

**BIOMASS ESTIMATION STUDY IN
HARYANA COMMUNITY FORESTRY PROJECT
VILLAGES**

Final Report

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BIOMASS ESTIMATION STUDY IN HARYANA COMMUNITY FORESTRY PROJECT VILLAGES

1.0 Introduction

The Haryana Forest Department (**HFD**) is currently implementing the Haryana Community Forestry Project (**HCFP**) in eleven districts of the State, targeting 337 villages in 37 Community Development Blocks of five Project forest divisions. The overall objective of the Project is capacity building of rural communities to improve the natural environment and to preserve land fertility by sustainable management of natural resources through activities undertaken in a participatory manner. Two key project purposes are: (i) to achieve improved sustainable management of common property resources that have been degraded because of the loss of biomass and of topsoil, due to both runoff and wind erosion; and (ii) to diversify farming systems on private lands in order to have block and boundary plantations.

Accordingly, a Forest Cover and Biomass Monitoring Baseline Study was commissioned by the Project in 2006-2007 through the Consulting Engineering Services (India) Private Limited, New Delhi. This baseline study included land use, tree density and biomass estimation for areas covered by five high resolution satellite imagery sub-scenes. The study was based on archive satellite imagery from the year 2000 and did not include plantations raised by the project subsequently. The study was also undertaken to see the implication of the activities planned under the Project in terms of bio-volume (biomass) trends and to suggest interventions that could be implemented in the Project villages.

The main objective of Forest Cover and Biomass Monitoring Study was to provide a baseline for monitoring subsequent changes in land use, vegetative cover and biomass. The other objectives of the study were as given below.

- To provide a baseline monitoring of forest cover changes on common lands, institutional lands and private farmlands.
- To provide a baseline for monitoring of biomass trends in the areas under forest cover and in other major land uses.
- To provide a baseline to enable monitoring of changes in the use of wastelands.

The study was undertaken in 27 selected villages of five Community Development (CD) Blocks included in five districts of the State as indicated in **Table 1**.

Table 1: Villages Included in Baseline Monitoring Study

District	Community Development Block	Villages included
Ambala	Barara	Bhudian Ramgarh Talheri Gujran Kakarkun Nurhad Taprian Thakurpura Gokalgarh Paplotha
Yamunanagar	Chhachhrauli	Darpur Ibrahimpur Jatanwala Khilanwala Meghuwala Baniwala Kansli Bagpat
Sirsa	Ellenabad	Podka Mithi Surera Khari Surera
Bhiwani	Loharu	Singhani Gothra Jhumpa Kalan
Mahendragarh	Kanina	Sihor Dhanunda/ Kharkharawas Chelawas Gudha

The volume tables used for calculation of bio-volumes of different land use classes and biomass components by various species (using 5 to 10% sampling) are given in **Tables 2 to 8**. Though the Haryana Forest Department has volume tables for certain species (*Eucalyptus*, poplars, shisham, etc), the volume tables used for the baseline study were slightly modified and reconstructed, using 15 cm girth classes on the basis of ground truth verification. Where no volume tables were available for certain species (*Ailanthus*), such species were taken as miscellaneous species using volume tables for *Acacia nilotica*.

Table 2: Volume Table for *Eucalyptus*

Girth (cm)	Girth Class	Total Volume (m ³)
0-15	1	0.013
15-30	2	0.0201
30-45	3	0.0753
45-60	4	0.1853
60-75	5	0.3453
75-90	6	0.5613
90-105	7	0.8263
105-120	8	1.1527
120-135	9	1.5327
135-150	10	1.9740
150-165	11	2.4690
165-180	12	3.0200
180-195	13	3.6200
195-210	14	4.2787
210-225	15	4.9887
225-240	16	5.6987
240-255	17	6.4087

Table 3: Volume Table for *Poplar*

Girth (cm)	Girth Class	Total Volume (m ³)
0-15	1	0.0160
15-30	2	0.0180
30-45	3	0.0460
45-60	4	0.1140
60-75	5	0.1960
75-90	6	0.3448
90-105	7	0.5740
105-120	8	0.8508
120-135	9	1.1835
135-150	10	1.5633
150-165	11	1.8900
165-180	12	2.5013
180-195	13	3.0580
195-210	14	3.6580
210-225	15	4.3240
225-240	16	5.0203
240-255	17	5.8048

Table 4: Volume Table for Shisham (*Dalbergia sissoo*)

Girth (cm)	Girth Class	Total Volume (m ³)
0-15	1	0.013
15-30	2	0.029
30-45	3	0.060
45-60	4	0.1354
60-75	5	0.24355
75-90	6	0.38645
90-105	7	0.56195
105-120	8	0.77565
120-135	9	1.01595
135-150	10	1.302
150-165	11	1.6168
165-180	12	2.0355
180-195	13	2.52195
195-210	14	3.06015
210-225	15	3.6501
225-240	16	4.2918
240-255	17	4.9864
255-270	18	5.73275
270-285	19	6.53085
285-300	20	7.3807
300-315	21	8.28345

Table 5: Volume Table for Babool (*Acacia nilotica*) and Miscellaneous Species

Girth (cm)	Girth Class	Total Volume (m ³)
0-15	1	0.0004
15-30	2	0.0114
30-45	3	0.0538
45-60	4	0.1276
60-75	5	0.2329
75-90	6	0.3696
90-105	7	0.5378
105-120	8	0.7374
120-135	9	0.9684
135-150	10	1.2308
150-165	11	1.6050
165-180	12	1.9800
180-195	13	2.4600
195-210	14	2.8300
Above 210	15	3.5400

Table 6: Volume Table for Khair (*Acacia catechu*)

Girth (cm)	Girth Class	Total Volume (m ³)
0-15	1	0.0215
15-30	2	0.0519
30-45	3	0.0816
45-60	4	0.1348
60-75	5	0.2542
75-90	6	0.4094
90-105	7	0.5845
105-120	8	0.7712
120-135	9	0.9654
135-150	10	1.1648

Table 7: Volume Table for Kikar (*Acacia tortilis*)

Girth (cm)	Girth Class	Total Volume (m ³)
0-15	1	0.024
15-30	2	0.075
30-45	3	0.125
45-60	4	0.235
60-75	5	0.315
75-90	6	0.575
90-105	7	0.915

Table 8: Volume Table for Jand (*Prosipis cineraria*)

Girth (cm)	Girth Class	Total Volume (m ³)
0-15	1	0.00024
15-30	2	0.00684
30-45	3	0.03228
45-60	4	0.07656
60-75	5	0.13974
75-90	6	0.22176
90-105	7	0.32268
105-120	8	0.44244
120-135	9	0.58104
135-150	10	0.73848

Five final reports (one for all villages in each CD Block) for the above baseline study were prepared in May 2007 and submitted to HCFP for their consideration. These reports present a detailed account of baseline assessment of biomass (volume) of the selected 27 HCFP villages of five CD Blocks. For each of the villages biomass has been given in m³ for stem wood only and not for other components of trees, like bark, leaves, roots etc.

2.0 The Present Study

The present study is a follow up to the earlier study on "Biomass Estimation Study in HCFP Project Villages." There have been a number of project interventions in these villages which are expected to have an impact on biomass trends in areas under forest cover and other major land uses.

Of the first 27 project villages where a baseline study was undertaken, one village namely *Paplotha* has been dropped from the present study while *Dhanunda/Kharkharawas* treated as one village in the earlier study, have been treated as two villages. The total number of villages in the present study, therefore, remain as 27 (as earlier). Four villages namely, *Bhudian*, *Nurhad*, *Thakurpura* and *Gokalgarh* have not been dealt with in the present study as there is no baseline data available for

plantations in these four villages. Only crown covers of these plantations have been recorded.

2.1 *Species Planted*

The species planted in various afforestation areas in different plantation years under different models are as follows.

