Final Report

August 2013

Final Impact Evaluation of GEF-SLEM Project

Submitted to

Watershed Management Directorate,

Dehradun

The Energy and Resources Institute

...towards global sustainable development

Table of Contents

List of Tables

List of Figures

Acknowledgement

We thank the Watershed Management Directorate (WMD), Government of Uttarakhand for giving us the opportunity to conduct the Baseline Survey and Final Evaluation of GEF-SLEM Project.

We are thankful to Mr B P Pandey, Forest and Rural Development Commissioner and Chief Project Director WMD, Dr Rekha Pai, Former Chief Project Director, WMD and Mr Bhaskaranand, Former Secretary, Watershed Management and Chief Project Director WMD for their support.

We are thankful to Mr D J K Sharma, Additional Director WMD, Mr W. Longwa, Project Director (Admin.), WMD, Ms Neena Grewal, Additional Director, WMD, Mr Gauri Shankar, Project Director, Kumaon Division and Ms Meenakshi Joshi, Joint Director, WMD for providing valuable guidance and cooperation in completion of this study.

We are also thankful to Mr B P Gupta, Former Addl Director, WMD, Mr. V K Pangtey, Former Project Director Garhwal Division, Mr. Naresh Kumar, Former Joint Director, WMD, Mrs. Prachi Gangwar, Former Dy. Director (Monitoring & Evaluation), WMD, Mr Amar Singh, Finance Officer, Dr R P Kavi, Joint Director, Animal Husbandry, Mr R. S Negi Former OSD, Dr J C Pande, Environment Specialist, Ms Rajul Pant, Social Development Specialist, and Dr P Pantola, Agribusiness Consultant for support at various stages.

We are thankful to Deputy Project Directors of 4 Project Divisions namely Mr. L.S Rawat, Mr. Akhilesh Tewari, Mr. S.K. Upadhyay, and Mr. R.K. Singh, and all field officers and their staff for support towards conduct of the field survey. We thank Mr Parmesh C Khanduri, GIS analyst WMD for providing us satellite data. Thanks are due to the various office staff of WMD, specially Mr Sohan Singh, Assistant to Additional Director, WMD.

Our sincere thanks are also due to the members of various Gram Panchayats/Revenue Village Committees and other village institutions, FIGs, SHGs and also to the people of the project area who spared their valuable time, patiently answering various questions and providing valuable information to our team.

Last but not the least we are thankful to Mr Kailash Khanduri, Supervisor of our survey team and all Field Surveyors who helped us in conducting the field survey, and to Ms Rakhi Pal and Mr Shehwaz for administrative support.

TERI Project Team

12 August, 2013

List of Abbreviations

AGB	Above Ground Biomass
ANR	Assisted Natural Regeneration
ATI	Appropriate Technology Institute
BA	Basal Area
BCR	Benefit Cost Ratio
BPL	Below Poverty Line
Cum	Cubic meter
DBH	Diameter at Breast Height
DLT	Drainage Line Treatment
DPD	Deputy Project Director
FD	Forest Department
FGD	Focus Group Discussions
FIGs	Farmer Interest Groups
FSI	Forest Survey of India
GBH	Girth at Breast Height
GEF	Global Environment Facility
Gen	General
GIS	Geographical Information System
GoUA	Government of Uttarakhand
GP	Gram Panchayat
GPWDP	Gram Panchayat Watershed Development Plan
Ha	Hectare
HH	Household
IAS	Invasive Alien Species
IGA	Income Generation Activity
IRR	Internal Rate of Return
IRS	Indian Remote Sensing

IVI	Importance Value Index
MAI	Mean Annual Increment
MAP	Medicinal and Aromatic Plants
MSL	Mean Sea Level
MWS	Micro Watershed
NDVI	Normalized Difference Vegetation Index
NGO	Non-governmental Organization
NPV	Net Present Value
NRM	Natural Resource Management
NRSC	National Remote Sensing Centre
NTFP	Non Timber Forest Produce
OBC	Other Backward Class
PAD	Project Appraisal Document
PAN	Panchromatic
PBM	Pine Briquette Machine
PBS	Pine Briquette Stove
PDO	Project Development Objective
PME	Participatory Monitoring and Evaluation
PMU	Project Management Unit
PRA	Participatory Rural Appraisal
RF	Reserve Forest
RV	Revenue Village
RVC	Revenue Village Committee
RWHT	Roof Water harvesting Tank
SC	Scheduled Caste
SHG	Self Help Group
SLEM	Sustainable Land and Ecosystem Management
SMPB	State Medicinal Plant Board
ST	Scheduled Tribe

TERI	The Energy and Resources Institute
ToR	Terms of Reference
UDWDP	Uttarakhand Decentralized Watershed Development Project
VP	Van Panchayat
WWC	Water and Watershed Committee
WHS	Water Harvesting Structures
WMD	Watershed Management Directorate

Executive Summary

Background

This report presents the findings of the Final Impact Evaluation of the GEF-SLEM project in Uttarakhand undertaken by The Energy and Resources Institute (TERI) during 2012-13.

The SLEM Project was implemented through additional funding under the World Bank funded Uttarakhand Decentralised Watershed Development Project (UDWDP), targeting 20 micro watersheds, and covering an area of about 60000 ha. The Project Development Objective was "*to restore and sustain ecosystem functions and biodiversity while simultaneously enhancing income and livelihood functions, and generating lessons learned in these respects that can be up-scaled and mainstreamed at state and national levels".*

Methodology

A baseline survey was conducted by TERI in 2011 in 51 Gram Panchayats with a sample of approximately 1000 households. The final impact evaluation survey was undertaken in 26 Gram Panchayats out of the ones covered in the baseline survey. Questionnaires at the household, Revenue Village and Gram Panchayat levels were used for the survey. To the extent possible, the same households who constituted the baseline sample were interviewed during the final impact evaluation survey in early 2013. Group Discussions and physical inspection of project interventions were also carried out. In both the baseline and final impact survey, a control group of 5 Gram Panchayats were surveyed for comparison of results.

In addition to the survey, vegetation assessment was done in 16 sites both in the baseline and final evaluation stage. For biomass estimation, remote sensing based techniques were used. Economic analysis was built upon questionnaire data and pertinent case studies.

Demography and Incomes

The demographic profile of the project and control GPs have not changed since the baseline survey. In our sample, 80% of the households belong to the general caste category followed by scheduled castes and scheduled tribe (19%) and other backward classes (1%). In terms of landholding, the largest group of sampled households (29%) possess less than 0.2 ha of land whereas the percentage of landless households is the least (3%).

Incomes in the project area have increased on the whole. From a baseline value of Rs.55,938 p.a., incomes have increased to Rs. 75,025 p.a. per household on an average – an increase of 34%. Based on General Consumer Price Indices (GCPI) for Rural Areas (Base 2010 = 100), the baseline value has been adjusted upwards to Rs 70,258. Thus, in real terms (that is accounting for price inflation), the incomes have gone up by approximately 7%.

Controlling land degradation at the watershed level

The SLEM interventions have focussed on microwatersheds that have high erosion indices, are socio-economically backward and are predominantly at the agricultural frontier. About 21% of the total eligible area has been covered under treatments, that include soil/water conservation works, plantations/ANR and medicinal plant demonstration and nurseries, The overall impact has been a 4% increase in irrigated agricultural land, a 20% increase in

the number of households who need less than an hour for fetching water for domestic needs, and a 5.5% increase in biomass. About 96 ha of land has been impacted in terms of control over land degradation, and about 7 ha of land has benefitted in terms of an enhanced moisture regime.

Fostering markets for NTFPs

The major activity under this component was the upscaling of pine briquette making which was promoted under UDWDP as a pilot intervention. Other activities include the promotion of solar cookers and Bio gas, all expected to reduce pressure on forests. In order to develop non-farm based livelihoods, renovation of traditional water mills (*Gharats*) and other activities were taken up through SHGs.

In our sample GPs, 12% of households have shifted (at least partially) to non-fuelwood energy sources, including pine briquettes, Bio gas and solar cooker. Of the households involved in pine briquetting, about 32% have entered the market. There is a significant enhancement in various non-farm livelihood activities, with a three fold increase in the number of beneficiary households. Success rates of traditional livelihoods have been typically higher than those that rely on external markets.

Enhancing biodiversity conservation through watershed planning and community participation

While it is unfair to expect any significant change in biodiversity within the time horizon of the project, enhanced species richness and diversity index of shrubs is observed in the final assessment as compared with the baseline survey. Since the shrub category also includes tree seedlings and saplings, the increase in species richness for shrubs, in particular, suggests that the plantation of several tree species as well as enhanced protection from grazing and biomass collection has resulted positive outcomes. That significant positive changes have occurred in a short span of a year suggests that this project proves effective in enhancing regeneration and the biodiversity status of the area.

The marketing of MAPs has been an important activity, though success has been mixed, except for ginger and turmeric that also serve as cash crops. A total of 65 FIGs (with a membership of 804 persons) were seen to operate in sampled GPs.

There has been a reduction in the number of fire incidence by 75% and area affected by fire by about 61.3% over the baseline. Since forest fires are caused both to natural and anthropogenic factors, this reduction may not be attributed completely to project interventions. However, the use of participatory approaches for fire prevention is a step in the right direction and likely to yield results over the longer run.

Community participation and institutional development

Watershed planning through community participation is envisaged approach in the SLEM project. The foundation for this was laid in UDWDP, and facilitators and mobilizers were engaged at the community level. Van panchayats were made implementing bodies for work in the inter GP areas, mainly in the Reserve Forests, and SHGs and FIGs were formed or strengthened. Importantly, women comprise 64% of the total membership of these institutions on the whole. Pine briquetting has been taken up as a major SHG activity for women, and its broad impact has been stated above. *Gharats* (traditional water mills) have received the highest share of funding, and is clearly emerging as one the most successful

activities. This activity has yielded 71% of the total benefits (earnings) from all SHG activities. Importantly, this activity benefits largely the landless and socially backward households.

Overall attendance and women's attendance in Gram Sabha meetings have gone up by 8 and 11 percentage points respectively.

Economic analysis

The Benefit Cost Ratio (r=6%) is estimated at 2.44 and 3.14 with 5 and 10 year horizons. Disaggregate analysis has also been presented and activities with relatively net returns include village ponds, soil conservation structures and alternative energy interventions such as biogas and solar cooker. As many of the benefits are captured through indirect methods and some are captured partially (specially ecosystem services of plantations), the results are indicative rather than conclusive.

Results Framework

Note: The baseline values reported in Baseline Report of TERI were based on a sample of 51 GPs. The baseline values reported below, in a few cases, are based on the subset of 26 GPs (out of the 51 baseline GPs) selected for final impact evaluation for the sake of more effective comparison. These have been indicated in the footnote.

S. No.	Project Development Objective	Result/Outcome Indicators	Baseline data/ evaluation method	Baseline value	Final Value
1	To restore and sustain ecosystem functions and biodiversity while simultaneously enhancing income and livelihood functions	20 number of Micro watershed management plans completed and under implementation	Availability of the plans	All plans completed and under implementation	All plans implemented effectively.
		10% increase in livelihood opportunities in treated areas (measured by increase in no. of person engaged in different livelihood opportunities)	Occupational structure and number of persons involved in various livelihood activities	Total number of people involved in local enterprises in 51 sampled GPs: 420 in 13 activities including 7 activities combined under heading Others	Total number of people involved in local enterprises in 26 sampled GPs: 2371 in 18 activities
	Community participatory watershed planning expanded with an additional focus on local benefits of sustainable land and ecosystem management	Sustainable Watershed Management mainstreamed into 20 GP plans including parts of watersheds for which two or more GPs have shared governance responsibility	Area of MWS to be brought under shared governance		36562.85 ha of RF area identified for SLEM treatment in the project (out of which 6706.8 ha of RF falls within the sample) identified for shared governance
2	Controlling land degradation through the SLEM approach at watershed level	20% of the area in selected MWS under improved SLEM techniques	Area under SLEM techniques	Project area comprises 39056 ha of Forest area, 18057 ha of Agriculture area and 3710 ha Blank area	- 21.24% of total area brought under improved SLEM techniques - 103.92 ha area directly impacted in terms of soil and moisture retention in sample GPs

S. No.	Project Development Objective	Result/Outcome Indicators	Baseline data/ evaluation method	Baseline value	Final Value
		Increase in availability of water in the dry season by 5% in the treated MWS	Hours spent in accessing water in dry season, access to various water sources for domestic use and irrigation	- 68.37% of hh spend < 1 hr to access water in dry season, 30.8% spend 1-2 hr to access water in dry season[1]	- 82.34% of hh spend < 1 hr to access water in dry season, 17.04% spend 1-2 hr to access water in dry season
				- Irrigated land (Average per GP) (13.24 ha), Unirrigated land (Average per GP) (64.50 ha)[2]	- Irrigated Land (Average per GP) (13.78 ha), Unirrigated land (Average per GP) (63.95 ha) indicating increase of 4.1% of irrigated land
		10% increase in vegetative and biomass index in the 20 MWS.	Biomass	Average value of biomass is 48.5 t/ha (Average of MWS)	5.5% (Weighted average) of biomass increase in microwatersheds, MWS areas are used as weights, Average value of biomass is 50.7 t/ha (Average of MWS)
		Implementation of 5 to 10 alternative technologies and approaches for enhancing water availability for agriculture and other domestic use	Number of technologies implemented	Technologies – 1) Roof Water Harvesting Tanks 2) Irrigation tanks and channels 3) Sprinklers 4) Naula . Khala rejuvenation	Technologies - 1) Roof Water harvesting structures, 2) Irrigation tanks with delivery system,34) Village ponds, percolation tank, contour trenches with bunds, 45) Rejuvenation of naula / khala 5) Controlling forest fire, 6) Plantations and ANR 7) River training works
3	Reduce pressure and dependence on the natural resource base through fostering Markets for NTFPs	Reduction in dependency of 2000 households on forest for fuel wood.	No. of households adopting alternative energy for cooking, Current	69 households partially shifted to pine briquettes 84.2% fuel needs	- 2000 households comprising of 13% of total households of project area as target for reducing fuelwood dependency - Fuelwood dependency

[1] Based on 26 GPs selected for final impact evaluation

[2] Based on 26 GPs selected for final impact evaluation

S. No.	Project Development Objective	Result/Outcome Indicators	Baseline data/ evaluation method	Baseline value	Final Value
			dependence of fuelwood from forests	met from forests.	reduced by 486 household directly (12%) in sampled GPs. In addition, 843 households have also received pine briquette stoves in sampled GPs who are potential users of pine briquettes. 79.25% of fuel needs are met from fuelwood
		At least 20% of targeted households enter market with pine briquettes (produced from pine needles)	No of households making pine briquettes in feasible areas. In the final assessment, the extent of marketing will also be assessed	Nil	- 20% of 2000 households i.e. 400 households targeted to enter market. - 145 households (31.7%) out of 456 households engaged in pine briquette making have entered market.
4	Enhance biodiversity conservation and management through watershed planning and community participation	Increase in direct and indirect evidence of presence of key species of flora and fauna in 20 MWS	Vegetation assessment	Shannon Weiner Index: Trees: 2.02, Shrubs: 3.04Herbs: 3.59, Species richness Trees: 32, Shrubs: 73, Herbs: 38	Shannon Weiner Index: Trees: 2.02, Shrubs 3.57, Herbs: 2.6, Species richness Trees: 32, Shrubs: 79, Herbs: 28*[3] Significantly higher diversity index and species richness values for shrubs, herbs and overall species richness of project site compared to control sites Significantly higher number of naturally regenerating seedlings in project than in control sites Significantly higher shrub and overall species richness

[3]The decrease in the richness and diversity of annual herbs was due to the timing of the assessments. The baseline survey was just after the monsoon while the final assessment was soon after the winter when many of the areas were covered by snow.

