI and the HFD. It essentially consists of a set of agreements on the part of HRMS members to curtail open grazing and restrict fuelwood and fodder collection. In combination with vegetative and physical measures, it can be extremely effective in meeting the three objectives of the micro-planning process.

### SITING

With reference to the Dhamala Beat Map accompanying this report, the techniques should be sited where the economic returns to the HRMS will be maximized. For example, there is no purpose served in stabilizing cliffs that are on the verge of falling. With the cliff goes the investment. On the other hand, the plan recommends some measures that have not been extensively used in the Shivaliks. These should be tried in order to get experience with their utility from a conservation perspective and their cost effectiveness, i.e., their relative ability to provide returns to investment.

Figure 1 on the next page summarizes the siting recommendations made in this plan. The various SWC techniques discussed in a previous section, which can be thought of 'options,' may be suitable only under certain circumstances. Figure 1 lists options and the sites where they may be suitable. For the definition of local terminology on landforms, refer to the Glossary.

Figure 1: Soil and Water Conservation Technique Siting  
(X = technique suitable)

No.	SWC Technique	Peak	Ridge	Steep Slope	Cliff	Debris	Mild Slope	Gentle Slope	Gully	Ravine Bank
1 a.	Bhabbar					X	X	X		
1 b.	Bh. + Subabul					X	X	X		
1 c.	Bh. + Khair						X	X		
2 a.	Dholu/Sarala					X	X	X	X	
2 b.	D/S + Fruit							X	X	X
3 a.	Jhoond								X	X
3 b.	Jh. + Shisham								X	X
3 c.	Jh. + Fruit								X	X
4	Churi	X	X	X	X					
5	Bamboo				*		X	X	X	X
6	Mendar/Karonda		X	X		X	X			
7	Agave	X	X	X	X					
8	Prosopis	X	X	X	X					
9	Chhal					X	X	X	X	
10 a.	Fruit: Ber						X	X	X	
10 b.	Jamun							X	X	X
10 c.	Guava								X	X
11	Brush Checkdams		X	X			X		X	
12	Trenches	X	X				X			
13	Gully Plugs			X					X	
14	Contour Bunds		X	X			X			
15	Checkdams								X	X
16	Gabion Ch'dams								X	X

### Hilltops

With good soil cover, khair is to be propagated with grasses. Where soil cover is poor, grasses alone may be suitable, or they may be interplanted with *Prosopis*.

### Cliffs

Little can be done to stabilize vertical cliff faces. Where possible, however, khair or other deep rooted species are to be planted on the area above the cliff. Churi and bhabbar may be propagated as high as the laborers can climb.

### Steep Slopes (>50 degrees)

Taking care to disturb the soil profile as little as possible, grasses should be dibbled, or propagated by shoots. Where soils are conducive to the formation of hard pan, churi grass should be dibbled. Physical SWC, with the exception of gully plugs should not be undertaken on steep slopes. Instead, brushwood checkdams are to be used.

### Medium Slopes (30 - 50 degrees)

Where soils are moisture retentive, a variety of trees and grasses may be intercropped. Only where soil moisture will allow vegetative growth on excavated or compacted soils should physical SWC measures be implemented, such as contour trenches and bunds on slopes. Gully plugs should always be used to check erosion in nalas.

### Mild Slopes (<30 degrees)

Where vegetative cover is good, i.e., groundcover density is greater than 50%, no interference should be made. Where groundcover density is 30% - 50%, the area should be planted with grass and shrubs and be allowed to regenerate naturally. If groundcover is less than 30%, it is likely due to high grazing pressure, or to inherent soil properties which inhibit vegetative growth. Such areas are to be treated on a last priority basis.

### Nala Beds

Shisham, bamboo, and jhoond grass are to be propagated along the bed to prevent damage from erosive monsoon flows. Where the potential for gravity irrigation of leveled agricultural fields exists, earthen dams may provide the incentive for HRMS members to raise fodder, thereby reducing grazing pressure on fragile forested areas.

## BUDGET AND PRIORITIES

In an effort to establish costing procedures for the various techniques, the HFD Revised Schedule of Rates (1990, for daily wage of Rs. 24.25) has been used to calculate development costs. These depend on the recommended per-hectare spacing and assumptions of the length of nala per hectare, for example. The costs presented in Figure 2 on the next page, have been rounded off to the nearest Rs. 100, given the flexible nature of the assumptions. Their ability to provide long term benefits has been assumed.

In assessing the various techniques, their assumed preference ranking by both HFD and HRMSs are presented in Figure 3 on the second following page. For example, bhabbar has an HFD preference ranking of 12, and HRMS preference ranking of 1, totaling 13, which places it higher than any other single technique. This method is obviously a simplification, in addition to the fact that the rankings are assumed. It does, however, provide an interesting mosaic of vegetative and physical conservation measures.