1. *Acacia catechu* (Khair)
2. *Eucalyptus hybrid* (*Eucalyptus*)
3. Poplar (*Populus deltoides*)
4. *Dalbergia sissoo* (Shisham)
5. *Mangifera indica* (Aam)
6. *Prosopis cineraria* (Jand/Jhanti)
7. *Tecomella undulate* (Rohida)
8. *Azadirachta indica* (Neem)
9. *Acacia tortilis* (Isrili Kikar/Tortlis)
10. *Cassia siamea* (Kasood)
11. *Ailanthus excelsa* (*Ailanthus*)
12. *Acacia nilotica* (Babul)
13. *Melia azedarach* (Bakain)
14. *Salvadora oleoides* (Jaal)
15. *Zizyphus mauritiana* (Beri)
16. *Embilica officinalis* (Amla)
17. *Acacia leucophloea* (Raunj)
18. *Albizzia lebbeck* (Siris)
19. *Cordia oblique* (Lasoda)
20. *Pongamia pinnata* (Papri)
21. *Morus alba* (Shehtoot)

2.2 *Land Use Classes/Project Components/ Models*

As a result of a preliminary field survey and the project documents/data available, the following land use classes/Project components/ Models have been identified for bio-volume (biomass) estimation for the project villages included in the present study.

Community/Village Woodlots: These woodlots include tree cover on *Panchayat*, community or village lands either owned by *Panchayat*, Communities or villagers.

Private Woodlots: These woodlots comprise of tree cover on private lands independently or jointly. These areas are not under cultivation.

Boundary Plantations: These plantations comprise of tree cover along field boundaries or in line plantations in a linear fashion.

Cultivated Land: These lands are under cultivation (including current/periodic fallows) and carry some trees.

2.3 Biomass and Bio-volumes

It has been explained in the earlier baseline study that a strict definition of biomass may not be applicable with regard to biomass estimation study. In order to monitor the changes in the cover types and cover condition, volume is a more accurate and reliable indicator of biomass and therefore, has been used as a parameter to reflect the bio-volume changes as a result of implementation of the Project. Bio-volumes therefore have been used in the present study also.

IKONOS imagery of 1 mm resolution was used in the baseline study along with field checks to meet the objectives of that study. A reference to the imageries shows that it was hard to delineate plantations carried out after 2001-02 and as such only plantations of 2001-02 and prior to that have been taken into account in the baseline study. It needs to be mentioned here that bio-volumes of plantations have been given in terms of species by total number of trees and not by area.

A perusal of the reports of the baseline study and thereafter discussions with HCFP, it was decided that all plantations raised under different models, in the 27 villages under study, should be enumerated and their bio-volumes calculated on per ha basis. It was also decided that bio-volumes of boundary plantations/line plantations should be calculated per 100 m of length of these plantations. This was accordingly done for all plantations of the 27 villages in the present study.

The enumeration of trees in all plantations of 27 villages included in the present study was done by various land use classes/models, the year of formation of plantations and species. The results of the enumerations were expressed on per ha basis (for community/village woodlots and private woodlots) and for 100 m of length (for boundary/line plantations) as mentioned above. Stratified random sampling technique was used in the study, using 10% sample for community/village and private woodlots and 5% sample for boundary/line plantations. All the trees standing on the cultivated lands were counted and measured.

3.0 Bio-volumes of Plantations

The bio-volumes of various plantations by villages in different blocks are given in tables subsequently. As much information as was available from the project records or otherwise, collected during the field survey and discussions with the villagers and project officials has been incorporated in these tables. Though complete and exact information was not available at times, to that extent the figures presented in the present study could be approximate.

3.1 Barara Block, Ambala District

Ambala District is bounded by Siwalik foothills of Sirmaur District (Himachal Pradesh) in the North, Yamunanagar District in the East, Kurukshetra District in the South and Patiala District (Punjab) in the West. The total geographical area of the District is 1,48,602 ha and its population (2001 census) was 10,13,660.

The District has an intermixed topography of sharply rising Siwalik hills, foothills, rolling plain in the North-East and a flood plain along the Ghaggar river. Morni hills lying in Panchkula tehsil constitute the highest point in the District as well as in Haryana. The general slope of the district is from North-East to South-West, in which direction majority of the rivers, streams and torrents laden with gravels and pebbles flow, spreading the load over their beds. The important rivers and streams of the District are Ghaggar, Markanda, Tangri, Begna and Baliali.

The climate of the area is generally sub-tropical, which is sub humid in nature with extreme temperature variations between summer and winter seasons. During summer the maximum and minimum temperatures vary from 35.8 to 39.6° C and between 19.6 and 26.6° C respectively. During winter the maximum and minimum temperature varies from 20.4 to 29.0° C and between 7.4 and 13.9° C, respectively. The relative humidity ranges between 84% and 41% (8.30 hrs) and between 70% and 26% (17.30 hrs) in the months of August and May. The total annual rainfall of the region is 960 mm. The region hardly faces any drought and has a good ground water irrigation network to support agricultural.

The soils of the district are mainly alluvial and deep. The texture varies from sandy to loam. The plains carry deep loam soil with sandy soils dominating along the rivers. Near the foothills gravel deposits occur and the soils are mixed with various proportion of gravel. Soils are well drained.

The vegetation consists of Subtropical and Tropical Dry Deciduous Forest confined to hills and foothills and degraded cover as shrubs and tall grasses along the rivers and streams. Shisham (*Dalbergia sissoo*), Kikar, Mango (*Mangifera indica*) are indigenous. *Eucalyptus* and poplar (*Populus deltoids*) constitute the dominant cover in the plains. Miscellaneous species like *Khair*, *Anogeissus latifolia*, *Diospyros* sp. are confined to the hills. Tall grasses like *scccharum* are found along the river.

There are nine villages of Barara Block of this District included in the present study of which one village namely *Paplotha* has been dropped from the study and four other villages – *Bhudian*, *Nurhad*, *Thakurpura* and *Gokalgarh* have no baseline data available and as such have not been included in the study. There are, therefore, only four villages – *Ramgarh*, *Talheri Gujran*, *Kakar Kun*, and *Taprian* of this block included in the present study. Brief details of these villages and their bio-volume (biomass) estimates are given hereafter.

3.1.1 Village Bhudian

There is no baseline data for this village and excluded from the study. The crown cover varies from 50 to 70%.

3.1.2 Village Ramgarh

Greater part of the village lies on the eastern bank of Markanda river and adjoins Jhar Majra village. The soil is deep, fertile and loamy but sandy near the river. The village is intensively cultivated. Agriculture is the principle economy.

The Bio-volumes (Biomass) estimates by different land use classes of the village are given in **Table 9**.

Table 9: Bio-volumes (Biomass) Estimates of village Ramgarh

Model	Plantation year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha Or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	2004-05	-	4x2.5	<i>Eucalyptus</i>	23.50	23.50
		-	4x2.5	<i>Eucalyptus</i>	29.80	
		-		Kikar	0.30	
		-		<i>Shisham</i>	0.23	
	2005-06	-	4x2.5	<i>Eucalyptus</i>	26.70	26.81
		-		Kikar	0.11	
		-				
Private Woodlot	3 year coppice	1.2	3x3	<i>Eucalyptus</i>	33.55	33.55
	2001-02	1.62	3x1	<i>Eucalyptus</i>	73.14	73.14
	2005-06	2.83	4.5x4	<i>Eucalyptus</i>	12.10	12.10
	2006-07	0.40	3.6x3.6	Poplar	12.16	12.16
Boundary Plantation	2001-02	-	2	Poplar	10.96/100 m	10.96/100 m
	2002-03	-	0.7	Poplar	19.22/100 m	19.22/100 m
	2003-04	-	2	<i>Eucalyptus</i>	7.12/100 m	7.12/100 m
	2003-04	-	1	<i>Eucalyptus</i>	18.53/100 m	18.53/100 m
	2004-05	-	1	Poplar	7.61/100 m	7.61/100 m
	2 year coppice	-	1.5	<i>Eucalyptus</i>	2.44/100 m	2.44/100 m
	2005-06	-	1	<i>Eucalyptus</i>	6.52/100 m	6.52/100 m
-	-		1	Poplar	3.62/100 m	3.62/100 m

3.1.3 Village Talheri Gujran

The village adjoins Gaganhari on the western side of Ganganhari protected forest. The soil is deep, fertile and loamy. The area is intensively cultivated and as such there are not any community woodlots except for one where Kikar has come up naturally. Agriculture is the main economy of the village.

The bio-volumes (Biomass) estimates for different land-use classes of the village are given in **Table 10**.