S. No.	Project Development Objective	Result/Outcome Indicators	Baseline data/ evaluation method	Baseline value	Final Value
					between baseline and final assessment. Significantly higher number of naturally regenerating seedlings in project than in control sites.
		20% reduction in incidence of fire in treated MWS	Area affected by fire (based on surveys and FD records)	19.5 hectare affected, 11 incidents in 51 GPs 8 incidents and 15.5 ha area affected in 26 GPs that were sampled for the final assessment (Compartments falling in the respective MWS plans) Baseline assessment year is 2010	16 hectare affected in 51 GPs. 2 incidents in 26 GPs and 6 ha area affected that were sampled for the final assessment (26 GPs) so 75% reduction in # of incidents & 61.3% reduction in fire area Final assessment year is 2013
		Cultivation of at least 5 local MAPs (medicinal and aromatic plants) by communities in 20 microwatersheds.	Number of MAP species cultivated	Ginger and Turmeric grown as cash crops	*Zingiber officinale* (Ginger or adrak)*Curcuma longa*(Turmeric or haldi), *Aloevera (*Aloe, ghritkumari*)*, *Rauvolfia serpentina*, (snake root or sarpgandha), *Amomum subulatum* (Black cardamom or badi elaichi), *Asparagus racemosus* (Asparagus or Satavar), *Cinnamomum tamala* (Indian bay leaf or Tejpatta) and *Phyllanthus emblica* (Indian gooseberry or amla)

S. No.	Project Development Objective	Result/Outcome Indicators	Baseline data/ evaluation method	Baseline value	Final Value
5	Improve adaptation to climate change in natural resource based production systems	Improved knowledge of the impact of climate change on mountain ecosystems documented and translated into coping strategy.	Not part of TERI TOR	NA	NA
6	Documentation of Best (Worst) practices to share within the state as well as nation-wide through the SLEM program	At least 5 to 10 new and innovative techniques and approaches documented, disseminated	NA at baseline	Nil	No of new innovative techniques and approaches - 1) Pine briquetting 2) Solar lights and lanterns 3) Solar cookers 4) Bio gas plants 5) MAP cultivation and marketing 6) River bank protection structures, 7) Roof Water harvesting structures, 8) Irrigation tanks with delivery system, 9) Village ponds, percolation tank, contour trenches with bunds, 10) Rejuvenation of naula / khala 11) Controlling forest fire, plantations and ANR for enhanced moisture regime and water percolation. 12) Renovation of gharats

1. Introduction

The Government of Uttarakhand through the Watershed Management Directorate (WMD) received a grant from Global Environment Facility Trust Fund (GEF) as an additional financing under the World Bank funded Uttarakhand Decentralized Watershed Development Project (UDWDP).

The project development objective (PDO) for the GEF additional funding is *"to restore and sustain ecosystem functions and biodiversity while simultaneously enhancing income and livelihood functions, and generating lessons learned in these respects that can be up-scaled and mainstreamed at state and national levels".*

Description of Project Area

The project area is located in the Mid Himalayan area within the height of 700m to 2000m above MSL. The additional financing targets 20 micro watersheds of the parent 76 micro watersheds where UDWDP was operational for implementation of Sustainable Land and Ecosystem Management (SLEM) activities. Micro-watersheds included in this project are identified based upon the severity of erosion, poverty and lack of infrastructure facilities. These micro-watersheds lie within the existing boundaries of the UDWDP divisions falling in Augustmuni, Bageshwar, Chinyalisaur and Nainital divisions.

A total of 125 Gram Panchayats (GPs) in 20 micro watersheds covering a total area of approximately 60,823 ha, benefiting approximately 74,000 people is covered under the SLEM project.

Project Duration

The project duration is for four years from Year 2009-10 to 2012-13.

Project Components

The project components are as follows:

1. Watershed planning through community participation

This component provides technical assistance for watershed planning and community participation. Community participation has been done through the development of participatory decision-making processes at the revenue village, Gram Sabha and Micro Watershed levels. The Gram Panchayat Watershed Development Plans (GPDWP) formulated under UDWDP have been consolidated into micro-watershed level plans. The various watershed interventions which could not be carried out under UDWDP have been identified using participatory approaches and consultation with the communities. Geographically contiguous areas of micro watershed, even if outside the Gram Panchayat (GP) but under the Forest Department, have been included in this approach to ensure a holistic approach in the management of watersheds. Apart from the GP, the Van Panchayat (VP), Revenue Village Committee (RVC) and other user groups are also involved in the development of the respective watershed development plans. In total 20 micro watershed plans are developed for implementation as a part of SLEM project. The planning process has been used to sensitize the communities on the ecosystem degradation and promote incremental measures for sustaining the ecosystem's functions.

2. Controlling land degradation through the SLEM approach at watershed level

This component is aimed to reduce soil erosion and enhance biomass and the availability of water in the watershed throughout the year. The planning process has resulted in a Micro Watershed (MWS) level watershed treatment plan which are finalized after consultation with all stakeholders groups. For watershed intervention in areas beyond the boundaries of the GP (inter GP - which are mainly Reserve Forest area), a share of the total budget allocation for the respective MWS is kept aside.

3. Reduce pressure and dependence on the natural resource base through fostering markets for NTFPs

This component focuses on the identification of new technologies to meet household energy needs, reduce dependence on firewood and to market the produce created through these technologies. The pine briquettes technology piloted successfully under UDWDP has been scaled up. SHGs and VGs are encouraged to take up the activity as an enterprise for income generation. Small market infrastructure and linkages to sell the briquettes have been developed.

4. Enhance biodiversity conservation and management through watershed planning and community participation

The aim is to qualitatively and quantitatively enhance biodiversity at the watershed level. This has been done through a series of interventions. There is a planned focus on biodiversity conservation through ongoing programs aimed at identification of sustainability livelihood options. The reduction of soil erosion, reduced pressure on biomass for energy and watershed management have directly and indirectly contributed to biodiversity conservation. Following interventions are taken up under this component: (i) Demonstration of cultivation of medicinal and aromatic plants; (ii) Promotion of IGA by SHGs/ VGs with training and input support; and (iii) Short studies for biodiversity and livelihood assessments.

5. Improve adaptation to climate change in natural resource based production systems

This component is aimed at improving the understanding of the impact of climate change on natural resource based mountain economies.[4]

6. Documentation of best (worst) practices to share them within the state as well as through the SLEM partnership

The documentation through short studies, publications, short films and documentaries is aimed at enhancing knowledge of SLEM, biodiversity conservation and adaptation to climate change in mountain ecosystems.

7. Project Management, monitoring and capacity building.

This component has financed hiring of technical and non-technical staff on contractual basis and other incremental operating costs under the project. For M&E, an external consultant has been hired. The component also financed capacity-building of staff including exposure visits and workshops.

[4] The study however has not been conducted and the budget re-allocated.

Project Implementation Agency

Two main institutions at the community level were responsible for project implementation. These were van panchayats (for forestry interventions) and gram panchayats (for village level activities). The responsibility for MWS plan preparation was with Revenue Village Committees (RVCs) and was to be approved by GPs.

Final Impact Evaluation

The key objective of the consultancy is to conduct a final impact survey in randomly selected SLEM project GPs and control GPs, after the commencement of SLEM project activities. The information collected during the survey and the approach and methodology used is consistent with that of the baseline study so that an effective comparison of the parameter values has been possible.

2. Methodology

This chapter presents the methodology for the assignment of Final Impact Evaluation of SLEM project, following the requirements of the ToR.

Objective

The final impact evaluation has been undertaken in the fourth year of the project. The key objective of the consultancy is to determine whether the project objectives set in terms of expected outcomes and outputs using various criteria and indicators as defined primarily in the Project Appraisal Document and supervision missions' aide memoires are being met. In order to assess the impact of the project and measure key outcome and results indicator, a baseline survey has been undertaken in 51 randomly selected project GPs (and 5control GPs).

In the final year of the project, a follow-up survey was undertaken among a sub-set of the GPs covered in the baseline survey in order to measure the project's impacts, and progress towards the project's development objectives.

The final impact Evaluation survey has attempted to assessed the project development objective *"To restore and sustain ecosystem functions and biodiversity while simultaneously enhancing income and livelihood functions, and generating lessons learned in these respects that can be up- scaled and mainstreamed at State and National levels*", and the project outcomes vis-a-vis results framework.

Selection of sample frame for baseline survey

As per the TOR, the baseline survey was carried out in a sample of 51 Gram Panchayats (GPs), 102 revenue villages (RVs) and approximately 1000 households (HHs)("Treatment" Group) In addition to this, the control group included 5 GPs, 10 RVs and approximately 100 HHs from micro-watersheds not included in the project area that have not been a part of any watershed development projects in the past 4 years, but have similar socio-economic characteristics to that of the "treatment" group.

Multi stage sampling was used for selection of sample, which is elaborated below:

Stage 1: Out of 125 GPs in the identified four districts viz. Bageshwar, Nainital, Rudraprayag and Tehri Garhwal, 51GPs have been randomly selected in proportion to the number of GPs where SLEM activities are being implemented

Stage 2: The selected GPs have been proportionately sampled by topography, i.e., ridge, middle, and valley.

Stage 3: From the above 51 GPs, 102 RVs were selected. 2 RVs have been selected from each GP on an average.

Stage 4: The final sampling units were individual households. Approximately 10 households were randomly selected from the village population based on the proportion of different castes (SC/ST/OBC/General) and/ or different economic levels in the village to represent all the sections of the population. Tables 1 and 2 provide a summary of the sample frame used for selection of the GPs and the RVs. The list was submitted to the Watershed Management Directorate (WMD) for approval. The control GPs, meeting the required criteria, were selected in consultation with WMD. These villages have similar socio-

economic characteristics as compared to project villages and have not benefitted from UDWDP or other major watershed interventions in the last four years.

Selection of sample frame for final impact evaluation

The sample for the final impact assessment consisted of 487 households, 49 RVs[5], and 26 GPs out of the 51 GPs covered in the baseline survey by TERI. The sample was selected in consultation with the WMD and DPDs of the four concerned Divisions (Bageshwar, Nainital, Rudraprayag and Chinyalisaur) from the baseline sample based on proportional representation to the four divisions covered, the topography of the sampled GPs (middle, valley, ridge) under the project and with due consideration to the need for covering all project interventions. The same RVs and households (within the set of GPs selected for the final assessment) have been selected for the survey as were covered in the baseline survey for the most effective comparison, as far as practicable. The same baseline Control Group consisting of the 5 GPs , 10 RVs and approximately 100 HHs from micro watersheds outside the project area was used in the final survey.

Tables 2 and 3 provide a summary of the sample frame used for selection of the GPs and the RVs. Detailed list of GPs/ RVs selected for the final survey is given in Table 3. The list has been approved by the Watershed Management Directorate (WMD), GoUA). The control GPs are the same that were surveyed during the baseline survey and the details are given in Table 4.