Once the plan is prepared, implementation is based on approval of the proposed budget. As it is difficult to allocate funds of this nature in advance, it is recommended that the procedures of the beat planning process stipulate the establishment of priority areas for implementation. In this manner, the plan will be executed to a level commensurate with funding.

In the case of Dhamala, budget allocation remains uncertain. Once the funding position is more clear, the HRMS Programme team will specify expenditures for various treatment measures. The HRMS field team in consultation with the respective HRMSs recommends the following priorities for SWC and afforestation:

1) Treat the Jhajra catchment portions of C-3, C-4 and DP-253 on a top priority basis. This will increase the likelihood of social fencing of the Sukhna catchment. Areas in pink on the map show the degraded areas in urgent need of treatment.

2) Treat the Sukhna catchment areas adjoining the villages as well as degraded DP areas not in the catchments of the eight dams on a second priority basis. Areas in yellow on the map indicate this priority.

3) Treat the Sukhna catchment areas having vegetative density of 0.3 - 0.5 and the remaining areas of the DP on a third priority basis. Areas in green cross-hatching on the maps indicate this priority.

4) Do not treat the areas in either catchment having density of greater than 0.5. Instead, allow them to regenerate naturally. Areas in green on the map indicate such areas.

Figure 2: Estimated SWC Development Costs at Given Spacing with Ranked Long-Term Benefit

No.	SWC Technique	Spacing (m) and Comments	Development Costs (Rs./ha)	Ranked Long-Term Benefit
1 a.	Bhabbar	0.5x0.5	2,400	2
1 b.	Bh. + Subabul	0.5x0.5 + 5x5	3,100	3
1 c.	Bh. + Khair	0.5x0.5 + 3x3	4,400	1
2 a.	Dholu/Sarala	1x1	1,400	5
2 b.	D/S + Fruit	1x1 + 5x5	2,200	4
3 a.	Jhoond	1x1 on nalas only	100	16
3 b.	Jh. + Shisham	1x1 + 3x3 nalas only	800	15
3 c.	Jh. + Fruit	1x1 + 3x3 nalas only	900	14
4	Churi	0.3x0.3 random dibbling	1,100	18
5	Bamboo	3x3	2,900	6
6	Mendar/Karonda	3x3	2,900	13
7	Agave	10x10	100	22
8	Prosopis	3x3	2,900	12
9	Chhal	3x3	2,900	11
10 a.	Fruit: Ber	3x3	2,900	21
10 b.	Jamun	3x3	2,900	7
10 c.	Guava	3x3	2,900	8
11	Brush Checkdam	100 BCDs per ha	1,600	17
12	Trenches	3x6 staggered	3,700	9
13	Gully Plugs	100 GPs per ha	3,800	10
14	Contour Bunds	20 m intervals	200	23
15	Checkdams	1 CD per ha	4,900	19
16	Gabion Checkdams	1 GCD per ha	6,200	20

Figure 3: SWC Assumed Preferences for HFD and HRMS  
with Combined Preference Ranking

SWC Technique	HFD Preference Ranking	HRMS Preference Ranking	Combined Preference Ranking	Preferred SWC Technique	Combined Preference Ranking	Ranked Long-Term Benefit
Agave	5	22	27	Bhabbar	13 (1)	2
Bamboo	6	8	14	Bamboo	14 (2)	6
Bh. + Khair	9	7	16	Dholu/Sarala	15 (3)	5
Bh. + Subabul	10	6	16	Bh. + Subabul	16 (4)	3
Bhabbar	12	1	13	Checkdams	19 (5)	19
Brush Checkdam	16	19	35	Gabion Ch'dams	21 (6)	20
Checkdams	2	17	19	Jh. + Shisham	21 (7)	15
Chhal	7	15	22	Prosopis	21 (8)	12
Churi	18	16	34	Trenches	21 (9)	9
Contour Bunds	17	23	40	Chhal	22 (10)	11
D/S + Fruit	19	3	22	D/S + Fruit	22 (11)	4
Dholu/Sarala	13	2	15	Gully Plugs	25 (12)	10
Fruit: Ber	21	14	35	Jhoond	25 (13)	16
Gabion Ch'dams	3	18	21	Bh. + Khair	26 (14)	1
Guava	22	4	26	Guava	26 (15)	8
Gully Plugs	4	21	25	Agave	27 (16)	22
Jamun	23	5	28	Mendar/Karonda	27 (17)	13
Jh. + Fruit	20	9	29	Jamun	28 (18)	7
Jh. + Shisham	11	10	21	Jh. + Fruit	29 (19)	14
Jhoond	14	11	25	Churi	34 (20)	18
Mendar/Karonda	15	12	27	Brush Checkdam	35 (21)	17
Prosopis	8	13	21	Fruit: Ber	35 (22)	21
Trenches	1	20	21	Contour Bunds	40 (23)	23