Table 10: Bio-volumes (Biomass) Estimates of village Talheri Gujran

Model	Plantation year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	<i>There is a three year old community woodlot of natural Kikar with a total volume of 3.83 m³/ha</i>					
Private Woodlot	2002-03	1.21	4.5x4.5	Poplar	71.82	71.82
	2004-05	1.01	3x2	<i>Eucalyptus</i>	53.15	53.15
	2005-06	1.21	2x2	<i>Eucalyptus</i>	37.99	37.99
			4x4	Poplar	59.68	59.68
			4x4	Poplar	27.68	27.68
	2006-07	-	4x4	Poplar	10.76	10.76
Boundary Plantation	2001-02	-	1.5	<i>Eucalyptus</i>	17.29/100 m	17.29/100 m
			3.0	Poplar	4.27/100 m	4.27/100 m
	2003-04	-	1.75	Poplar	11.01/100 m	11.01/100 m
	2004-05	-	1.0	<i>Eucalyptus</i>	10.57/100 m	10.57/100 m
	2005-06	-	1.0	<i>Eucalyptus</i>	2.57/100 m	2.57/100 m
			1.25	<i>Eucalyptus</i>	2.17/100 m	2.17/100 m
			1.5	Poplar	3.11/100 m	3.11/100 m
	2006-07	-	2.25	<i>Eucalyptus</i>	0.62/100 m	0.62/100 m
			2.0	Poplar	0.90/100 m	0.90/100 m
Cultivated Land	<i>There are 20 plants of Mango planted in 1989-90 (18 years) existing at present with a total volume of 6.45 m³</i>					

3.1.4 Village Kakarkun

The village lies on both sides of Markanda river which follows close to the settlement. The village adjoins Dharaura village on the south and Nurhad village on north-east, greater part of the village lying on the north of the river. The soils are deep, fertile and

loamy, though they are sandy near the river. The village is extensively cultivated, agriculture being the principal economy.

The bio-volumes (Biomass) estimates for different land use classes of the village are given in **Table 11**.

Table 11: Bio-volumes (Biomass) Estimates of village Kakarkun

Model	Plantation Year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	2002-03	12	4x2.5	<i>Eucalyptus</i>	30.88	30.88
	2003-04	2	4.x25	<i>Eucalyptus</i> <i>Shisham</i>	2.96 28.12	31.08
Village Woodlot	15 year old	2.0	2x2	<i>Eucalyptus</i>	174.77	174.77
	8 year old	-	-	<i>Shisham</i>	36.476	36.476
Private Woodlot	2005-06	0.51	4.5x4.5	Poplar	17.84/100 m	17.84
	2006-07	-	4x2	Poplar	15.72/100 m	15.72
Boundary Plantation	1997-98	-	2.0	Poplar	24.4/100 m	24.4/100 m
	2002-03	-	1.0	<i>Eucalyptus</i>	22.23/100 m	22.23/100 m
	2004-05	-	1.0	<i>Eucalyptus</i>	3.81/100 m	3.81/100 m
	2005-06	-	1.0	<i>Eucalyptus</i>	2.12/100 m	2.12/100 m
				1.5	Poplar	2.91/100 m
Cultivated Land	<i>There are at present, (1) 10 trees of Mango (12-13 years of age) with a total volume of 8.47 m³, and (2) 8 trees of Shisham (7-14 years of age) with a total volume of 5.18 m³.</i>					

3.1.5 Village Nurhad

There is no baseline data for this village, hence excluded from the study. The crown cover is 20%

3.1.6 Village Taprian

The village adjoins Mehwa Kheri and Nurhad villages. Soil is deep, fertile, and loamy, the area being intensively cultivated, with limited community woodlots. There is inadequate irrigation and hence *Eucalyptus* is important for boundary plantations. Agriculture is the main economy.

The bio-volumes (Biomass) estimates for different land-use classes in village Taprian are given in **Table 12**.

Table 12: Bio-volumes (Biomass) Estimates of village Taprian

Model	Plantation Year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	2002-03	14.0	4x2.5	<i>Eucalyptus</i>	40.96	44.89
			4x2.5	Kikar	3.93	
	2003-04	2.0	4x2.5	<i>Eucalyptus</i>	44.90	44.90
Private Woodlot	2 year coppice	2.0	3x2	<i>Eucalyptus</i>	25.80	25.80
	1 year Coppice	2.20	4x2.5	<i>Eucalyptus</i>	11.96	11.96
Boundary Plantation	2002-03	-	1.0	<i>Eucalyptus</i>	14.16/100 m	14.42/100 m
	2003-04	-	1.0	<i>Eucalyptus</i>	1.56/100 m	1.56/100 m
	2004-05	-	1.0	<i>Eucalyptus</i>	1.65/100 m	1.65/100 m
	2005-06	-	1.0	<i>Eucalyptus</i>	1.30/100 m	1.30/100 m
	2006-07	-	1.25	<i>Eucalyptus</i>	1.29/100 m	1.29/100 m

3.1.7 Village Thakurpura

There is no baseline data for this village and as such excluded from the study. The crown cover is varies from 35 to 50%.

3.1.8 Village Gokalgarh

There is no baseline data for this village and as such excluded from the study. The crown cover is 70%.

3.2 Chhachhrauli Block, Yamunanagar District

Yamunanagar District is bounded by the State of Himachal Pradesh in the north, Uttar Pradesh in the east and south-east, districts of Karnal and Kurukshetra in the south-west and by Ambala District in the west. Yamuna river forms the eastern boundary with Uttar Pradesh and the main Siwalik ridge separates the state boundary between Haryana and Himachal Pradesh in the north.

The configuration of the district can be broadly distinguished into three types: the Siwaliks, the foothills and the plains. A large part of the district comprises of Government forest, the bulk of the forest lying in one broad belt along the northern boundary of the tract extending west from the river Yamuna to a length of 16 km, with width varying from 7 to 10 km.

The soils, due to variation in topography, intensity of erosion, parent material, and other factors, exhibit variation in many characteristics like texture, depth, colour, drainage, moisture status etc.

The plains are formed by alluvial deposits of river Yamuna and its tributaries. The soils range from heavy clay to light loamy, mostly mixed with gravel and sand stones. Soils are generally deep with good drainage. Soil erosion varies from slight to moderate.

Siwalik belt consist of sand stone and conglomerates which are often soft and friable. The bands of clay are interbedded with these sand stones and conglomerates giving cohesion to the soils. The soils resulting from Siwalik sand stone are mostly sandy loam. On the steeper slopes it is dry and tends to support xerophytic vegetation. The soils on steeper slopes and ridges are shallow, but the lower slopes have a proportional amount of clay and the drainage is good.

The climate of the area is sub-tropical with distinct seasons of winter, summer and the monsoon. Normally the months from November to February are cold whereas the hot season extends from March to the advent of the monsoons in the last week of June or first week of July.

The vegetation of the area consists of Tropical Dry Deciduous Forest confined to hills, foothills and degraded cover of *shrubs* and tall grasses along the rivers and streams. Khair (*Acacia catechu*), Shisham (*Dalbergia sissoo*), Kikar, Mango (*Mangifera indica*) are natural species. *Eucalyptus* and poplar (*Populus deltoids*) constitute the dominant cover in the plains. Miscellaneous species like *Anogeissus latifolia*, *Diospyros* sp. are confined to the hills. Tall grasses like *saccharum* are found along the river. Babul (*Acacia nilotica*) and Neem (*Azadiracta indica*) are important species grown in the plains.

There are eight villages of Chhachhrauli Block of this district included in the present study, namely Darpur, Ibrahimpur, Jatanwala, Khilanwala, Meghuwala, Baniawala, Kanshi and Bagpat. Brief details of these villages and their Bio-volume (Biomass) estimates are given hereafter.

3.2.1 Village Darpur

The village lies north-east of Jatanwala village on the right bank of Palasi Khol and adjacent to it. The soil is generally deep and varies from heavy clay to light loam mostly mixed with gravel and sandstones. The soil is more or less sandy near the river. It has generally good drainage and suitable for cultivation.

Bio-volumes (Biomass) estimates for different land use classes for the village are given in **Table 13**.