Table 1 Summary of the sample frame for the baseline and final impact survey

Name of District	Name of Development Block	Total No. of GPs/RVs under SLEM Project		No. Selected for Baseline Survey		No. Selected for Final Assessment Survey	
		GP	RV	GP	RV	GP	RV
Bageshwar	Kapkot	11	19	4	8	3	7
Nainital	Dhari and Okhalkhanda	40	61	17	32	7	13
Rudraprayag	Augustmuni	52	108	20	42	10	18
Tehri Garhwal	Thauldhar	22	41	10	20	6	11
Total		125	229	51	102	26	49

Source: TERI Baseline Report 2012 and WMD

Table 2 Summary of the sample frame based on topographical stratification

Distt.	Total Project GPs				GPs selected for Baseline Survey				GPs selected for Final Impact Survey			
	Ridge	Middle	Valley	Total	Ridge	Middle	Valley	Total	Ridge	Middle	Valley	Total
Bageshwar	3	3	5	11	1	1	2	4	0	1	2	3
Nainital	12	21	7	40	5	9	2	16	2	4	1	7
Rudraprayag	16	24	12	52	6	9	5	20	3	3	4	10
Tehri Garhwal	10	4	8	22	5	2	3	10	3	2	1	6

Source: TERI Baseline Report 2012 and WMD

Table 3 Detailed list of GPs/ RVs selected for the final impact survey

S.No. of GP	GP	RV	Location in MWS	MWS	Dev. Block	District
1	Gainar	Gainar	Valley	Ginargad	Kapkot	Bageshwar
	Gainar	Bithi Panyali	Valley	Ginargad	Kapkot	Bageshwar
2	Sumati Baisaini	Sumati	Middle	Gagnigad	Kapkot	Bageshwar
	Sumati Baisaini	Baisani	Middle	Gagnigad	Kapkot	Bageshwar
	Sumati Baisaini	Posari	Middle	Gagnigad	Kapkot	Bageshwar
3	Harsilla	Harsilla	Valley	Kumgad	Kapkot	Bageshwar
	Harsilla	Kapholi	Valley	Kumgad	Kapkot	Bageshwar
4	Majyuli	Majyuli	Middle	Dolgad	Dhari	Nainital
	Majyuli	Kafroli	Middle	Dolgad	Dhari	Nainital
5	Mehtoliya gaon	Mehtoliya gaon	Middle	Dolgad	Dhari	Nainital
	Mehtoliya gaon	Nadgal	Middle	Dolgad	Dhari	Nainital
6	Thaladi	Thaladi	Ridge	Pasiyagad	Okhalkanda	Nainital
7	Thali	Thali	Middle	Pasiyagad	Okhalkanda	Nainital
	Thali	Mohanagaon	Middle	Pasiyagad	Okhalkanda	Nainital

S.No. of GP	GP	RV	Location in MWS	MWS	Dev. Block	District
8	Katna	Katna	Ridge	Khujetigad	Okhalkanda	Nainital
	Katna	Kotla	Ridge	Khujetigad	Okhalkanda	Nainital
9	Kukuna	Kukuna	Middle	Sunkot	Okhalkanda	Nainital
10	Digauli	Digauli	Valley	Sunkot	Okhalkanda	Nainital
	Digauli	Kafrauli	Valley	Sunkot	Okhalkanda	Nainital
	Digauli	Bagot	Valley	Sunkot	Okhalkanda	Nainital
11	Vora	Vora	Ridge	Surgad	Augustmuni	Rudraprayag
12	Kyudi	Kyudi	Middle	Surgad	Augustmuni	Rudraprayag
	Kyudi	Kanda	Middle	Surgad	Augustmuni	Rudraprayag
13	Baniyari	Baniyari	Valley	Baniyarigad	Augustmuni	Rudraprayag
14	Ginwala	Ginwala	Valley	Baniyarigad	Augustmuni	Rudraprayag
	Ginwala	Talsari	Valley	Baniyarigad	Augustmuni	Rudraprayag
15	Kamsal	Kamsal	Middle	Baniyarigad	Augustmuni	Rudraprayag
	Kamsal	Aita	Middle	Baniyarigad	Augustmuni	Rudraprayag
16	Kinjani	Kinjani	Ridge	Kyunjagad	Augustmuni	Rudraprayag
17	Bhatwari Sunar	Bhatwari Sunar	Valley	Kyunjagad	Augustmuni	Rudraprayag
	Bhatwari Sunar	Mathkhani	Valley	Kyunjagad	Augustmuni	Rudraprayag
	Bhatwari Sunar	Dubarkhau	Valley	Kyunjagad	Augustmuni	Rudraprayag
18	Tevadi Sem	Tevadi Sem	Middle	Kyunjagad	Augustmuni	Rudraprayag
	Tevadi Sem	Kauntha	Middle	Kyunjagad	Augustmuni	Rudraprayag
19	Sari	Sari	Valley	Chhinka-Pogthagad	Augustmuni	Rudraprayag
	Sari	Chamsil	Valley	Chhinka-Pogthagad	Augustmuni	Rudraprayag
	Sari	Jhalimath	Valley	Chhinka-Pogthagad	Augustmuni	Rudraprayag
20	Agar	Agar	Ridge	Chhinka-Pogthagad	Augustmuni	Rudraprayag

S.No. of GP	GP	RV	Location in MWS	MWS	Dev. Block	District
21	Bhenti	Bhenti	Valley	Gairgad	Thauldhar	Tehri Garhwal
	Bhenti	Majhiyari	Valley	Gairgad	Thauldhar	Tehri Garhwal
22	Indiyan	Indiyan	Ridge	Malogigad	Thauldhar	Tehri Garhwal
	Indiyan	Pandogi	Ridge	Malogigad	Thauldhar	Tehri Garhwal
23	Majhkhet	Majhkhet	Middle	Ghattugad	Thauldhar	Tehri Garhwal
	Majhkhet	Thirani	Middle	Ghattugad	Thauldhar	Tehri Garhwal
24	Gair Nagun	Gair Nagun	Ridge	Gairgad	Thauldhar	Tehri Garhwal
	Gair Nagun	Loldi	Ridge	Gairgad	Thauldhar	Tehri Garhwal
25	Pokhari	Pokhari	Ridge	Gairgad	Thauldhar	Tehri Garhwal
26	Ghoun	Ghoun	Ridge	Chamargad	Thauldhar	Tehri Garhwal
	Ghoun	Lalaudi	Ridge	Chamargad	Thauldhar	Tehri Garhwal

Table 4 List of Control GPs for the Final Impact assessment

S.No	GP	RV	Division	MWS	District
1	Sulla Bamangaon	Sulla Bamangaon	Augustmuni	Utrasu	Rudrapryag
		Gadanu			
2	San	San	Augustmuni	Dungri	Rudrapryag
		Kyark			
3	Dharogi	Dharogi	Chinyalisaur	Jaspur	Tehri Garhwal
		Sano			

S.No	GP	RV	Division	MWS	District
4	Patena	Patena	Haldwani	Dalgad	Nainital
		Ramolagaon			
5	Faltania	Faltania	Bageshwar	Joshigarh	Bageshwar
		Gad gaon			

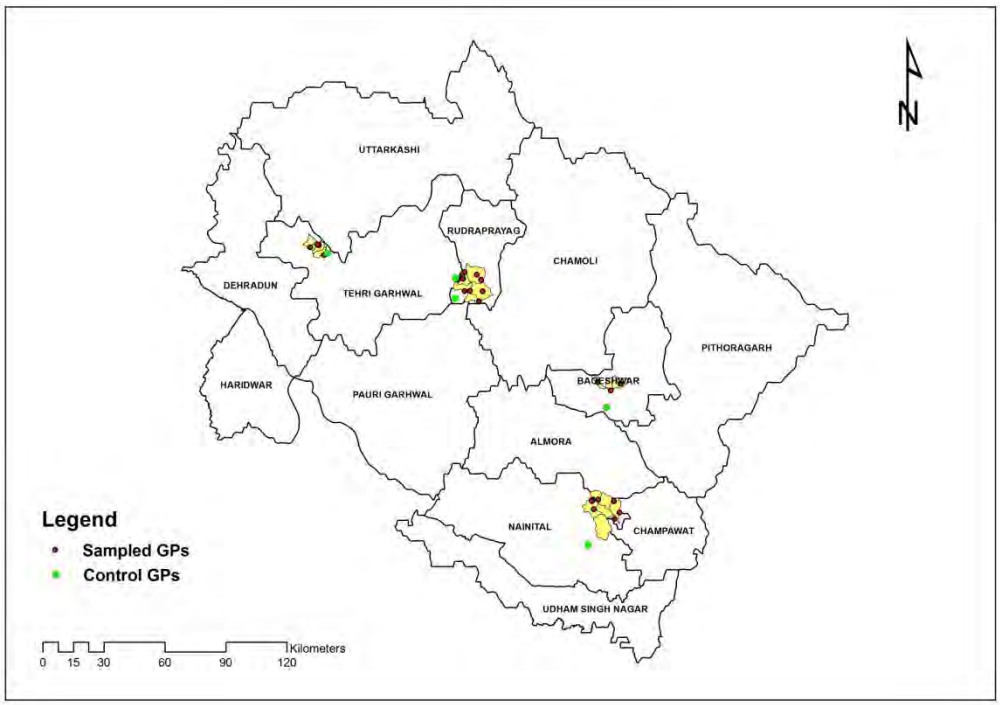


Figure 1 Location of Sampled and Control GPs

Survey Instruments – Revision and refinement

The basic survey instruments were questionnaires at three levels which were reviewed and refined taking into account the requirements of final impact assessment of SLEM project.

The HH questionnaire was designed to collect information for a particular identified household. Information at the RV and GP level was intended to be collected mainly through group discussions at the respective level and through the use of structured questionnaires.

A few additional questions at HH, RV and GP levels were framed based on an understanding of the ToR and were sent to the WMD for comments and suggestions. These formed a part of the survey questionnaires. The questionnaires finally used are provided as Annexure to the report.

Mobilization and training of the survey team and finalisation of formats

The survey team that had participated in the baseline survey of SLEM (undertaken by TERI) was re-mobilised for the SLEM baseline survey. There was a single team which conducted the survey of Garhwal region first and then of Kumaon region. About 10 field surveyors were enlisted to conduct the survey.

A two day training programme was organized for the survey team at *The Wildlife Preservation Society of India* office, Dehradun during 27.12.2012 to 28.12.2012. The training programme was conducted by key professionals of the TERI team Concerned staff of WMD participated in the programme and provided expert inputs. During the training programme, broad field techniques were explained, and the survey questionnaires were discussed in detail and the questionnaires were further refined and modified, and subsequently vetted by WMD.

Conduct of the socio-economic survey

The survey programme was developed by the TERI Project Monitoring Unit (PMU) at Dehradun in close consultation with the New Delhi based TERI research team and field supervisors.

The survey for the treatment and control group was completed in the covered GPs. The filled-in questionnaires were checked in the field by TERI professionals. A data entry structure was prepared in MS-EXCEL. A trained data entry operator carried out the data entry.

Analysis and reporting

Data analysis and reporting was done based on the requirements of the ToR and the Results Framework of the project. Baseline and final values have been compared in most cases, and qualitative assessment of the impact reported based on field observations.

Specialised methodology for selected project components

Soil and water conservation

Physical assessment of structures was combined with data sourced from socio-economic surveys to evaluate the impact. Use of proxy indicators was made wherever needed. For example, the time saved for fetching water was used as proxy for enhanced water availability. Increase in cultivated area under irrigation was estimated based on village surveys. The area under various SLEM techniques was estimated by summing up the impacted area under various SLEM activities, as detailed in Chapter 4 of the report.

Assessment of plant species diversity

Vegetation surveys were carried out in sixteen locations spread over four districts of Uttarakhand state in a stratified random sampling design. Two blocks (Augustmuni, and Thauldhar) were from the Garhwal region, while two blocks (Okhalkanda and Kapkot) were from the Kumaon region. All the selected sites fall within an altitudinal range of 700 m to 2000m and have a subtropical to temperate climate and vegetation. Most of the plantations under SLEM were carried out in the Van panchayats and Reserve Forests. Field data was collected from February to March, 2013, soon after winter.

To assess the vegetation composition of planted sites and the survival percentage of planted seedlings and saplings, nested quadrat sampling approach was used in all the selected sixteen sites. At all the selected sites, quadrats of size 20 x 20 m for trees, 10 x 10 m for shrubs and seedlings and saplings, and 1 x 1 m for herb species were laid out. The seedlings/saplings assessed in the 10 x 10 m shrub quadrats included those planted under the SLEM project, as well as any natural regeneration that may have occurred. The total number of tree, shrub or herb species and their abundance was used to calculate a diversity index for each of these categories for each site. In addition, the total number of species of trees, shrubs and herbs were used to determine the species richness of each vegetation category, as well as to obtain the total plant species richness for each site so as to understand the key species of flora in the MWS

Shannon-Weiner Diversity Index was used to calculate diversity.

$H'=-\sum p_i \ln p_i$

Number of individuals of one species /Total number of all individuals in the samples

'ln' is the natural logarithm to base e.

The Shannon Weiner Index takes both species richness and the relative abundance of each of these species in a community into account to determine the uncertainty that an individual picked at random will be of a given species. It provides a simple measure of the degree to which species in a community are represented.

Biomass Calculation using Remote Sensing Techniques

The biomass calculation for the final impact evaluation survey followed the methodology used in the baseline study. IRS satellite data was used to calculate biomass at the MWS level. The data for the study was procured from the National Remote Sensing Centre (NRSC) through the WMD . The same sixteen sampling sites and plots used for plant species diversity survey were used for calculating biomass and ground truthing of the satellite information.

Biomass surveys for all selected sites were carried out in early 2013. The standing biomass stock was then calculated through volume equations. In order to extrapolate the results to the entire study area, the standing biomass stocks (quadrats) were correlated with the NDVI values of the satellite images.

Once the biomass was calculated for the whole study area, comparison of the figures was made with those of the baseline study at the MWS level.

Economic analysis

The economic analysis of the project followed conventional techniques of cost-benefit analysis as applicable to watershed/NRM projects. Benefits were captured for the major interventions by analyzing data from sub-samples/ case studies. . The benefits were then aggregated across interventions and compared with overall project costs. The data for the economic analysis was sourced largely from the economic analysis survey, household survey and supplemented by secondary data. Reasonable assumptions were used for computing indirect benefits such as the opportunity cost of time saved and the potential returns from land that has been saved from getting eroded. The economic analysis results are reported in terms of BCR both at the aggregate level and for a few specific interventions, where needed.

Sensitivity analysis was done for benefit-cost ratios under three discount rates (4%,6%,8%) and two time horizons (5 yr and 10 yr). In view of a large proportion of indirect benefits and high sensitivity to assumptions, IRR computations have not been done as they present a misleading picture if not referenced to the range of assumptions. As such, BCR has been used as the criterion for economic analysis of the project. It may be noted that BCRs presented in the report represent a conservative estimate of benefits, as several benefits have not been monetised. For example, the ecosystem services of plantations and the landscape wide benefits of soil conservation works have not been captured as they require more intensive study with greater resources and time. Thus the results may be taken as indicative, rather than conclusive.