## **IMPLEMENTATION**

The success of beat level micro-planning has its basis in the interaction between the Forest Guard (FG) and the village HRMS. It has been observed that the Rakha often has excellent rapport with villagers; this should be utilized by the FG to full advantage. Additionally, the HRMS Programme staff will provide support in resolving critical problem issues. It is intended that such a process become part of the HFD's regular program; as such, it is critical that other staff, from Divisional Forest Officer (DFO), to Range Officer (RO), and Block Officer (BO), be included in various phases of planning. Responsibility for implementation will ultimately lie with the DFO and associated staff.

The suitable timeframe for the implementation of the Dhamala Beat Plan depends on the intensity of treatment. Top priority treatment could be done over three consecutive years. Periodic maintenance is also proposed; this makes the implementation an ongoing process.

## **FOLLOW-UP**

As follow-up to the beat micro-planning exercise for Dhamala, the consultant has prepared the materials for an extension manual on SWC including vegetative, physical, and management options for use by the Rakha, the FG, and the BO in an interactive process with HRMSs in other beats of the Pinjore and Morni Ranges.

## **GLOSSARY OF LOCAL TERMINOLOGY**

### Erosion Control

Daul - field bund, specifically in agricultural fields  
Jhadi ki bad - brushwood checkdam, also brush fence  
Naka - stone barrier or wall  
Nakabandi - gully plugging  
Tarwala dam - gabion reinforced checkdam  
Vatbandi - earthen bunding

### Hydrology

Choa - ravine  
Jhiri - rill  
Nala - gully  
Nali - rivulet

## Landforms

Choti - peak, also high ridge  
Dhang - vertical cliff  
Ghati (kati) - valley  
Halka Dhalan - medium to low slope  
Khud - chasm, as opened by erosive flow of water  
Lassa (dhang ka lassa) - debris collapsed from a vertical cliff  
Shamba - steeply sloped, denuded face of hard soil  
Thapar - gently sloped area of deep soils supporting rich  
vegetation  
Tibbi - peak

## Resource Use and Management

Baan - rope made of bhabbar, either by hand or by machine. Baan  
sells for Rs. 5-8/kg (hand-made), or Rs. 7-10/kg (machine-made).  
Dati - literally, sickle; also annual rate payable to the HRMS by  
one member [household] to harvest MFP under lease from the HFD  
Rakha - Forest watchman employed by the FD on a daily wage basis.  
The Rakha was traditionally appointed by villagers for non-cash  
remuneration.

## Soils

Bajri - gravel  
Balu - sand  
Chhara - sodic soil, specifically agricultural  
Chikun - clay  
Dakkar - deposited sediment  
Domut - literally, two soils; mixed soil  
Kalar - saline soil, specifically agricultural  
Kankar - stone, also hardpan  
Mulwa - organic matter  
Rode - pebbles  
Sil - boulder  
Siyoti - sloping land, suitable for rainfed agriculture

## Species

Amrud - Guava  
Bans - *Dendrocalmus strictus*, Bamboo  
Bhabbar - *Eulaliopsis binata*  
Ber - *Zyzyphus*  
Buti - *Lantana*  
Chhal - *Anugosis latifolia*  
Churi - ?  
Curry patha - *Morinda cunigii*  
Dholu - *Chrysopogon fulvus*

Gesain - ?  
 Jamun - *Syzygium cumini*  
 Kachnar - *Bauhinia variegata*  
 Khahand - ?  
 Khair - *Acacia catechu*  
 Khus - *Vetiveria zizanioides*  
 Jhoond - *Sacharum manja*  
 Jingan - *Lania coromandelica*  
 Karonda - ?  
 Kikar - *Acacia nilotica*  
 Mascat - *Prosopis juliflora*, mesquite  
 Mendar - *Didonia*  
 Neem - *Azadirachta indica*  
 Phulai - *Acacia modesta*  
 Ramban - *Agave*  
 Reru - *Acacia leucophloea*  
 Sapheda - *Eucalyptus spp.*, Eucalyptus  
 Saras - *Albizzia procera*  
 Shisham - *Dalbergia sisoo*  
 Sarala - *Heteropogon contortus*  
 Subabul - *Leucaena leucocephala*  
 Thur - *Euphorbia*

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