Table 13: Bio-volumes (Biomass) Estimates of village Darpur

Model	Plantation Year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³ /ha or per 100m)
Community Woodlot	2001-02	11.0	4x2.5	<i>Eucalyptus</i>	77.28	77.28
	2002-03	6.0	4x2.5	Khair	35.99	35.99
	2003-04	20.0	4x2.5	<i>Shisham</i>	7.12	19.81
				Khair	12.69	
	2005-06	20.0	4x2.5	<i>Eucalyptus</i>	31.36	31.36
				9.0	4x2.5	<i>Eucalyptus</i>
			<i>Eucalyptus</i>			17.42
Private Woodlot	2001-02	-	2.5x2.5	<i>Eucalyptus</i>	61.52	61.52
	1 year coppice	-	2.5x1.5	<i>Eucalyptus</i>	30.81	30.81
	2002-03	-	4x4	Poplar	54.32	54.32
	2005-06	-	2.5x2.5	<i>Eucalyptus</i>	22.10	22.10
Boundary Plantation	2001-02	-	1.0	<i>Eucalyptus</i>	12.74/100 m	30.25/100 m
				Poplar	17.51/100 m	
	2 year coppice	-	1.5	<i>Eucalyptus</i>	1.65/100 m	1.65/100 m
	2002-03	-	1.0	<i>Eucalyptus</i>	7.52/100 m	7.52/100 m
	2005-06	-	1.0	<i>Eucalyptus</i>	1.49/100 m	1.49/100 m
				Poplar	5.39/100 m	5.39/100 m
2006-07	-	1.0	Poplar	1.77/100 m	1.77/100m	
Cultivated Land	<i>There are existing at present (1) 10 Mango trees (15 years of age) with a total volume of 7.32 m³, and Shisham (9 years of age) with a total volume of 1.33 m³.</i>					

3.2.2 Village Ibrahimpur

The village lies on left bank of Boli Nadi at the foothills of Siwalik which comprises of Ibrahimpur RF. The soil is mostly sandy loam, with bands of clay interbedded with sand stones and conglomerates, providing a binding nature to the soil. Generally the soil near the river is sandy and deep supporting good tree cover.

The bio-volumes (Biomass) estimates for different land use classes for village Ibrahimpur are given in **Table 14**.

Table 14: Bio-volumes (Biomass) Estimates of village Ibrahimipur

Model	Plantation year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	2001-02	4.0	4x2.5	<i>Eucalyptus</i>	37.90	37.90
	2002-03	10.0		Khair	15.17	15.17
Private Woodlot	2 year coppice	-	3x2.5	<i>Eucalyptus</i>	15.18	15.18
	2003-04	-	3x2.5	<i>Eucalyptus</i>	75.25	75.25
	2004-05	-	3x3	<i>Eucalyptus</i>	55.88	55.88
	2005-06	-	3x2	<i>Eucalyptus</i>	22.21	22.21
	2006-07	-	3x1	<i>Eucalyptus</i>	29.51	29.51
Boundary Plantation	2 year coppice	-	1.0	<i>Eucalyptus</i>	1.53	1.53/100 m
	1 year coppice	-	1.0	<i>Eucalyptus</i>	1.3/100 m	1.3/100 m
	2003-04	-	1.0	<i>Eucalyptus</i>	7.75/100 m	7.75/100 m
			1.0	Poplar	4.10/100 m	4.10/100 m
	2004-05	-	1.0	<i>Eucalyptus</i>	4.22/100 m	4.22/100 m
	2005-06	-	1.0	<i>Eucalyptus</i>	1.88/100 m	1.88/100 m
	2006-07	-	1.0	<i>Eucalyptus</i>	1.30/100 m	1.30/100 m
Cultivated Land	<i>There are present existing (1) two trees of Mango (25 years of age) with a total volume of 1.91 m³, and two trees of shisham (10-20 years of age) with a total volume of 1.97 m³.</i>					

3.2.3 Village Jatanwala

The village lies on the right bank of Palasi Khol and is located north-east of Sipianwala village. The soil is generally deep and shows marked variations from sandy to clayey varying between heavy clay to light loam mostly mixed with gravels and sandstones. Drainage is generally good and well suited for raising of plantations.

The bio-volumes (Biomass) estimates for different land use classes are given in **Table 15**.

Table15: Bio-volumes (Biomass) Estimates of village Jatanwala

Model	Plantation year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	2001-02	10.0	4x2.5	<i>Shisham</i>	35.99	35.99
			4x2.5	Khair	21.71	34.02
				<i>Shisham</i>	12.31	
Private Woodlot	2 year coppice	-	4x1.5	<i>Eucalyptus</i>	51.56	51.56
	2 year coppice	-	3x3	<i>Eucalyptus</i>	24.26	24.26
	2002-03	0.8	4x4	Poplar	70.72	70.72
Boundary Plantation	1 year coppice	-	1.0	<i>Eucalyptus</i>	2.40/100 m	2.40/100 m
	2001-02	-	1.0	Poplar	10.10/100 m	10.10/100 m
	2002-03	-	1.0	<i>Eucalyptus</i>	12.62/100 m	12.62/100 m
			1.0	Poplar	14.99/100 m	14.99/100 m
	2004-05	-	1.0	<i>Eucalyptus</i>	2.35/100 m	2.35/100 m
			1.0	Poplar	3.98/100 m	3.98/100 m
Cultivated Land	<i>There are existing 10 Mango trees (20 years old) with a total volume of 7.23 m³</i>					

3.2.4 Village Khilanwala

The village lies in the foothills of Siwalik on the right bank of Khilonwala Khol. Khilonwala PF is located north of the village in the Siwalik hills. The other villages which lies adjacent to Khilanwala are Meghawala in the west and Baniawala in north-west. The soil is generally deep, fertile, which varies from heavy clay to light loam mostly mixed with gravel and sandstone. Soil drainage is generally good and is suitable for cultivation.

The bio-volumes (Biomass) estimates for different land use classes in village Khilanwala are given in **Table16**.

Table 16: Bio-volumes (Biomass) Estimates of village Khilanwala

Model	Plantation Year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot Reserve Forest Area	2001-02	8.0	-	Khair	<i>The plantation has been lost due to fire. Presently the plants are all undersized, with too much crown cover</i>	

3.2.5 Village Meghuwala

The village lies on the left bank of Kansli Khol and is located south of Baniawala and west of Khilanwala villages. Soil is generally deep, fertile and varies from heavy clay to light loam, mostly mixed with gravel and sandstone. Soil drainage is generally good which is mostly sandy near the river.

The bio-volumes (Biomass) estimates for different land use classes of village Meghuwala are given in **Table 17**.

Table 17: Bio-volumes (Biomass) Estimates of village Meghuwala

Model	Plantation Year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	2002-03	12.0	4x2.5	<i>Shisham</i> Khair	4.69 13.10	4.69 13.10
	2003-04	10.0	4x2.5	<i>Eucalyptus</i> Shisham	25.60 4.62	30.22
			4x2.5	<i>Shisham</i> Khair	1.68 0.86	2.54
	2002-03		4x2.5	<i>Shisham</i>	6.93	6.93
Private Woodlot	2002-03	0.4	4x4	Poplar	58.28	58.28
Boundary Plantation	2002-03	-	1.0	Poplar	10.70/100 m	10.70/100 m
	2003-04	-	1.0	<i>Eucalyptus</i>	9.12/100 m	9.12/100 m
	2004-05	-	1.5	<i>Eucalyptus</i>	5.09/100 m	5.09/100 m
	2005-06	-	1.0	<i>Eucalyptus</i>	1.37/100 m	1.37/100 m
				Poplar	1.21/100 m	1.21/100 m
	2006-07	-	1.5	Poplar	1.10/100 m	1.10/100 m

3.2.6 Village Baniawala

The village lies north of Meghuwala village and is located between Chikan Khol and Kansli Khol which flow on the west and east respectively. The soil is deep, fertile and varies from heavy clay to light loam with a mixture of gravels and sandstones. Soils are generally sandy near the river. As soil drainage is good, it is good for raising plantations.

The bio-volumes (Biomass) estimates for different land use classes are given in **Table 18**.

Table 18: Bio-volumes (Biomass) Estimates of village Baniawala

Model	Plantation year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	2002-03	17.0	4x2.5	<i>Shisham</i>	15.20	15.20
			4x.25	Khair	5.19	5.19
Private Woodlot	2 year coppice	1.6	-	<i>Eucalyptus</i>	70.05	70.05
	2003-04	0.8	3.5x1	<i>Eucalyptus</i>	45.71	45.71
	2004-05	2.0	4x1	<i>Eucalyptus</i>	39.97	39.97
	2006-07	-	4x4	Poplar	6.24	6.24
Boundary Plantation	2002-03	-	1.5	<i>Eucalyptus</i>	8.45/100 m	8.45/100 m
				Poplar	12.42/100 m	12.42/100 m
	2003-04	-	1.0	<i>Eucalyptus</i>	1.96/100 m	1.96/100 m
	2004-05	-	1.0	<i>Eucalyptus</i>	1.39/100 m	1.39/100 m
	2006-07	-	1.0	Poplar	1.66/100 m	1.66/100 m
Cultivated Land	<i>There are existing 5 Mango trees (25 years old) with a total volume of 3.35 m³.</i>					

3.2.7 Village Kansli

Kansli is located between Kansli Khol in the east and Chikan Khol in the west. The Khilonwala PF is located in the eastern side of the village in the Siwlik foothills. The soil is mostly sandy loam, with layers of clay embedded with sandstones and conglomerates having a binding impact on the soil.