3. Demography and Incomes

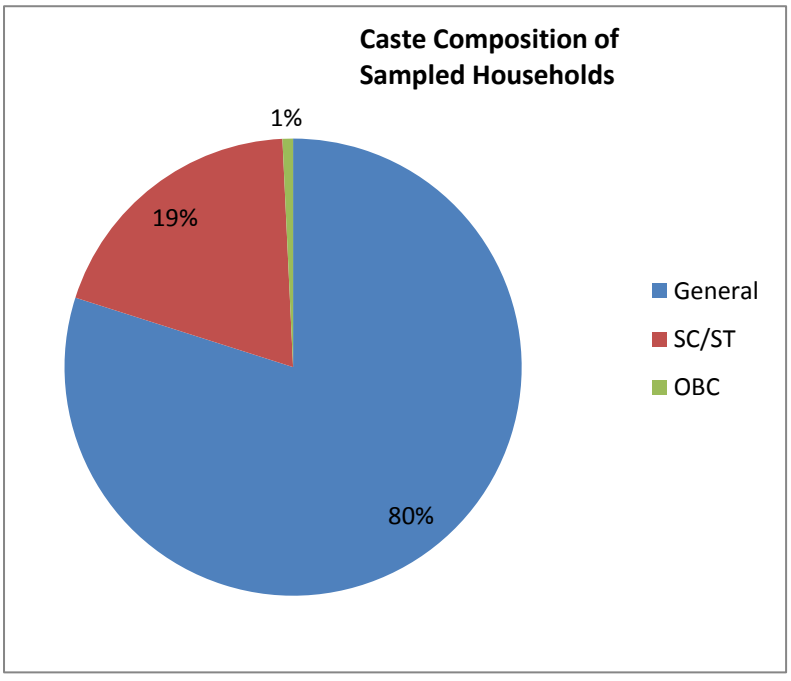
Introduction

The total population of the state of Uttarakhand is 1,01,16,752 (Census 2011) and given that much of the state is hilly and mountainous, Uttarakhand is sparsely populated relative to the rest of the country. The population density of the State as per the recent 2011 census is 189 persons per sq. km, half of the national average of 382. Uttarakhand's sex ratio of 963 females per 1000 males is far better than the national average of 940 females.

In this chapter, we provide information on the demographical profile of the study area.

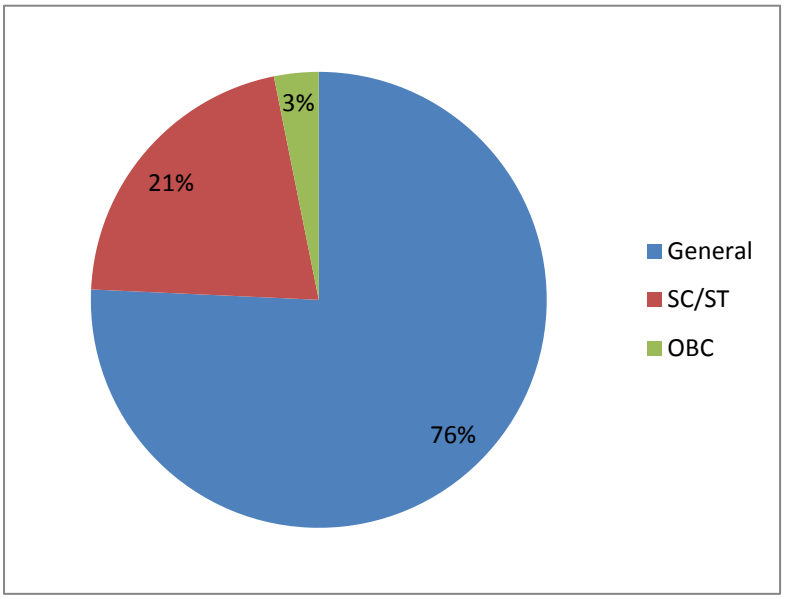
Demographic Profile

The demographic profile of the project and control GPs (details in Table 6, 7 & 8) have not changed since the baseline survey. In our study, 80% of the households belong to the general caste category followed by scheduled castes and scheduled tribe (19%) and other backward castes (1%). The composition of the sampled households is very similar to the control group (Figure 2). This is corroborated by t-test for means across means for main caste categories.



Source: TERI Primary Survey, 2013

Figure 2 Caste Composition of the Sampled Households

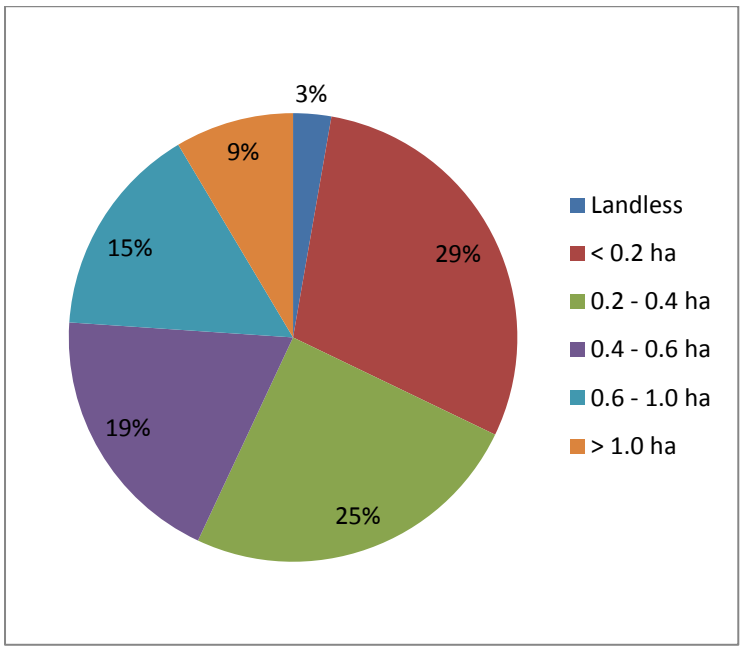


Source: TERI Primary Survey, 2013

Figure 3 Caste Composition of the Control Households

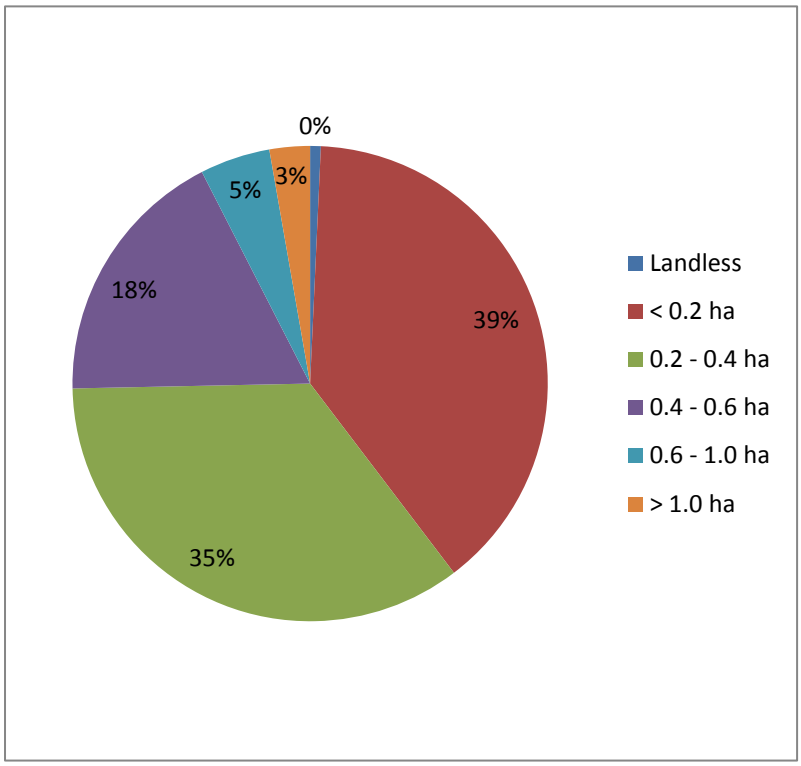
Landholding

In terms of landholding, the largest group of sampled households (29%) possess less than 0.2 ha of land whereas the percentage of landless households is the least (3%) (Figure4). For the control GPs, the largest group of sampled households (39%) also held less than 0.2 ha of land (Figure 5).



Source: TERI Primary Survey, 2013

Figure 4 Distribution of households by landholding in the sampled project GPs

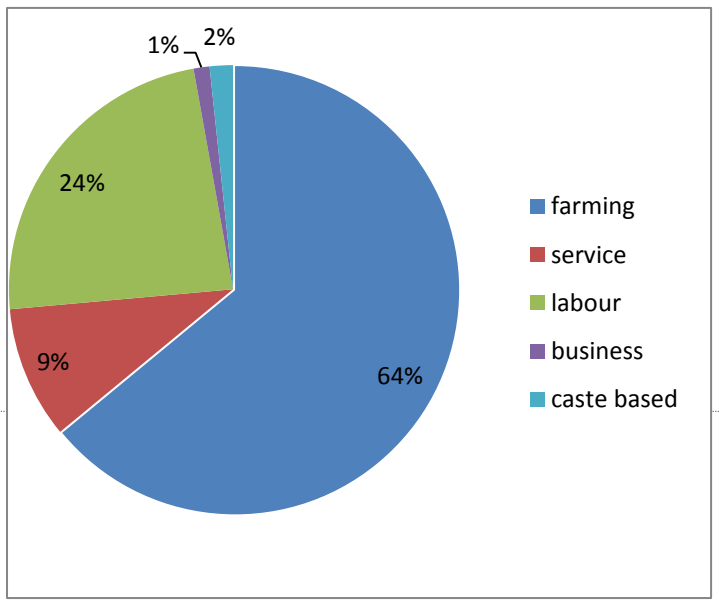


Source: TERI Primary Survey, 2013

Figure 5 Distribution of households by landholding in Control GPs

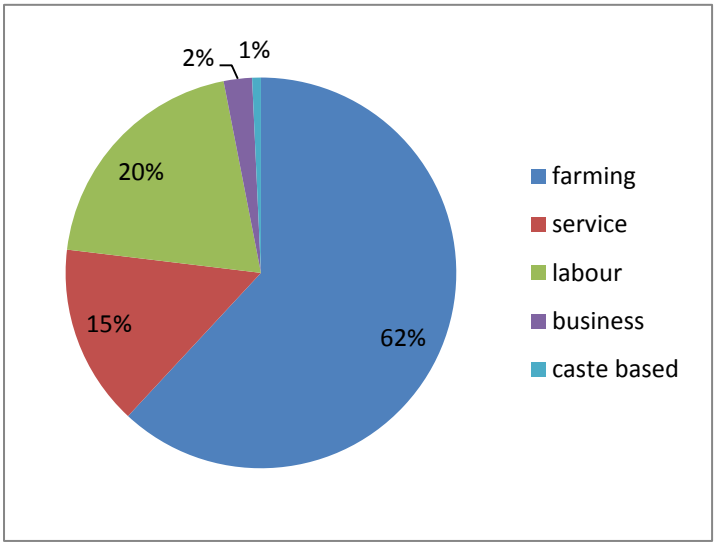
Occupational structure

The composition of sampled households in terms of key primary occupations is shown in Figure 6. The figure shows that a majority (64%) of sampled households were involved in agriculture as their primary occupation, followed by labour (24%) and service (9%). Caste-based occupations refer to occupations (usually tertiary) that are peculiar to specific castes such as black smiths and carpenters. The study group had a similar occupational structure to the control group, with most of the households involved in agriculture.



Source: TERI Primary survey, 2013

Figure 6 Occupational structure of households in sampled project GPs



Source: TERI Primary Survey, 2013

Figure 7 Occupational structure of Households in control GPs

Incomes and Assets

Incomes in the project area have increased on the whole. From a baseline value of Rs.55,938 p.a., incomes have increased to Rs. 75,025 p.a. per household on an average – an increase of 34%. Based on General Consumer Price Indices (GCPI) for Rural Areas (Base 2010 = 100), the

baseline value has been adjusted upwards to Rs 70,258.[6] Thus, in real terms (that is accounting for price inflation), the incomes have gone up by approximately 7%. In the control group, the average income has gone up from Rs 41,486 p.a. to Rs 45,581 p.a. – an increase of about 10%. Disaggregation of incomes has not been possible in the study as the interventions of the project have been largely community targeted, except in case of livelihood support activities for SHGs. Economic analysis has been presented separately for this activity in Chapter 8.

There is a significant increase in the ownership of consumer durables, which indicates a general improvement in living standards.

Table 5 Assets in sampled project GPs (in numbers)

	Baseline(no)	final (no)	% increase
Non-farm generating equipment	144	151	4.86
Consumer durables	1678	1971	17.46
Vehicle	23	22	-4.34

Source: TERI Primary Survey, 2013

Annexure to the Chapter

Table 6 Demographic profile of the sampled project GPs

	Households	Population	Male	Female	General	SC	ST	OBC	BPL
Gainar	101	538	280	258	97	4	0	0	19.19
Sumati	166	812	415	397	135	31	0	0	24
Harsila	207	1265	627	638	90	117	0	0	49.68
Majhyuli	61	345	168	177	56	5	0	0	15.25
MahtoliyaGaon	122	572	220	352	99	23	0	0	37.82
Thladi	151	692	337	355	124	27	0	0	18.12
Thali	241	1239	534	705	222	19	0	0	67.48
Katna	95	746	370	376	83	12	0	0	25.65
Kukna	57	787	354	433	41	8	8	0	9.12
Digauli	281	1987	1012	975	189	92	0	0	56.2

[6] GCPI (Rural) = 125.6 (March 2013) for Uttarakhand (Base 2010 = 100)

	Households	Population	Male	Female	General	SC	ST	OBC	BPL
Vora	220	1410	680	730	197	23	0	0	24.2
Kyudi	163	791	410	381	129	34	0	0	30.97
Baniyari	138	630	303	327	119	19	0	0	21.78
Giwala	190	1013	512	501	87	103	0	0	36.1
Kamsal	227	1252	636	616	227	0	0	0	38.59
Kinsani	174	838	430	408	149	25	0	0	52.08
BhatwariSunar	230	942	467	475	209	21	0	0	92
Tewadisem	114	606	299	307	76	38	0	0	17.1
Sari	69	281	133	148	60	9	0	0	15.18
Aagar	189	678	378	300	160	29	0	0	46.25
Gairnagun	185	1344	734	610	162	23	0	0	27.6
Pokhri	130	675	347	328	114	16	0	0	34.83
Bheti	218	1395	708	687	163	55	0	0	38.88
Indyan	94	363	187	176	58	6	0	30	22.56
Majhkhet	128	433	200	233	100	28	0	0	15.6
Dhaun	72	415	207	208	69	3	0	0	15.12

Source: TERI Primary Survey, 2013

Table 7 Demographic profile of the control GPs

GP Name	Households	Population	Male	Female	General	SC	ST	OBC	BPL
Faltania	120	660	325	335	54	41	0	25	42

GP Name	Households	Population	Male	Female	General	SC	ST	OBC	BPL
Patena	60	430	195	235	54	6	0	0	12
SillabamanGaon	261	1600	862	738	161	100	0	0	30
San	140	549	251	298	132	8	0	0	28
Darogi	210	878	438	440	198	12	0	0	10

Source: TERI Primary Survey, 2013

Table 8 Two sample t-test with unequal variances

Number of households in the general category						
Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
control	5	119.8	28.82776	64.46084	39.76129	199.8387
treatment	26	123.6538	10.63925	54.24975	101.7419	145.5658
combined	31	123	9.8515	54.851	102.9127	143.1518
diff		-3.85385	30.72839		-82.1629	74.45523
diff = mean(ctrl) - mean(trt)				t = -0.1254		
Ho: diff = 0		Satterthwaite's degrees of freedom = 5.14858				
Ha: diff < 0		Ha: diff != 0		Ha: diff > 0		
Pr(T < t) = 0.4525		Pr(T > t) = 0.9049		Pr(T > t) = 0.5475		

Number of households in the SC category						
Group	Obs	Mean	Std.Err	Std.Dev.	[95% Conf Interval]	
control	5	33.4	17.8146	39.83466	-16.0613	82.86126
treatment	26	29.61538	5.93609	30.26824	17.38978	41.84099
combined	31	30.22581	5.614059	31.25776	18.76037	41.69124
diff		3.784615	18.77757	-44.698	52.26724	
diff = mean(ctrl) - mean(trt)				t = 0.2015		

Number of households in the SC category		
Ho: diff = 0	Satterthwaite's degrees of freedom = 4.92785	
Ha: diff < 0	Ha: diff != 0	Ha: diff > 0
Pr(T < t) = 0.5758	Pr(|T| > |t|) = 0.8483	Pr(T > t) = 0.4242

4. Controlling land degradation through the SLEM approach at watershed level

Introduction

Over 86% of the geographical area of Uttarakhand consists of hills and mountains made up of fragile soils prone to erosion, especially during the monsoon. At the same time, pressure on natural resources continues to grow with population increasing rapidly (at the decadal rate of19.34% for the period 1991-2011), leading to increasing demand of land for livestock grazing, firewood and industry. Concern of land degradation becomes even greater in the context of 70% of the state population being dependent on agriculture, livestock, and horticulture activities coupled with high poverty levels (39%). The poor people are mainly dependent on natural resources for livelihood. It is therefore, important to identify ways to eliminate poverty while also enhancing the productive natural resource base and the livelihood basis of the majority of the population.

Status of landuse in Uttarakhand

Land use classification for Uttarakhand is provided in Table 1 below. The total cultivated area (net area sown and current fallow) is 7,66,459 ha which is 13.5% of the reported area for land utilization. The cropping intensity is 161.75% (Plains – 167.89 %and Hills – 157%).

Table 9 Landuse in Uttarakhand

Landuse	Area in ha
Reporting area for land utilization	5672636
Forest area	3484803
Land not available for cultivation	442412
Permanent pastures and other grazing lands	198526
Land under misc. tree crops and groves	385548
Cultural wasteland	310390
Fallow lands other than current fallows	84498
Current fallows	43295
Net area sown	723164

Source: Land Use Statistics, Government of Uttarakhand, 2010-11

Table 10 provides basic land use statistics for the microwatersheds under SLEM. It is seen that the actual agricultural area under cultivation is 9963 ha which is about 55% of the total available agricultural area (18057 ha) in the MWS. Out of the actual area under cultivation, a majority of the area (8711 ha or 87%) is under rainfed agriculture . About 64% of the area of MWS is recorded as forest[7].

Table 10 Statistics for the selected MWS

Name of Districts/ Division	No. of MWS	MWS area (ha)	Forest Area (ha)	Agri. Area (ha)	Actual area under cultivation			Blank Area (ha)	No. of GPs	Area of GPs (ha)	GP Population
					Irrigated (ha)	Un-irrigated (ha)	Total				
Rudraprayag (Augustmuni)	5	20349	10449	7956	520.00	2935.93	3455.93	1944	52	9968.7	3811
Bageshwar (Bageshwar)	5	8742	6308	1661	268.03	512.57	780.60	773	11	3446.03	8057
TehriGarhwal (Chinyalisaur)	5	8357	5044	2619	167.69	1540.25	1707.941	694	22	3542.8	10414
Nainital (Haldwani)	5	23375	17255	5825	295.95	3722.66	401861	299	40	8154.7	17674
Total	**20**	**60823**	**39056**	**18057**	**1251.67**	**8711.41**	**9963.08**	**3710**	**125**	**25112.2**	**74256**
Percentage			**64.21***	**29.69***	**12.56+**	**87.44+**	**55.18@**	**6.10***			

Source: WMD

***% total area of MWS.**

@ % to total agriculture area.

+ % to actual cultivated area.

The annual rainfall in Uttarakhand is 1700 mm spread over 100 rainy days. Most (95%) of the precipitation that falls in the catchments area as surface water, is lost due to steep slopes and mountainous terrain.

SLEM approach

Under the SLEM approach, activities have focussed on 20 micro watersheds that have high erosion indices, which are socio-economically backward and are predominantly situated close to the agricultural frontier. In the context of soil and water conservation, the project has focussed on the principles of Sustainable Watershed Management mainstreamed into 20

[7] This is the recorded forest area, rather than the actual area under forest cover.

local government plans including parts of watersheds for which two or more Gram Panchayats have shared governance responsibility. This component of SLEM was intended to reduce soil erosion, and enhance biomass and the availability of water in the watersheds throughout the year. Importantly, for watershed interventions in areas beyond the boundaries of the GP (Inter GP - mainly Reserve Forest area), ashare of the total budget allocation for the respective MWS was kept aside.

Extent of Soil Erosion in Microwatersheds under SLEM

Uttarakhand is a hilly state and expectedly, a large land area under SLEM project is prone to soil erosion (Table 11).

Table 11 Land under different Erosion intensity categories of land erosion

	Agriculture				Forest				Blank				Other	Total (ha)
Erosion class	E1	E2	E3	E4	E1	E2	E3	E4	E1	E2	E3	E4		
Area (ha)	5375	10165	2349	168	7347	20416	11235	58	137	1333	1951	0	289	60823

Source: Land Survey Directorate, State Forest Department

The classification of erosion intensity categories (for arable land) is as follows:

a) E1 = Where erosion intensity is slight. (Arable land having natural slope upto 25%, field slope below 5%).

b) E2 = Where erosion intensity is moderate. (arable land having i) slope between 25% to 60% with proper terracing; ii) Natural slope upto 25%, and defective terracing)

c) E3 = Where erosion intensity is severe (i) all unterraced fields with no defined gullies; ii) Natural slope between 25% and 60% with defective terracing and iii) slope over 60% with proper terracing)

d) E4 = Destroyed (i) all unterraced fields with gullies, cut up and heavy silt discharge; ii) all defectively terraced fields beyond 60% slope)

It is to be noted that the high erosion intensity areas, though relatively less in area terms as compared with the low erosion intensity areas, are critical in terms of their impact on the latter. The E3 and E4 categories, followed by the E2 category, therefore remain the most eligible areas for SLEM treatment. Moreover, the soil and water conservation activities benefit not just the location of the intervention, but also the adjoining agricultural and habitation areas, and thus it becomes important to treat high erosion areas for the sake of conserving the entire productive landscape.

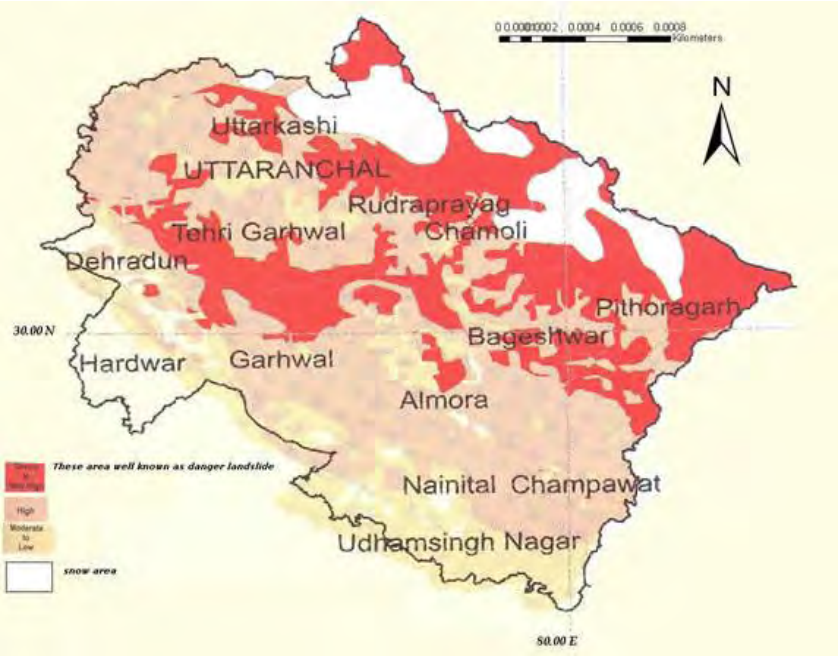
It is also to be noted that along with the extent of erosion, Uttarakhand is also vulnerable to natural calamities. Table 12 provides the extent of damage in 2012 in districts where the SLEM project has been implemented.

Table 12 Damage by Natural calamities in selected districts of Uttarakhand in year 2012

District	Human Loss		Loss of livestock	Damage to Houses		Damage to Agriculture land	Damage to common property		
	Death	Injury		Partial	Full		Roads (places)	Buildings and other property	Soil and Water conservation structures
Bageshwar	13	4	37 + 124 (goats)	51	27	10 to 30% crop damage in two villages	Motor road-29 Foot path – 09	1	Drinking water-06, culverts-05, Irrigation channels-01, checkdams-05, Gharat-05
Nainital	4	2					Motor road-3		
Tehri Garhwal	1	3	4				Motor road-01	Car-01	
Rudraprayag	76	34	86	7	65	1.8 ha	Motor road-03	Car-01,	Drinking water-02, Irrigation channel-01

Source: Uttarakhand State Disaster Management Authority

Landslide is an extremely common phenomenon in Uttarakhand. The following map (Figure 8) shows that out of four selected districts three (Bageshwar, Tehri Garhwal and Rudraprayag) fall in the zone of landslide.



Source: Uttarakhand State Disaster Management Authority

Figure 8 Landslide zone in Uttarakhand

16th June 2013 has brought the greatest ever calamity in Rudraprayag district including the MWSs falling under SLEM project. The extent of soil erosion has crossed all past records and there has been a heavy damage to soil and water conservation structures created in the project. The exact extent of damage is yet to be estimated. Heavy rains at several places continuously for 4 days has caused heavy soil erosion in other districts covered under the project and it would be important to carry out a detailed survey of damage caused to project activities in other districts as well. Due to unprecedented rains in upper catchments of Rudraprayag, Chamoli, Uttarkashi and Pithoragarh the high silt load in major rivers was responsible for washing away roads, bridges, houses, agricultural land and other properties, causing heavy loss of human life and livestock in the areas.

Soil and Water Conservation Interventions of SLEM

The soil conservation interventions are covered under the activity head "Controlling land degradation through the SLEM approach at watershed level". The total area of the selected MWSs is about 60823 ha out of which 12727.39 ha has been under intensive soil and water conservation treatment. The soil conservation activities include vegetative check dams, drystone check dams, cratewire checkdams, cratewire spurs, contour bunds and trenches, river bank protection works, retaining wall/cross barrier, diversion drains, landslide treatment and road side erosion control works as detailed in Table 13.

Table 13 Soil and water conservation structures

Name of Dist./ Division	Vegetative Check dam (No.)	Dry stone Check dam (cumt)	Crate-wire Check dam (cumt)	Crate wire spurs (cumt)	Contour Trenches with Bunds (No)	River Bank Protection works (cumt)	Retaining wall/cross barrier (cumt.)	Diversion drain (cumt)	Land slide treatment works (cumt)	Road side Erosion Control (cumt)
	1	2	3	4	5	6	7	8	9	10
Bageshwar (Bageshwar)	-	141.56	439.44	-	5676	3517.62	348.62	-	79.5	-
Nainital (Haldwani)	66	1568.23	9582.29	-	8298	937.7	569.8	3353	-	-
Rudraprayag (Augustmuni)	20	2199.6	3952.62	300	7952	650	801.82	310	-	2213.72
Tehri – Garhwal (Chinyalisaur)	-	3803	2560	-	-	676	38	-	-	-
Total	**86**	**7712.39**	**16534.4**	**300**	**21926**	**5781.32**	**1758.24**	**3663**	**79.5**	**2213.72**

Source: TERI Survey 2013

Methodology

Table 14 Result framework for soil and water conservation activities

Project Development Objective	Result/Outcome Indicators	Baseline data / evaluation method	Baseline value	Final Value
Controlling land degradation through the SLEM approach at watershed level	20% of the area in selected MWS under improved SLEM techniques	Area under SLEM techniques	Project area comprises 39056 ha of Forest area, 18057 ha of Agriculture area and 3710 ha Blank area	- 21.24% of total area brought under improved SLEM techniques - 103.92 ha area directly impacted in terms of soil and moisture retention in sample GPs
	Increase in availability of water in the dry season by 5% in the treated MWS	Hours spent in accessing water in dry season, access to various water sources for domestic use and irrigation	- 68.37% of hh spend < 1 hr to access water in dry season, 30.8% spend 1-2 hr to access water in dry season[8]	- 82.34% of hh spend < 1 hr to access water in dry season, 17.04% spend 1-2 hr to access water in dry season
			- Irrigated land (Average per GP) (13.24 ha), Unirrigated land (Average per GP) (64.50 ha)[9]	- Irrigated Land (Average per GP) (13.78 ha), Unirrigated land (Average per GP) (63.95 ha) indicating increase of 4.1% of irrigated land
	10% increase in vegetative and biomass index in the 20 MWS.	Biomass	Average value of biomass is 48.5 t/ha (Average of MWS)	5.5% (Weighted average) of biomass increase in microwatersheds, MWS areas are used as weights, Average value of biomass is 50.7 t/ha (Average of MWS)
	Implementation of 5 to 10 alternative technologies and approaches for enhancing water availability for agriculture and	Number of technologies implemented	Technologies – 1) Roof Water Harvesting Tanks 2) Irrigation tanks and channels 3) Sprinklers 4)	Technologies - 1) Roof Water harvesting structures, 2) Irrigation tanks with delivery system,34) Village ponds, percolation tank, contour trenches with bunds, 45) Rejuvenation of naula / khala 5) Controlling forest fire, 6) Plantations and ANR 7) River

[8] Based on 26 GPs selected for final impact evaluation

[9] Based on 26 GPs selected for final impact evaluation

Project Development Objective	Result/Outcome Indicators	Baseline data / evaluation method	Baseline value	Final Value
	other domestic use		Naula . Khala rejuvenation	training works

The broad methodology for this impact evaluation study has already been described in Chapter 2. Apart from data sourced from the questionnaire survey, remote sensing/GIS techniques have been used for assessing the impact of this component. The changes in biomass in the project MWSs have been calculated by using RS-GIS technology, using NDVI (Normalised Difference Vegetation Index).