The bio-volumes (Biomass) estimates for different land use classes of village Kansli are given in **Table 19**.

Table 19: Bio-volumes (Biomass) Estimates of village Kansli

Model	Plantation year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Private Woodlot	2 year coppice	3.64	4x2	<i>Eucalyptus</i>	18.467	18.467
	2004-05	4.0	4x2	<i>Eucalyptus</i>	28.44	28.44

3.2.8 Village Bagpat

The village lies east of Khilonwala Khol. It is located south-east of Khilonwala village lying on the opposite bank of Khilonwala Khol. Nakud Nala flows east of Bagpat village. The soil varies from heavy clay to light loam mixed with gravels and sandstones and is generally deep with good drainage, making it suitable for cultivation.

The bio-volumes (Biomass) estimates for different land use classes of village Bagpat are given in **Table 20**.

Table 20: Bio-volumes (Biomass) Estimates of village Bagpat

Model	Plantation year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³ /ha or per 100 m)	Total volume (m ³ /ha or per 100m)
Community Woodlot	12 year old	16.0	4x2.5	Khair	72.11	72.11
Private Woodlot	2003-04	2.0	3x1.5	<i>Eucalyptus</i>	84.70	84.70
	2005-06	-	2.5x1	<i>Eucalyptus</i>	36.80	36.80
	2006-07	-	3x1.5	<i>Eucalyptus</i>	9.36	9.36
Boundary Plantation	2003-04	-	1.5	<i>Eucalyptus</i>	8.35/100 m	8.35/100 m
	2004-05	-	1.0	<i>Eucalyptus</i>	2.97/100 m	2.97/100 m
	2005-06	-	0.6	Poplar	2.42/100 m	2.42/100 m
	-	-	1.0	<i>Eucalyptus</i>	1.44/100 m	1.44/100 m
	2006-07	-	1.0	<i>Eucalyptus</i>	1.46/100 m	1.46/100 m

3.3 Ellenabad Block, Sirsa District

Sirsa District is bounded by Punjab in the north and north east, by Hisar District (Haryana) in the east and by Rajasthan in the South and South-west. The total area of the district is 4,27,600 ha.

The district consists of alluvial and sandy aeolian plains. The various landforms identified in the district comprise of sand dunes, aeolian plains, low lands/depressions and flood plains of river Ghaggar. Aeolian activity is mostly concentrated in the western and southern parts of the district. The dunes in this region are undulating in nature, plains relatively flat and majority of the depressions have concave topography. Ghaggar is the major river of this district along with river Saraswati.

The soil mainly consists of large alluvial tract between the Peninsula and Extra-Peninsula covered by thick alluvium deposited by river Ghaggar. The soil consists of clay, silt, fine to coarse sand and *kankar* in the lower depths. In south and south-west aeolian plains and sand dunes are also seen.

The climate is generally semi-arid with extreme temperature variations between summer and winter. During the summer the maximum and minimum temperatures vary from 41.0° C to 36.8° C and between 19.4° C and 27.2° C respectively. The total annual rainfall is between 200 to 400 mm most of which is received in July and August.

The natural vegetation is of Tropical Dry Deciduous Type. The important species are Babul (*Acacia nilotica*), Shisham (*Dalbergia sissoo*), Mesquite (*Prosopis chilensis*), Siris (*Albizzia lebbek*), Jaal (*Salvadora oleoides*), Jand (*Prosopis cineraria*) and Neem (*Azadirachta indica*), species like *Eucalyptus* and Poplar (*Populus deltoids*) have been introduced.

There are three villages of Ellenabad Block of this district included in the present study namely, Podka, Mithi Surera and Khari Surera. Brief details of these villages and their bio-volumes (Biomass) estimates are given hereafter.

3.3.1 Village Podka

The village is situated about 32 km from Sirsa. Bulk of the land is cultivated. The southern half and the eastern side of the village are having sandy features. The soil varies from sandy to loam with pockets of silty loam. On the southern side the sand is coarse in texture. Agriculture is the main economy of the village.

The bio-volumes (Biomass) estimates for different land use classes of village Podka are given in **Table 21**.

Table 21: Bio-volumes (Biomass) Estimates of village Podka

Model	Plantation Year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	2001-02	4	4x2.5	<i>Tortilis</i>	42.94	51.55
				<i>Ailanthus</i>	8.61	
	2002-03	4	4x2.5	<i>Raunj</i>	12.20	38.18
				<i>Tortilis</i>	25.98	
		4	4x2.5	<i>Eucalyptus</i>	32.916	32.93
				<i>Kikar</i>	0.012	
2005-06	4	4x2.5	<i>Eucalyptus</i>	33.09	33.09	
	3	4x2.5	<i>Shisham</i>	7.44	19.86	
			<i>Ailanthus</i>	12.42	19.86	
		1	4x2.5	<i>Tortilis</i>	18.72	18.72
Private Woodlot	2001-02	32.2	4x2.5	<i>Jandi</i>	3.52	3.52
		4	4x2.5	<i>Tortilis</i>	37.95	37.95
	2004-05	0.8	4x2.5	<i>Beri</i>	0.814	2.84
				<i>Jandi</i>	2.029	
		-	4x2.5	<i>Eucalyptus</i>	61.70	61.70
		-	4x2.5	<i>Babul</i>	18.83	18.83
	3.5	4x2.5	<i>Shisham</i>	32.41	32.41	
	2005-06	-	4x2.5	<i>Tortilis</i>	19.32	19.32
		1	4x2.5	<i>Eucalyptus</i>	6.41	6.41
		4	4x2.5	<i>Jandi</i>	0.18	0.18
2002-03	5.2	5x4	<i>Beri</i>	2.83	2.83	
Boundary Plantation	2001-02	-	4	<i>Shisham</i>	3.40/100 m	3.78/100 m
				<i>Kikar</i>	0.38/100 m	
	2002-03	-	3	<i>Eucalyptus</i>	6.80/100 m	6.80/100 m
		-	3	<i>Shisham</i>	3.61/100 m	3.61/100 m
		-	3	<i>Eucalyptus</i>	3.07/100 m	3.27/100 m
				<i>Kikar</i>	0.20/100 m	
	2003-04	-	3	<i>Eucalyptus</i>	2.77/100 m	2.77/100 m
		-	-	<i>Shisham</i>	1.43/100 m	1.50/100 m
		-	-	<i>Kikar</i>	0.06/100 m	
		-	-	-	-	-
	2004-05	-	3 m	<i>Eucalyptus</i>	0.69/100 m	0.69/100 m
		-	3 m	<i>Shisham</i>	0.81/100 m	0.87/100 m
			<i>Kikar</i>	0.06/100 m		
2005-06	-	3	<i>Shisham</i>	0.95/100 m	0.95/100 m	
	-	4	<i>Eucalyptus</i>	0.36/100 m	0.36/100 m	

3.3.2 Village Mithi Surera

The village is situated on the eastern side of the northern railway Hanumangarh – Sadulpur branch meter gauge line and south of *Sheranwali* distributory. The land in this village is largely cultivated. The soil varies from sandy to loam. The sandy areas are located on the eastern side of the village. Agriculture is the main economy of the village.

The bio-volumes (Biomass) estimates for different land use classes of village Mithi Surera are given in **Table 22**.