Methods adopted for result outcomes / indicators

The PAD and the Result Framework have identified specific result outcomes / indicators to measure the efficacy of the project as described below -

1. 20% of the area in selected MWS under improved SLEM techniques

It is evident that only partial areas of selected GPs (and inter GP areas) were treated under SLEM techniques. The RF areas where rights and concessions of the sampled GPs are exercised have also been treated under SLEM techniques. The methodology for calculation of the treated area is as follows:

a) Area under soil and water conservation in GPs and associated RFs: The soil and water conservation structures have been constructed in identified streams within the areas of respective GPs. The catchment area of these treated streams has been estimated by measuring the length of the streams and the associated area which forms the catchment of the respective stream. Area under soil and water conservation of RFs associated with sampled GPs have been estimated using the same approach and reported together.

b) Area covered by contour trenches and bunds in the respective GPs: Based on average number of trenches per hectare.

c) The area under medicinal plant cultivation under each GP: Based on the actual reported area under medicinal plant cultivation, as verified during the survey.

d) The area under afforestation: Based on the actual area of plantation/ ANR as verified in the field.

As an example, we consider the streams in Tevadi Sem GP in Kyunjagad MWS where at Patiyun Tok, dry stone check dams and crate wire check dams have been constructed in two first order streams, merging into a second order stream. The length of the streams selected for treatment is about 600 m and 400 m respectively. The average width of the area surrounding the streams and forming their catchment is about 125 m. Hence the total area under treatment is estimated as 1000 m X 125 m = 125000 m^2 or 12.5 ha.

2. Increase in availability of water in the dry season by 5% in the treated MWS

As mechanisms for physical measurements are not established, proxy indicators such as time saved for collecting water in summer months have been used.

3. 10% increase in biomass in the 20 MWS.

To assess the change in biomass in the 20 MWS field level sampling and satellite based assessment of vegetation have been carried out.

The selection of sites has been done with a stratified random sampling approach so as to cover the altitudinal range of the project area and the diversity in the forest types from sub-tropical to temperate forests. Two blocks (Augustmuni and Thauldhar) were selected from the Garhwal region and two blocks (Kapkot and Okhalkanda) were selected from the Kumaon region for laying the sample plots. The sample plots fall in the following sites: Agar, Sari, Ginwala, Kontha, Loladi, Indiyan, Majkhet from the Garhwal region and Gainar, Baisani, Harshilla, Dholigaon, Pajaina, Kwaidal and Thali from the Kumaon region. All the selected sites fall within an altitudinal range of 700 m to 2000 m in subtropical to temperate climatic zone.

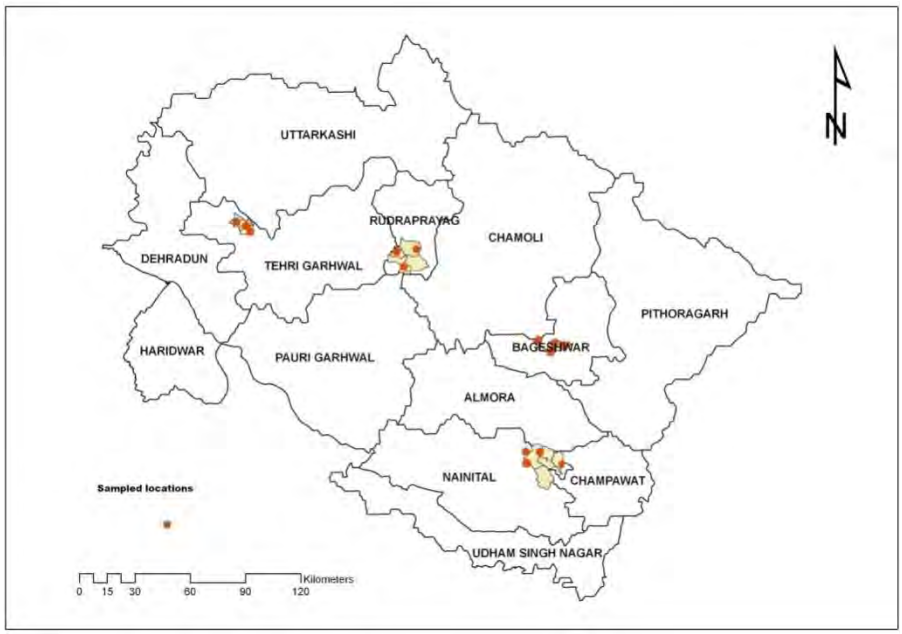


Figure 9 Sampling sites for biomass assessment

Field data for biomass assessment was collected from the sample plots in the months of February and March 2013 . To assess the standing biomass, quadrat sampling method was used in all the selected fourteen sites. At all the selected sites, nested quadrats were laid of the size 20 m x 20m for trees; within that 10 m x 10 m quadrat for shrub and saplings, and 1 m x 1m for herb species were laid out. The number of quadrats varied based on the size of the plantation. For 5 ha plantation sites three quadrats were laid while for 10 ha plantation sites 6 quadrats were laid as a part of sampling design. In the adjacent untreated site, one quadrat was laid as the control quadrat in each case.

On the basis of the field data, standing biomass was calculated separately for the treated and control sites. The standing biomass was calculated using volume equations for the respective

species. In case of non availability of the equation for some of the species the tree bole was assumed as cylinder and volume was accordingly calculated. The volume of tree was multiplied with the specific gravity value to calculate the above ground biomass (AGB) of the given tree.

For the purpose of remote sensing based analysis, in the present study IRS panchromatic (PAN) and LISS III data were used. The data set was procured by WMD from the National Remote Sensing Centre (NRSC) and forwarded to TERI for further analysis. A few vector layers such as micro-watershed boundaries were also provided by WMD to facilitate the assessment.

The satellite data sets of 2009- 10 and 2012 - 13 provided by NRSC (National Remote Sensing Centre) were geo - rectified and mosaicked (stitched together) for further processing. Several sampling quadrats were laid (as mentioned above) and the data from the quadrats were used to validate the classified image. For each quadrat, NDVI was calculated from the satellite data. NDVI is a graphical indicator that can be used to analyze remote sensing measurements, and assess whether the target being observed contains live green vegetation or not.[10]

To estimate the increment of biomass in the treated area, two point satellite data have been used, as mentioned above. It is assumed that within the treated areas, due to afforestation, maintenance, fencing and protection against grazing/over-exploitation, the natural vegetation (bushes, shrubs and grasses etc.) will grow and accumulate more biomass within project period as against the untreated areas.

NDVIs and biomass of the respective plots were correlated (R^2=0.67) so as to extrapolate the validated information at the microwatershed level to assess the change in the biomass at this scale.

Results

Area under improved SLEM techniques

The GP wise area under improved SLEM techniques as estimated by the methodology presented shown below (Table 15).

[10]NDVI = (Channel 2 - Channel 1) / (Channel 2 + Channel 1). The principle behind NDVI is that Channel 1 is in the red-light region of the electromagnetic spectrum where chlorophyll causes considerable absorption of incoming sunlight, whereas Channel 2 is in the near-infrared region of the spectrum where a plant's spongy mesophyll leaf structure creates considerable reflectance. As a result, vigorously growing healthy vegetation has low red-light reflectance and high near-infrared reflectance, and hence, high NDVI values. Calculations of NDVI for a given pixel always result in a number that ranges from minus one (-1) to plus one (+1); A zero means no vegetation and close to +1 indicates the highest possible density of green leaves.

Table 15 Area covered under improved SLEM Techniques in sampled GPs

S. no.	GP	GP area (ha) (A)	RF area (ha) (B)	Area for treatment (ha) (A+B)	Area under SLEM Techniques				Total area treated (ha)
					Soil and Water conservation (ha)	Medicinal and Aromatic Plants (ha)	Afforestation (ha)	Contour trenches with bunds (ha)	
1	Ghoun	154.43	994	1148.43	72.9	5.49	20	-	98.39
2	Majkhet	236.71	0	236.71	101.05	15.42	40	-	156.47
3	Bhenti	164.84	50	214.84	33.75	8.17	0	-	41.92
4	Gairnagun	188.04	60	248.04	61.7	5.3	5	-	72.00
5	Pokhari	141.81	150	291.81	40	4.59	5	-	49.59
6	Indiyan	155.87	80	235.87	39	5.36	10	-	54.36
7	Agar	209.07	500	709.07	11.35	-	10	1	22.35
8	Sari	177.38	500	677.38	60	8.81	5	-	73.81
9	TewariSem	136.79	160	296.79	29.1	7.592		2	38.69
10	Giwala	133.49	35	168.49	22.5	6.29	5		33.79
11	Baniyadi	78.49	35	113.49	39	1.21	-	1.5	41.71
12	BhatwadiSunar	75.47	160	235.47	30	7.1	-	-	37.1
13	Kinjani	272.32	160	432.32	30	-	5	2	37
14	Kamsal	163.16	35	198.16	0	4.68	-	-	4.68
15	Vora	114.73	100	214.73	0	4.62	-	6	10.62
16	Kyudi	443.85	110	553.85	5.75	5.1	15	13	38.85
17	Mehtoliagaon	174.14	141.7	315.84	62.8	6.72	-	2.5	72.02
18	Majyuli	528.94	76.1	605.04	154.5	8.55	10	0	173.05
19	Thali	398.85	177	575.85	195	6.73	7	5	213.73
20	Thaladi	183.34	150	333.34	15	5	15	6	41.0
21	Katna	402.27	400	802.27	48.95	13.63	5	1	68.58

S. no.	GP	GP area (ha) (A)	RF area (ha) (B)	Area for treatment (ha) (A+B)	Area under SLEM Techniques				Total area treated (ha)
22	Kukna	108.54	275	383.54	109.95	2	8	4	123.95
23	Digauli	169.41	275	444.41	104.75	7.73	15	8	135.48
24	Harsilla	269.85	230	499.85	170.52	5.17	25	2.5	203.19
25	Gainar	352.11	65	417.11	206.83	1.77	10	-	218.60
26	Sumati Baisani	586.69	1788	2374.69	579.4	3.41	45	15	642.81
	TOTAL	**6020.59**	**6706.8**	**12727.39**	**2223.8**	**150.442**	**260**	**69.5**	**2703.74**

Source: TERI Primary Survey, 2013

The area covered under SLEM techniques is 2703.74 ha, which is 21.24% a total area for treatment of 12727.39 ha, or 21.24% of the total area. Extrapolating the area at project level, it can be assumed that about **12919** ha would have been covered under SLEM techniques in the entire project.

Water availability in the sampled GPs

Table 16 below shows the extent of important water and moisture conservation works done in sampled GPs.

Table 16 Water and moisture conservation work in sampled GPs

Name of District (Division)	Contour trenches with bunds (no.)	Recharge pits (no.)	RWH Tanks (no.)	Irrigation Tanks (no.)	Village Ponds (no.)	Tal/Nala/ khala rejuvenation (no.)
Bageshwar (Bageshwar)	3250	-	-	-	2	57
Nainital (Haldwani)	4929	-	-	-	51	64
Rudraprayag (Augustmuni)	3952	-	34	3	18	30
Tehri-Garhwal (Chinyalisaur)	-	-	-	-	10	3

Name of	Contour	Recharge	RWH	Irrigation	Village	Tal/Nala/
Total	12131	-	34	3	81	154

Source: TERI Survey 2013

These structures have been important in enhancing the moisture regime and augmenting water availability for irrigation and domestic use. Change in irrigated area in the sampled RVs is shown below:

Table 17 Change in irrigated area by source in sampled RVs

Irrigated area by source (ha)	Treatment (ha)				Control (ha)			
	Sum (baseline)	Sum (final)	Average (baseline)	Average (final)	Sum (baseline)	Sum (final)	Average (baseline)	Average (final)
Channel/Gul	314.92	325.92	6.43	6.65	47.29	47.33	5.91	5.92
Tank/pond	19.40	22.40	0.40	0.46	1.02	1.02	0.13	0.13
Water Harvesting Structures (WHS)	9.70	9.86	0.20	0.20	0.00	0.00	0	0

Source: TERI Primary Survey, 2013

The overall change in the extent of irrigated and rainfed area is as below:

Table 18 Changes in irrigated and rainfed agricultural areas in the RVs

	Treatment			Control		
Land use	Baseline (Total- ha)	Final (Total-ha)	Change (%)	Baseline (Total-ha)	Final (Total-ha)	Change (%)
Irrigated area	344.143	358.303	4.1	48.312	48.340	0.05
Rainfed	1676.972	1662.809	-0.84	302.487	302.328	-0.05

	Treatment	Control
area		

Source: TERI Primary Survey, 2013

The table shows that there is a 4.1% increase in irrigated land over the baseline in the sampled project villages. In control villages, the change is negligible.

The increased water availability has impacted the access to domestic water as seen below. (Table 19)

Table 19 Access to domestic water

Source of water	Treatment			Control		
	Baseline (%)	Final (%)	Change (% points)	Baseline (%)	Final (%)	Change (% points)
Tap Water	78.6	89.5	10.9	77.6	79.59	2.04
Hand Pump	2.3	1.4	-0.9	5.1	6.1	1.0
Tank	2.5	0.6	-1.9	3.1	3.1	0.0
Stream/River/Pond	21.8	15.8	-6.0	17.3	17.3	0.0
Other Sources	2.3	0.8	-1.5	0.0	0.0	0.0

Source: TERI Primary Survey, 2013

Note: The changes in the table above are reported as percentage points rather than as percentage for ease of comparison.

The interventions of the project related to soil and water conservation are intended to augment the existing water availability for domestic use and irrigation. In the treatment areas there has been increase in access to tap water in spite of the fact that tap water is not a direct project intervention. Tap water is sourced from the natural springs and streams, and carried to villages by gravity. As tap water sources are augmented, it is likely that a greater number of people would use tap water as compared with other sources.

Table 20 shows that there is a 20% increase in the number of households who need less than an hour to fetch water in summer season. 68 households in our sample report a decrease in time for fetching water. In control GPs, a reverse trend is seen.

Table 20 Time taken by the households to fetch water for domestic use in summer season

	Treatment	Control

	Treatment			Control		
Time taken	No. of HH (Baseline))	No of HH (Final)	% change	No. of HH (Baseline))	No of HH (Final)	% change
Less than 1 hr	333	401	20.4	44	33	-25
Between 1-2 hrs	150	83	-45	48	56	16.7
Between 2-3hrs	3	3	0	4	7	75
More than 3 hrs	1	0		1	1	0

Source: TERI Primary Survey, 2013

Implementation of 5 to 10 alternative technologies and approaches for enhancing water availability for agriculture and domestic use.

Under SLEM techniques DLT and soil conservation works have been implemented. Several types of structures have been constructed in upper and lower portions of streams, river banks and land erosion sites so as to reduce the soil loss, enhance water availability for domestic purposes and irrigation. The benefits are summarised below:

1. Construction of river bank protection structures is responsible for taming the river flow in a manner so as to save the fertile soil from loss and to maintain water for irrigation. . Additional agricultural land has been brought under irrigation , as reported in Table 18.
2. Rejuvenation of Naula/Khalas are responsible to enhance the water augmentation by recharging the natural water sources close to the villages. This activity has been responsible for increased water availability for domestic uses (Table 19) and irrigation of kitchen garden.
3. Irrigation tanks with delivery system have been mainly constructed on the individual lands for enhancing irrigation and thus influencing the cropping pattern and productivity. (Elaborated in Section below)
4. Construction of roof water harvesting structures primarily attempts to harvest the rain water. While augmenting domestic water supply, they open up possibilities of vegetable cultivation in kitchen garden. While reducing drudgery of women, they also augment nutritional status of households.
5. Construction of village ponds, percolation tank, contour trenches with bunds and other soil conservation measures have been done mainly on the common property lands so as to augment the flow of water in the natural streams and springs. These structures are responsible for enhancing the soil moisture regime and also recharging the aquifers feeding the natural water sources.
6. Controlling forest fires, plantations and ANR are responsible for retaining and enhancing the soil moisture regime, and serve to enhance the ecosystem services of forests.

Impact on agriculture

The soil and water conservation activities have impacted agriculture through increase in the area under irrigation.

Table 21 below compares the average agricultural productivity in sampled GPs with the state average. It is seen that for all crops, the sample average exceeds the state average for hill districts, and that productivity under irrigated conditions is higher than that in unirrigated conditions. It is evident that with an addition of 14 ha of irrigated land in the sampled GPs, the overall returns from agriculture would increase.

Table 21 Average Agricultural Productivity in Sampled GPs (Qtl/ha)

Name of Crop	Average productivity in sampled GPs (Q/ha)		Average productivity of Uttarakhand (Q/ha) (For Hills)
	Irrigated	Un irrigated	
Paddy	22.50	17.25	13.33
Wheat	20.90	15.10	13.40
Manduwa	-	18.00	13.95
Maize	-	17.75	13.23
Toria / Sarson	-	8.60	5.74
Gahat	-	11.80	8.04
Soyabean	15.70	13.60	10.45
Rajma	15.75	12.75	10.27
Other (mixed)	18.50	17.25	
Potato	125.00	105.75	104.53
Pea	15.75	9.25	6.58
Tomato	130.50	120.00	
Cauliflower	120.75	110.50	
Cabbage	130.25	111.18	
Capsicum	30.10	25.00	
French bean	135.50	115.75	
Ginger	135.00	115.00	111.12

Name of Crop	Average productivity in sampled GPs (Q/ha)		Average productivity of Uttarakhand (Q/ha) (Two Hills)
Onion	57.0	-	52.74
Turmeric	80.75	-	
Fodder (Napier)	66.75	22.25	
Fodder (Jai)	-	30.00	

Source: TERI Primary Survey, 2013 / Statistics Department, Uttarakhand Government

The common cropping pattern in hills in irrigated condition is wheat (*Rabi*) and paddy (*Kharif*). Vegetables are generally grown in Rabi season, and in irrigated areas also during summer. The additional irrigation being made available due to SLEM project has created an opportunity of growing two or three crops in a year. In such conditions, cropping intensity is expected to increase to 200% as compared to the normal 157% in hills.

Change in Biomass in the MWS

Table 22 below provides information on change in biomass in the treated micro watersheds. Increase in biomass is on account of increment in trees and other woody vegetation. In project interventions such as plantations and ANR, areas were fenced to reduce anthropogenic pressure, which resulted in growth of woody plants and non-removal of tree biomass (fuelwood and fodder).

Table 22 Change in biomass in MWS

MWS	2010 (ton/ha)	2013 (ton/ha)	% change
Baniyari	48.97	50.54	3.21
Chamargad	23.07	23.65	2.52
Chhinka	68.07	70.15	3.05
Dantagad	56.72	57.75	1.81
Dolgad	49	52.53	7.22
Gairgad	48.97	49.98	2.07
Ghatugad	50.56	51.91	2.67
Ginargad	52.56	55.02	4.68
Jargad	23.02	23.92	3.92

MWS	2010 (ton/ha)	2013 (ton/ha)	% change
Kanalgad	20	21.53	7.62
Khujetigad	57.46	61.21	6.52
Kumgad	52.9	55.61	5.13
Kyarigad	38.34	40.28	5.06
Kyunjgad	61.43	65.98	7.4
Malogigad	55.32	56.89	2.84
Pasiya Gad	37.86	40.54	7.07
Sunkot	50.08	52.59	5.01
Surgad	62.11	63.55	2.31
Pogtagad	65.54	70.05	6.88
Average	48.5	50.7	

Source: TERI Survey, 2013

The average increase in biomass is 5.50% (Weighted average of biomass increase in the individual microwatersheds, MWS areas are used as weights).

Controlling land degradation

Various DLT and soil conservation work like checkdams, diversion drains, contour bunds and trenches constructed in project area under the component "Controlling land degradation through the SLEM approach at watershed level" have impacted agricultural, forest and barren lands by protecting them from being eroding away, particularly on the bank of rivers and Nallas, thereby sustaining land for continued agriculture possibly enhanced production. Various moisture conservation work like percolation tank/pits, contour trenches with bunds, recharge pits, kuchha village pond etc. have helped to enhance moisture regime in the vicinity of the structures.

Various types of soil and water conservation structures have been constructed in Ist to IVth order streams which cut across steep slopes. Structures constructed in RF land mostly impact the forest land but indirectly they also impact the agricultural land in the lower reaches of the streams. In many cases the river beds have been protected by various structures which have not only saved agricultural land on both sides of these rivers but has also increased the irrigated agricultural land by recovering land lost to bank cuttings and repeated silting. The impact of this activity would sustain over a relatively longer duration. Such lands are generally irrigated and therefore benefit is more significant. In many cases active landslides have been checked due to treatment which has saved land in the zone of influence of such landslides.

As mentioned in the Table 23 below in the sampled GP about 30.38 ha of agriculture land, 53.08 ha of forest land and 12.96 ha of other land have been directly impacted by various interventions in SLEM project. This land would have otherwise been lost or subjected to degradation, leading to a loss of productive potential. Similarly about 4.12 ha of agricultural land, 3.34 ha of forest land and 0.24 ha of other land have been impacted due to the enhanced moisture regime in the sampled GPs. The assessment of the impact is based on field observations and discussions.

Table 23 Impacted area due to soil and water conservation interventions in the sampled GPs

S.No.	Impact	Impacted Area (ha)			
		Agriculture	Forests	Other	Total
1	Control of land degradation	30.38	53.08	12.96	96.42
2	Moisture regime enhancement	4.12	3.34	0.24	7.70

Source: TERI Primary Survey, 2013

In case of agriculture the impacts include saving land from getting washed away, adding additional land under agriculture by way of constructing structures close to the cultivated land, saving soil loss by checking erosion, and conserving moisture to improve yield. The effect of bank erosion widens as the streams join the higher order streams or as the gullies initiating landslides widen their effect and engulf more of agricultural land when they move downhill. The overflowing streams contribute silt to the cultivated land on their banks but when the streams are channelized by various structures, they are contained within limits and do not cause loss of land by silting either on their banks or downstream.

The forests are generally on the upper elevations where the streams originate and if the erosion is checked at its very origin, then the agricultural land and other areas of use for grazing and fuel wood collection are saved from being washed away and getting silted. Soil conservation structures apart from checking loss of various productive land categories also help in water conservation by way of increasing percolation and decreasing run off. This not only charges the springs and augments their flow in the lean season but also helps in increasing soil moisture, resulting in better agricultural yield and better growth of trees, shrubs and grasses. This is useful, in turn, in increasing biomass, enhancing availability of water in lean season for birds and animals, enhancing biodiversity and reducing chances of forest fire.

Construction of water percolation tanks, percolation pits and contour trenches with bunds were also taken up in the project. These structures were found to have impacted the land by way of moisture conservation and enhancing the moisture regime in the immediate vicinity apart from increasing the flow of natural springs and augmenting/ maintaining their flow for longer periods during lean season.

Thus, in sampled GPs various soil and water conservation works done for controlling land degradation has resulted in impacting about 96 ha of land which would have been otherwise degraded and lost. Similarly, about 7.70 ha land have shown substantial enhancement of moisture regime in the sampled GPs.

Box 1

Case study of effective Landslide treatment in GP Majuli (Nainital Division)

In Meladogh *nala*in Kafrauli RV of Majuli GP in Nainital District a major landslide had occurred in 2009-10 which had caused a sinking effect for the agricultural land and part of the habitation was endangered. This area was proposed to be treated under SLEM project by the Gram Panchyat. The treatment work was started in 2010-11 under which 500 meter long diversion drain was constructed to divert the rain water and 3 spurs were constructed to divert the *nala* away from the landslide affected area which otherwise was getting eroded by toe cutting. In addition to the above, 5 check dam and 23 retaining walls were constructed at strategic locations to check the erosion. The structures were responsible to save about 200*nali* of agricultural land and 100*nali* of civil land apart from saving the houses which were in the danger zone. The total amount spent on all the soil conservation works was Rs.1,80,000. Mr. D. K Arya and Mr. Lalit Mohan Sharma of village Majuli played an active role in proposing the site for treatment and mobilizing villagers for the work. There was a general appreciation among the villagers for this work. The works were done under the supervision of Smt. Puspha Devi Pradhan GP Majuli.

Overall land use change

Overall land use change in the sampled GPs is shown in Table 24 below:

Table 24 Landuse change in the sampled GPs

Landuse category	Treatment (ha)			Control (ha)		
	Baseline	Final	% Change	Baseline	Final	% Change
Irrigated land	344.143	358.303	4.11	48.312	48.338	0.05
Rainfed land	1676.972	1662.809	-0.84	302.487	302.328	-0.05
Horticulture	101.616	100.622	-0.97	0	0	0
Culturable wasteland	855.046	856.038	0.11	148.546	148.676	0.09
Barren land	511.183	511.183	0	15.68	15.68	0.02
Civil and Soyam	479.939	479.939	0	16.895	16.895	0
Van Panchayat	2013.211	2013.211	0	172.285	172.285	0
Other	38.563	38.563	0	2.22	2.22	0

Landuse category	Treatment (ha)		Control (ha)	
Total	6020.67	6020.67	706.42	706.42

Source: TERI Survey, 2013

Conclusion

The impacts of the soil and water conservation interventions under SLEM have been described in this chapter. In broad terms, it can be said that there has been an increment in irrigated land, a reduction in time needed to fetch water, and an enhancement of moisture regime. The areas under agriculture, forests and barren land that have been impacted - in terms of being saved from being eroded or lost – have also been estimated and reported.

The coverage of activities is estimated at about 21% of the total MWS area – in line with the 20% target. It may be noted that treatment of areas with high erosion indices is important not just for the sake of the area being treated but for conserving the adjoining productive landscape.

Though the project does not have any direct agricultural intervention, conversion of rainfed land to irrigated land is expected to enhance productivity and cropping intensity. The agricultural productivity increases achieved under UDWDP through formation of FIGs, User Groups, SHGs for improved agricultural practices, supply of inputs and marketing of surplus produce have sustained impact on agricultural productivity.