Table 22: Bio-volumes (Biomass) Estimates of village Mithi Surera

Model	Plantation Year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m	
Community Woodlot	15 year old 2001-02	56	3x3	Tortilis	53.12	53.12	
		2	2.5x2.5	<i>Ailanthus</i> Neem	72.35 13.01	85.36	
	2002-03	1	2.5x2.5	<i>Ailanthus</i> <i>Shisham</i> <i>Jandi</i>	207.59 46.17 0.61	254.37	
		1.2	2.5x2.5	<i>Ailanthus</i> <i>Shisham</i>	73.39 35.08	108.47	
		3.5	4x2.5	<i>Ailanthus</i> <i>Shahtoot</i>	233.23 11.28	244.51	
	2003-04	38.4	4x2.5	<i>Ailanthus</i> <i>Shisham</i>	42.99 20.26	63.25	
		0.6	4x2.5	Neem	2.11	2.11	
		1.6	2.5x2.5	<i>Ailanthus</i> <i>Shisham</i> <i>Jandi</i>	39.52 92.65 0.02	132.19	
	Private Woodlot	2002-03	1.5	5x4	<i>Shisham</i>	27.30	27.30
		2003-04	1.0	5x4	<i>Amla</i>	4.09	4.09
Boundary Plantation	2001-02	-	3	<i>Shisham</i>	5.51/100 m	5.51/100 m	
		-	3	<i>Shisham</i>	5.07/100 m	5.07/100 m	
		-	3	<i>Ailanthus</i>	8.74/100 m	8.74/100 m	
	2002-03	-	3	<i>Shisham</i>	2.65/100 m	2.65/100 m	
		-	4	<i>Eucalyptus</i>	3.90/100 m	3.90/100 m	
	2003-04	-	9	<i>Shisham</i>	1.18/100 m	1.18/100 m	
	2004-05	-	4	<i>Shisham</i>	1.46/100 m	1.46/100 m	
	2005-06	-	3	<i>Shisham</i>	0.55/100 m	0.55/100 m	

3.3.3 Village Khari Surera

The village is located close to Mithi Surera village on the western side of Hunumangarh-Sadulpur branch meter gauge railway line. It is largely cultivated with small patches of woodlots. The soil is deep, alluvial and varies from sandy to loam. The sandy areas are located on the southern side of the village. The climate and other physical features are similar to the district. Agriculture is the main economy of the village.

The vegetation consists of largely *Jhand*, *Neem Shisham*, *Beri*, *Rohera* (*Tacomella undulate*) etc.

The bio-volumes (Biomass) estimates for different land use classes of village Khari Surera are given in **Table 23**.

Table 23: Bio-volumes (Biomass) Estimates of village Khari Surera

Model	Plantation Year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	<i>There is an old community woodlot raised on institutional land (School) in 1987-88 and 1994-95 with Neem, Eucalyptus and Cassia siamea. The total number of trees existing with their volume is as (i) Neem (300 trees), volume 21.82 m³, (ii) Eucalyptus (20 trees), volume 9.36 m³, and (iii) Cassia siamea (300 trees), volume 28.35 m³.</i>					
Private Woodlot	2003-04	24	4x2.5	<i>Tortilis Babul</i>	10.94 1.69	12.63
Boundary Plantation	2001-02	-	4	<i>Shisham</i>	2.60/100 m	4.48/100 m
	-	-		<i>Eucalyptus</i>	1.16/100 m	
	-	-		<i>Ailanthus</i>	0.72/100 m	
	2003-04	-	3	<i>Shisham</i>	1.29/100 m	2.05/100 m
				<i>Eucalyptus</i>	0.76/100 m	
	2005-06	-	3	<i>Shisham</i>	0.40/100 m	0.65/100 m
				<i>Eucalyptus</i>	0.25/100 m	
	2006-07	-	3	<i>Shisham</i>	0.44/100 m	0.44/100 m
Cultivated Land	<i>There are existing 10 plants of Shisham (20 years), 15 plants of Jandi (20-25 years old) and 10 plants of Neem (20-25 years old) in the cultivated land. The total volume of these plants is 8.99, 5.03 and 4.37 m³ respectively.</i>					

3.4 Loharu Block, Bhiwani District

Bhiwani District is surrounded by Hisar District in the north, some area of Jhunjunu and Churu districts (Rajasthan) on the west, portions of Mahendragarh and Jhunjunu districts in the south and District Rohtak in the east. The total geographical area of the Bhiwani District is 50,9,900 ha and its population as per 2001 Census was 14,24,000.

The district has an intermixed topography with alluvial plains in the north and semi-desert with remnants of Aravalli ranges in the south.

The soils in the district are mainly sandy, sandy loam in flat plain and coarse sand on the dunes in the south-west region. The ground water in the project area varies from good to saline, the degree depending on location and flooding by local streams.

The natural vegetation belongs to Northern Tropical Thorn Forests, the composition varying according to topography. In the hills, it is constituted by *Acacia Senegal*, *Acacia nilotica*, *Butea monosperma*, *Zizyphus mauritiana*, *Cassia fistula*, *Amogeissus pendula* etc. In the plains *Prosopis cineraria* is the principal species. Other species are *Dalbergia sissoo*, *Neem*, *Ailanthus excelsa*, *Siris*, *Cordia obliqua*, *Capparis decidua*, *Salvadora oleoides* and *Tamarix articulata*. Important grasses are *Cenchrus ciliaris*, *Cenchrus setigerus*, *Cenchrus biflorus*, *Panicum antidotale* etc. *Erianthus munja* is an important grass on waste lands.

The greater part of the project falls under arid climate. The variations in temperature are extreme, varying from 2 to 45° C. Frost is common and adversely effects several tree species. Frost in 2005 killed even tall trees of *Neem* and younger plantations were severely damaged. The total rainfall is 483 mm, mostly in the months of July and August with occasional showers during the winter.

The predominant Kharif crops grown in this region are Millet (Bajra) and Pulses (Dal), while some of the main Rabi crops are Wheat (Grain), Barley (Jawar) and Gram.

There are three villages of Loharu Block of this district includes in the present study namely, Singhani, Gothra and Jhumpa Kalan. Brief details of these villages and their bio-volume (Biomass) estimates are given hereafter.

3.4.1 Village Singhani

Singhani village is surrounded by Kharkhari, Hasanpur, Jhanjhara Nayawas, Gignaw, Jhumpa Klan and Kishanpura villages in the north, west, south-west, south and south-east and east directions. The soil is deep and fertile and varies from sand to sandy loam in texture. It is intensively cultivated through irrigation canals and ground water sources like deep tube wells. Agriculture is the main source of economy in this village.

The bio-volumes (Biomass) estimates for different land use classes of village Singhani are given in **Table 24**.

Table 24: Bio-volumes (Biomass) Estimates of village Singhani

Model	Plantation Year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	2001-02	46.8	4x2.5	Tortilis	6.48	6.84
	2002-03	20.5	4x2.5	Tortilis	33.69	33.69
	2003-04	10.0	4x2.5	Babul	0.13	0.13
	2003-04	4.0	6x6	Neem	0.02	0.30
				Siris	0.07	
Shisham				0.20		
			Bakain	0.01		
<i>There are at present existing on a 16 ha of old community woodlot, 25 trees of Acacia tortilis (8 to 10 years (old) and 150 trees of Jaal (old trees). The total volume of these trees is: Acacia tortilis, 3.95 m³ and Jaal 108.39 m³</i>						
Private Woodlot	2001-02	-	5x4	Ailanthus Shisham Jandi	33.50 9.60 0.12	43.22
	2005-06	24.0	4x2.5	Ailanthus	5.14	5.14
Boundary Plantation	2002-03	-	2.5	Shisham	1.14/100 m	1.14/100 m
	2003-04	-	3	Shisham	0.95/100 m	0.95/100 m

3.4.2 Village Gothra

Village Gothra is surrounded by Gignaw, Singhani, Jhanjara Nayawas, Jhanjara Soran, Damkura and Kushalpura villages in east, north-east, north, north-west and west and south directions. The Loharu canal which flows along the southern boundary of the village, transcends in a west to east direction. The Jhanjara Minor passes through the village in a north-west to south direction.

Soil is deep and sandy loam in texture. It is, fertile and is intensively cultivated through irrigational canals and ground water sources namely, deep tube wells. The lands are largely cultivated. Agriculture is the main economy of the people of this village.

The bio-volumes (Biomass) estimates for different land-use classes of village Gothra are given in **Table 25**.

Table 25: Bio-volumes (Biomass) Estimates of village Gothra

Model	Plantation year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	2003-04	-	2.5x2.5	<i>Ailanthus</i>	21.09	21.09
Private Woodlot	2001-02	-	-	<i>Shisham</i> <i>Ailanthus</i> <i>Papri</i> <i>Janti</i>	10.79 0.04 0.02 0.01	10.86
	2001-02	1.6	5x4	<i>Shisham</i> <i>Janti</i> <i>Ailanthus</i> <i>Siras</i>	5.51 -- 1.28 0.54	
		0.8	5x4	<i>Janti</i> <i>Ailanthus</i>	0.01 0.02	0.03
	2002-03	5.0	5x4	<i>Ailanthus</i> <i>Shisham</i>	13.81 14.09	27.90
	2002-03	0.5	5x4	<i>Shisham</i> <i>Ailanthus</i> <i>Amla</i>	0.55 16.46 4.72	21.73
	Boundary Plantation	2002-03	-	2.5	<i>Ailanthus</i>	9.63/100 m
2004-05		-	2.5	<i>Ailanthus</i>	0.77/100 m	0.77/100 m
Cultivated Land	<i>There are 10 trees of Shisham (12 years old), in the cultivated land with a total volume of 4.78 m.³</i>					

3.4.3 Village Jhumpa Kalan

Jhumpa Kalan village is surrounded by Kishanpura, Singhani, Jhumpa Khurd, Gignaw, Dhani Toda, Dadowala, Johar and Jhumpa Khurd and Govindpura Kalan villages in north-east, north, west, south-west, south, south-east and east directions.

Soil is deep and varies from sandy to sandy loam in texture. Predominant texture of the soil is sandy. It is fertile and intensively cultivated through canal irrigation and ground water sources in the form of deep tube-wells. Agriculture is the principle source of economy of this village.

The bio-volumes (Biomass) estimates for different land use classes of village Jhumpa Kalan are given in **Table 26**.

Table 26: Bio-volumes (Biomass) Estimates of village Jhumpa Kalan

Model	Plantation Year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	2003-04	19.0	-	<i>Kikar</i>	Plantation lost due to frost. Present vegetation is under girth.	
	-	-	-	<i>Ailanthus</i>		
	2004-05	19.0	-	<i>Kikar</i>		
	-	-	-	<i>Ailanthus</i> <i>Tortilis</i>		
Private Woodlot	2004-05	-	-	<i>Ailanthus</i>	Plantation lost due to frost action. Present vegetation is under girth	
	-	-	-	<i>Tortilis</i>		
	2005-06	22.0	-	<i>Ailanthus</i> <i>Tortilis</i> <i>Ronz</i>		
Boundary Plantation	2003-04	-	-	<i>Ailanthus</i> <i>Ronz</i>	The plants in the area are under girth	
Private Woodlot	2004-05	-	-	<i>Amla</i> <i>Rattan jot</i> <i>Shisham</i> <i>Ailanthus</i>	The plants in the area are all under girth.	
	-	-	-			
	2005-06	-	-			
Boundary Plantation	2003-04	-	-	<i>Shisham</i> <i>Shahtoot</i> <i>Jandi</i> <i>Cassia</i>	These plantations were lost due to frost. The existing vegetation is all under girth	
	2004-05	-	-	<i>Shisham</i> <i>Eucalyptus</i> <i>Jandi</i> <i>Ailanthus</i> <i>Guava</i>		
	2005-06	-	-	<i>Shisham</i> <i>Eucalyptus</i> <i>Jandi</i> <i>Amla</i> <i>Neem</i> <i>Shahtoot</i>		
Cultivated Land	There are 10 trees of <i>Jandi</i> (average height of 7 to 9 m), 10 trees of <i>Shisham</i> (average height of 7 to 9 m) and 10 trees of <i>Rohida</i> (average height of 6 to 9 m). The volume of these trees is 2.80 m ³ (<i>Jandi</i>), 4.74 m ³ (<i>Shisham</i>) and 3.0 m ³ (<i>Rohida</i>).					

3.5 Kanina Block, Mahendragarh District

Mahendragarh district is bounded by Rewari District in the East and North- East, Bhiwani District in West and North- West and Rajasthan State in West, South-West, South and South-East. The total geographical area of the Mahendragarh District is 1,89,900 ha and its population as per 2001 Census was 8,13,000.

Greater part of the project falls under arid climate. The climate is mostly hot during summer and cold in winter. Due to close proximity of Rajasthan state hot winds are experienced during summers. The variations in temperatures are extreme, varying from 4° to 45° C. Frost is common and many tree species are adversely effected; even tall trees of Neem were killed is the frost of 2005.

The average rainfall of the district is 40-50 mm being concentrated to the months of July and August with occasional showers in winter.

The soils in the district are mainly sandy, sandy loam in flat plains and coarse sand on the dunes in the south-west region. Ground water varies from good to saline, the degree depending on location and flooding by local streams.

The natural vegetation of the project area belongs to Northern Tropical Thorn Forests, the composition varying according to topography. In the hills it is constituted by a scrub cover of *Acacia Senegal*, *Acacia nilotica*, *Butea monosperma*, *Zizyphus maurtiana*, *Cassia fistula*, *Anogeissus pendula* etc. In the plains *Prosopis cineraria* is the principal species. Other species are *Dalbergia sissoo*, *Neem*, *Ailanthus excelsa*, *Siris*, *Cordia obliqua*, *Capparis decidua*, *Salvadora oleoides*, *Holoptelea integrifolia* (Papri), *Acacia eucophloea* (Raunj), *Citrus aurantifolia* (Nimbu) and *Tamarix articulata*. Important grasses of the project area are *Cenchrus ciliaris*, *Cenchrus setigerus*, *Cenchrus biflorus*, *Panicum antidotale* etc. *Erianthus munja* is an important grass on waste lands and other sub sites.

The predominant *Kharif* crops grown in the region are Millet (Bajra) and pulses while wheat, barley and gram are grown as important *Rabi* crops.

There are five villages of Kanina Block included in the present study namely, Sihor, Dhanunda, Kharkharawas, Chelawas and Gudha. Brief details of these villages and their bi-volumes (Biomass) estimates are given hereafter.

3.5.1 Village Sihor

Sihore village lies south of Unhani. It is surrounded by Kanina, Gahara, Bawa Chittroli and Dhanaunda Bas villages in south, east, north-east, west and south-west. The soil is shallow and sandy loam in character. It is fertile and is intensively cultivated with the help of irrigation canals and ground water sources from deep tube wells. Agriculture is the main source of economy in this village.

The bio-volumes (Biomass) estimates for different land use classes are given in **Table 27**.

Table 27: Bio-volumes (Biomass) Estimates of village Sihor

Model	Plantation Year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	2002-03	14	4x2.5	<i>Kikar</i>	2.04	2.04
	2003-04	12.2	4x2.5	<i>Kikar</i>	3.38	3.38
	2003-04		4x2.5	<i>Ailanthus</i>	18.45	18.45
Private Woodlot	2002-03	-	5x4	<i>Ailanthus</i>	118.57	118.57
	2002-03	-	5x4	<i>Shisham</i>	10.22	29.39
				<i>Ailanthus</i>	19.17	
	2002-03	-	5x4	<i>Shisham</i>	8.07	31.78
				<i>Ailanthus</i>	23.70	
			<i>Aonla</i>	0.004		
Boundary Plantation	2002-03	-	1	<i>Ailanthus</i>	18.42/100 m	18.42/100 m
			1	<i>Neem</i>	2.84/100 m	2.84/100 m
			4	<i>Shisham</i>	2.78/100 m	2.78/100 m
			2	<i>Amla</i>	0.57/100 m	0.57/100 m
Cultivated Land	<i>There are 100 trees of Shisham of 2004-05, 100 trees of this same species of 2005-06 and 30 years old 50 trees of Jandi in the cultivated land. The volume of these trees is: Shisham (2004-05), 5.19 m³; Shisham (2005-06), 1.43 m³ and 28.83 m³ for Jandi.</i>					

3.5.2 Village Dhanunda/Kharkharawas

The two villages of Dhanunda and Kharkharawas have different *Panchayats* but both of them have a common boundary. Presently village Dhanunda and Kharkharawas have a common *Panchayat* but all land area falls under Dhanunda village.

These two villages have been separately dealt with in present study.

The bio-volumes (Biomass) estimates for different land use classes of villages Dhanunda and Kharkharawas are given in **Tables 28 and 29**.

Table 28: Bio-volumes (Biomass) Estimates of village Dhanunda

Model	Plantation Year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	2001-02	-	4x2.5	<i>Kikar</i>	48.82	48.82
	2001-02	-	4x2.5	<i>Kikar</i>	16.68	52.08 (Total volume for 20 trees)
		-	-	<i>Jaal</i>	35.40	
	30-35 year old	-	-	<i>Jaal</i>	59.2708	
Private Woodlot	2002-03	-	5x4	<i>Ailanthus</i>	52.13	52.13
	2002-03	-	5x4	<i>Shisham</i>	16.52	16.52
Boundary Plantation	2001-02	-	4	<i>Shisham</i>	3.28/100 m	3.28/100 m
				<i>Rhodia</i>	0.68/100 m	0.68/100 m
				<i>Ailanthus</i>	4.77/100 m	4.77/100 m
	2002-03	-	3	<i>Shisham</i>	2.72/100 m	2.72/100 m
				<i>Ailanthus</i>	3.92/100 m	3.92/100 m
				<i>Neem</i>	1.79/100 m	1.79/100 m
				<i>Rohida</i>	0.13/100 m	0.13/100 m
	2003-04	-	7	<i>Shisham</i>	0.86/100 m	0.86/100 m
				<i>Ailanthus</i>	1.02/100 m	1.02/100 m
	2004-05	-	3	<i>Shisham</i>	2.02/100 m	2.02/100 m
Cultivated Land	<i>There are 25 years old of Jandi (30 trees) and Ailanthus (15 trees) in the cultivated land. The volume of these trees is 15.84 m³ (Jandi) and 5.03 m³ for Ailanthus.</i>					

Table 29: Bio-volumes (Biomass) Estimates of village Kharkharawas

Model	Plantation Year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	2001-02	4	4x2.5	<i>Kikar</i>	14.76	34.76
				<i>Tortilis</i>	7.62	
				<i>Masquit</i>	12.38	
Private Woodlot	2003-04	-	5x4	<i>Ailanthus</i>	6.82	6.82
	2004-05	-	5x4	<i>Ailanthus</i>	13.67	13.67
Boundary Plantation	2001-02	-	4	<i>Shisham</i>	3.26/100 m	3.26/100 m
				<i>Ailanthus</i>	4.24/100 m	4.24/100 m
				<i>Rohida</i>	0.63/100 m	0.63/100 m
	2002-03	-	3.5	<i>Shisham</i>	2.03/100 m	2.03/100 m
				<i>Ailanthus</i>	1.84/100 m	1.84/100 m
				<i>Neem</i>	5.38/100 m	5.38/100 m
				<i>Rohida</i>	0.40/100 m	0.40/100 m
	2003-04	-	4	<i>Shisham</i>	1.40/100 m	1.40/100 m
				<i>Ailanthus</i>	2.27/100 m	2.27/100 m
	2004-05	-	3	<i>Shisham</i>	0.97/100 m	0.97/100 m

3.5.3 Village Chelawas

Chelawas village is located east of Gudha. Unhani, Kanina Khas and Nandal. Soil is shallow, fertile, and sandy loam in character. It is intensively cultivated through good irrigation network and deep tube wells.

Bio-volumes (Biomass) Estimates

The bio-volumes (Biomass) estimates for different land use classes are given in **Table 30**.

Table 30: Bio-volumes (Biomass) Estimates of village Chelawas

Model	Plantation Year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	2003-04	13	4x2.5	<i>Babul</i>	2.28	2.28
	200-300 year old	-	-	<i>Jaal</i>	114.11	114.11
	12 year old	-	-	<i>Tortilis</i>	70.0	70.0
Private Woodlot	2003-04	-	5x4	<i>Ailanthus</i>	52.30	52.30
	2003-04	1	5x4	<i>Aonla</i>	0.012	
				<i>Beri</i>	0.004	
				<i>Shisham</i>	0.650	0.67
	2003-04	0.60	-	<i>Shisham</i>	8.9	8.9
Cultivated Land	2003-04	-	-	<i>Shisham</i>	Total volume for 100 trees is 4.05 m ³	
				<i>Neem</i>	Total volume for 15 trees is 0.17 m ³	
				<i>Amla</i>	Total volume for 10 trees is 0.004 m ³	
				<i>Beri</i>	Total volume for 10 trees is 0.004 m ³	
				<i>Rohida</i>	Total volume for 10 trees is 0.28 m ³	
				<i>Shahtoot</i>	Total volume for 10 trees is 0.09 m ³	
	2004-05	-	-	<i>Shisham</i>	Total volume for 30 trees 0.49 m ³	
	30-32 year old			<i>Jandi</i>	Total volume for 10 trees is 6.64 m ³	

3.5.4 Village Gudha

The village lies on the south of Kaimla village. The soil is sandy loam, fertile and is intensively cultivated. Agriculture is the principle source of economy. Canals and Ground water are the main sources of irrigation.

The bio-volumes (Biomass) estimates for different land use classes are given in **Table 31**.

Table 31: Bio-volumes (Biomass) Estimates of village Gudha

Model	Plantation Year	Plantation Area (ha)	Spacing (m)	Species	Volume (m ³)/ha or per 100 m	Total volume (m ³)/ha or per 100m
Community Woodlot	15-16 year old	16	4x2.5	<i>Tortilis</i>	137.67	137.67
	2001-02	5.5	4x2.5	<i>Tortilis</i>	24.00	24.00
	2001-02	5.5	4x2.5	<i>Ailanthus</i>	57.82	57.82
	2002-03	-	4x2.5	<i>Tortilis</i>	22.20	22.20
Cultivated Land	2001-02	-	-	<i>Shisham</i>	Total volume for 45 trees is 5.87 m³	
				<i>Neem</i>	Total volume for 10 trees is 0.61 m³	
				<i>Ailanthus</i>	Total volume for 25 trees is 12.51 m³	
	2002-03	-	-	<i>Shisham</i>	Total volume for 50 trees is 4.58 m³	
	2003-04	-	-	<i>Shisham</i>	Total volume for 10 trees is 0.29 m³	
	2004-05	-	-	<i>Shisham</i>	Total volume for 25 trees is 0.72 m³	
	2005-06	-	-	<i>Shisham</i>	Total volume for 25 trees is 0.50 m³	
	25-30 year old	-	-	<i>Jandi</i>	Total volume for 25 trees is 13.66 m³	
<i>Ailanthus</i>				Total volume for 15 trees is 7.79 m³		

4.0 Growth Analysis

It has been difficult to have an analysis of the increase in bio-volumes (biomass) in different villages, as the baseline data did not indicate area specific growth data that could be compared with the areas in the present study. Moreover, the bio-volumes given in the baseline study are generally by land uses classes, total number of trees and species but not by area. Further, as it was difficult to delineate plantations undertaken after 2001-02 from the imageries, only plantations of 2001-02 and prior to that have been taken into account in the baseline study, barring a few exceptions. However, some plantations could be demarcated, with great difficulty, for analysis of increase in bio-volume (biomass) for particular areas under different land use classes. The details of these areas are given in **Table 32**.

A perusal of the Table on Bio-volumes (Biomass) increase in demarcated plantations (**Table 32**) indicates that there has been considerable increase in bio-volumes of these plantations in all the three land use classes, namely community woodlots, private woodlots and boundary/line plantations. This increase has ranged from 11 to 58% in case of community woodlots, 10% in private woodlots and 30 to 86% in boundary/line plantations, depending on the species planted, area and age of plantations.

The remaining current biomass volumes as specified in various village tables of this report – barring around seven older plantations not raised under HCFP – represent net growth of biomass for these particular areas under different land use classes, as these areas were not under tree cover at the time of the baseline study.

Table 32: Bio-volume (Biomass) increase of selected plantations

Name of Village	Model	Area (ha)	Approximate age (yrs)	Species	Volume (m ³ /ha) or per 100 m (Baseline study)	Volume (m ³ /ha) or per 100 m (Present study)	% increase in bio-volume
Bagpat	Community Woodlot	16	12	<i>Khair</i>	53.41	72.11	26
Jatanwala	Community Woodlot	10	6	<i>Shisham</i>	14.8	35.99	58
Taprian	Community Woodlot	14	5	<i>Eucalyptus</i>	34.97	40.96	15
Ibrahimpur	Community Woodlot	4	6	<i>Eucalyptus</i>	33.80	37.90	11
Darpur	Private woodlot	-	7	<i>Eucalyptus</i>	55.42	61.52	10
Bagpat	Boundary Plantation	-	5	<i>Eucalyptus</i> <i>Poplar</i>	2.72 m ³ /100 m	3.86 m ³ /100 m	30
Meghuwala	Boundary Plantation	-	2	<i>Eucalyptus</i> <i>Poplar</i>	1.98 m ³ /100 m	2.58 m ³ /100 m	23
Darpur	Boundary Plantation	-	5	<i>Eucalyptus</i>	1.51 m ³ /100 m	7.52 m ³ /100 m	80