It is seen that productivities of all crops at baseline and final assessment periods is higher than the state average for hill districts. In this scenario, bringing additional area under irrigated cultivation is likely to enhance net returns to agriculture. A major part of project activities in SLEM are covered under soil and water conservation in which different kinds of site specific Soil Conservation Structures have been made. These structures have technical specifications and need to be constructed under supervision of technical field staff. In the absence of technical staff, capacity building and training was imparted to WMD supervisory staff and micro watershed level institutions. During field survey by TERI, the site selection for different structures was found satisfactory and the structures were by and large technically sound. If there is no excessive rain or cloud burst then they are expected to live their life and serve their purpose. In case of water conservation structures like digging of ponds, making trenches etc. which are temporary in nature, their life span will be short due to nature of terrain and biotic pressure in that area. Some of them were found silted just after one year of their construction.

5. Reducing Pressure and Dependence on the Natural Resource Base through Fostering Markets for NTFPs

Introduction

This component involves the up-scaling of chir pine briquette making undertaken in UDWDP (as a pilot intervention) for meeting energy requirements of the community at household and other levels. The switch from fuelwood to a non-wood based fuel is expected to reduce pressure on adjoining natural forests, while emerging as a viable Income Generating Activity for SHGs operating in the project area.

Other interventions under this component include solar cookers and bio gas, both intended to reduce pressure of forests.

In SLEM project demonstrations of moulding machines to make pine briquettes has been done along with distribution of stoves. . The interventions such as distribution of solar lanterns and cookers, installation of biogas units and provision of small infrastructure facilities like utensils, crates, drums, and electric balance have been made in order to enthuse entrepreneurial skills and infrastructural support by constructing multi-utility centre has also been provided.

To develop non-farm based sustainable livelihood opportunities, various activities like renovation of water mills, stitching / knitting, biodiversity awareness creation, cement casting, etc. have been undertaken through SHGs. Most important of these activities is the renovation of *Gharats* or traditional water mills. Harnessing the potential energy of water streams for running of water mills has been an age old practice in the hills. This was slowly getting replaced by diesel operated mills, resulting in neglect of local Gharats. These Gharats were rejuvenated under SLEM to revive them as eco-friendly water mills.

Methodology

The data and observations presented in this chapter are based on socio-economic survey and group discussions.

Table 25 Result framework for reducing pressure and dependence on the natural resource base

Project Development Objective	Result/Outcome Indicators	Baseline data / evaluation method	Baseline value	Final Value
Reduce pressure and dependence on the natural resource base through fostering Markets for NTFPs	Reduction in dependency of 2000 households on forest for fuel wood.	No. of households adopting alternative energy for cooking, Current dependence of fuelwood from forests	- 69 households partially shifted to pine briquettes 84.2% fuel needs met from forests.	- 2000 households comprising of 13% of total households of project area as target for reducing fuelwood dependency - Fuelwood dependency reduced by 486 household directly (12%) in sampled GPs. In addition, 843 households have also received pine briquette stoves in sampled GPs which are potential users of pine briquettes. 79.25% of fuel needs are met from fuelwood
	At least 20% of targeted households enter market with pine briquettes (produced from pine needles)	No of households making pine briquettes in feasible areas. In the final assessment, the extent of marketing will also be assessed	Nil	- 20% of 2000 households i.e. 400 households targeted to enter market. - 145 households (31.7%) out of 456 households engaged in pine briquette making have entered market.

Analysis of SLEM interventions

Reduction in dependency of 2000 households on forest for fuel wood

To reduce the dependency of the households on forests for fuel wood, three specific activities have been carried out, namely pine briquette making/distribution of briquette stoves, installation of bio-gas and distribution of solar cookers.

Pine needle briquettes and briquette stoves

Heavy pressure on forests for meeting fuelwood demand leads to degradation of forestland resulting in loss of soil and moisture, drying up of natural water sources, biodiversity depletion and adverse impact on agricultural yields.

The technology to convert chir pine needles to briquettes for household energy consists of equipment such as charring drum for production of needle charcoal, briquette moulding machine and a stove to utilize briquettes. The technology will encourage people in the project area to go for pine briquetting as an alternate source of clean fuel which can also serve as an income generation activity for village women. This is a technique for fuel switch

from traditional wood based fuel to a non-wood based one which will go a long way towards reduction of fuel wood collection from adjoining forest areas apart from reducing the fire hazard in them. This activity has been taken up by vulnerable groups or SHGs functional in the project area as mentioned in table 26.

Table 26 Status of Pine briquetting in the sampled GPs

Name of Division	Name of GP	No. of moulds distributed	No. of Stoves distributed	No. of SHGs	Persons engaged	Production (in Kg)	Income (in Rs. for 1 yr)
Augustmuni	Kamsal	2	41	2	28	500	1500
	Baniyari	1	35	1	20	5000	-
	Giwala	1	37	1	20	900	-
	Agar	1	25	1	7	800	-
	Sari	2	34	2	18	700	-
	Vora	2	47	1	11	300	3000
	Kinjani	2	30	1	30	1000	1500
	TevadiSem	1	22	1	8	200	-
	BhatwariSunar	2	16	1	10	300	-
Tehri Garhwal	Pokari	1	35	1	20	100	-
	Bhenti	3	61	1	13	200	-
	Gairnagun	4	85	2	34	600	-
	Indiyan	4	105	1	18	200	3000
	Ghoun	3	75	2	33	300	-
Nainital	Majhkhet	4	80	2	20	400	-
	Digauli	3	45	2	18	1000	-
	Katna	5	130	2	20	700	-
	Mehtoliyagaon	2	30	1	30	1100	-
	Majyuli	5	120	1	29	2500	-
	Thaladi	2	60	-	-	-	-
	Thali	-	30	2	11	1100	-
	Harsilla	1	30	3	24	13200	52500

Name of Division	Name of GP	No. of moulds distributed	No. of Stoves distributed	No. of SHGs	Persons engaged	Production (in Kg)	Income (in Rs. for 1 yr)
Bageshwar	Sumati Baisani	4	93	3	29	4200	24000
	Gainar	2	62	1	5	1900	1500
Total		**57**	**1328**	**35**	**456**	**37200**	**87000**

Source: TERI Primary Survey, 2013

In the initial stages of the project, WMD field functionaries helped in marketing by collecting briquettes at their headquarters and publicizing the produce. Orders were given to SHGs from various offices located in the project area. The marketing effort was most successful in Bageshwar Division as the product was sold to *Bagnath Zila Swayat Sahkarita, SARAS Bazar Bageshwar,* and *Shikhar Swayat Sahkarita, Bageshwar* with an earning of Rs 78,000, which is 89% of the total earnings from all Divisions, although the number of operating SHGs in sampled GPs in this district is relatively less (only 6). Pine briquetting is a seasonal activity and starts after pine needle fall in summer when woman folk collect them and store them near their houses or agricultural fields. No activity is done during the rainy season. During winter when the agricultural activity is slack, women take up the activity of pine briquetting. The number of active SHG members involved in this activity varied from 25% to 75%. Some women who initially had not been a part of such SHGs also became active after realizing the importance of the activity. All SHGs were not able to sell the briquettes and utilized whatever they produced. The Table 26 indicates that in six of the sampled GPs, an income was realised from the sale of briquettes. 35 SHGs consisting of 145 members have marketed Pine briquettes and have earned Rs 87,000 till March 2013.In some cases, the production did not go beyond a demonstration phase Active SHGs were seen storing a good amount of charcoal in advance even before starting briquette moulding. The waste of tree fodder left by cattle was also being used in making charcoal for briquettes, which is an added advantage.

Table 26 also shows the number of households that are using briquettes for cooking and heating in the sampled GPs. The highest share of such households is in Augustmuni Division (152 households). In all 1328 stoves have been distributed in the sample villages for utilising pine briquettes which also includes 456 SHG members involved in pine briquette making. Remaining 843 households are also potential users of pine briquettes and in future when production of pine briquettes increases, these households will also contribute in reducing use of forest fire wood.

Of the 456 households who have been involved in pine briquetting, 145 households (31.7%) have entered into pine briquette marketing. The marketing was done in the final year of the project for which the average rate was Rs 15/kg. Out of the total production of 37200kg, 21300kg of pine briquettes were marketed and remaining 15900kg were consumed for domestic purposes.

Looking at the incentives and support given for this activity, the training imparted and the efforts of SHGs to market the briquettes, it appears to be a sustainable activity for most SHGs. This activity is very important as it helps in reducing fire hazards to a great extent, apart from saving the forest around the villages from degradation.

Box 2

Case Study of Successful Pine briquetting module in Harsilla GP of Bageshwar Division

Pine briquetting is a pioneer activity started under UDWDP and carried forward in SLEM Project. Bageshwar Division started this activity by forming women SHGs in December 2011. In all 6 SHGs with 58 members were formed under this programme in 6RVs & 7 briquette molding machines and 185 briquette stoves were distributed. Till the end of May 2013, 193 Qts. of pine briquetts were produced by these SHGs out of which 42Qts were marketed in Bageshwar town *through Bagnath Jila Swayat Shahkarita, SARAS market and Shikhar Swayat Shahkarita f*or a total cost of Rs 78000/-.

Most successful pine briquetting activity was conducted in Harsilla RV by Sheranwali Maa SHG with 15 women members headed by Smt. Vimla Gadhiya. The Chairperson Smt Vimla took keen interest in the activity and mobilized all her members. With 2 mould machines they produced 106 quintals of pine briquettes in the year 2010-11 (32Q), 2011-12 (35Q) and 2012-13 (69Q). Out of the above they marketed 30Q in the years 2010-11 (7Q), 2011-12 (11Q) and 2012-13 (12Q) for an amount of Rs. 45000/-. The selling rate of Rs.15/- per kg gives a project of about Rs 5/- per kg. After distributing the labor cost and part of profit to is members the net saving in account no. 3206 of the SHG in Uttarakhand Gramin Bank Harsilla is Rs 4050/-. During field survey TERI team met Smt. Vimla Devi and some of the SHG members and saw the enthusiasm of Smt. Vimla who was even selling pine briquettes at her home on a day today basis to the villagers. Smt Vimla is also a master trainer for pine briquetting programme of the Division. She was just High School pass when she was married. She has 2 daughters and one son all of them are studying in higher classes. She herself is a widow and has persuade her studies upto graduation as a private candidate . She gives the credit to the UDWDP and SLEM projects which brought the awareness in her during various training and motivation programmes organized during the period these projects were implemented in her village. With her keen interest and enthusiasm she has been a beneficiary in many of the project activities.

Biogas as a source of alternative rural energy

Biogas plants are a source of clean energy with relatively low investment. In rural hill areas where keeping domestic cattle is a necessity for better agriculture, establishment of biogas plants has been feasible. By anaerobic decomposition of cattle dung, 55 to 75% inflammable methane can be generated. In rural areas only cattle dung is used; so these plants are commonly called 'Bio Gas' Plants.

A Bio gas plant consists of an inlet tank, a digester and a gas holder that is connected through a gas pipe to the kitchen stove. One Bio gas plant of 3 cum capacity is enough to meet the energy requirement of a 5 member family which would need around 35 kg of dung every day that can be generated from a buffalo, one cow and a pair of bullocks. Dung is mixed with water which is then decomposed in the digester in the absence of oxygen. The left over slurry is rich in N, P and K and is stored in a pit for use as manure in agriculture. One Bio gas plant of 3 cum capacity can produce cooking gas which is equivalent to 15 LPG cylinders in a year. Under the SLEM project biogas plants were provided to willing farmers. The entire cost of the plant was borne under this project except transportation of equipment from the road head to the place of commissioning.

This activity has been extensively done in the Bageshwar Division. The Chhuria Pannaura village in Utrauda GP (not in our sample) is a standout example where as many as 15 such plants have been set up; and a large number of villagers in this village use slurry for vegetable production. In many cases, upto two bulbs are also being powered through Bio gas.

Table 27 Status of Bio gas plants in the sample villages

Name of Division	GP	No of plants installed	No. of families using biogas	Approx. Quantity of fuel hood saved (in Kg/yr)
Augustmuni	Giwala	1	1	2400
	Sari	3	3	7200
	TewadiSem	1	1	2400
	Bhatwari Sunar	3	3	7200
Tehri Garhwal	Indiyan	2	2	3800
	Ghaun	1	1	2400
Bageshwar	Sumati Baisaini	2	2	4800
	Gainar	2	2	4800
Total		**15**	**15**	**36000**

Source: TERI Primary Survey, 2013

Approximately, 2400 kg/yr of fuelwood was observed to be saved for each Bio gas unit. In the hilly areas of Uttarakhand, exploitation of forests for meeting day to day fuel wood needs of rural people has put tremendous pressure on the forests which have degraded badly in the vicinity of habitation. The degradation compels the women folk to walk longer distances to gather fuel wood which increases their drudgery. The availability of alternative cooking energy through Bio gas thus reduces the pressure of forests for fuelwood and at the same time the associated drudgery faced by the women folk in the sampled GPs. About 4.6% of households surveyed have reported a reduction in the number of rounds for fuelwood collection and about 29.3% of households have reported a reduction in the number of days (in a year) that are spent for fuelwood collection.

Box 3

Case Study of successful Biogas plant in Sari GP of Rudraprayag District.

Sari GP of Rudraprayag district is on the right bank of Alaknanda opposite Gauchar about 2km from roadside. The villages are dependent on forest for fuel wood needs and the women folk require to travel about two to three kilometers to the chirpine forests to collect fuel wood twice a week or even more. Sari GP has 3RVs namely Sari, Chamsil and Jhalimath. The adjoining forests around these RVs are badly degraded due to continued exploitation for fuelwood. Under SLEM project activities like pine briquetting, biogas, solar cooker and plantation were undertaken to reduce degradation of forests.

Mr. Harender Lal, a scheduled caste member of Jhalimath, was first to be motivated to install a biogas plant for his family. He has a buffalo, a pair of bullocks and a cow of his own. TERI team visited the village for survey and group discussions, and also visited Mr Harendra Lal's biogas plant. He has a 5 member family and a gas connection from the 3 cum plant has been installed in his kitchen. A 60 watt light bulb is also connected with biogas for domestic light. The family is cooking all their meals with biogas and the house lady is very happy as she is free from the drudgery of walking to forest and bringing a load of 30-40 kg of fuel wood twice a week. We could also see the slurry collected from the plant which is rich in NPK and has been used in the irrigated fields which the family owns. The lady enthusiastically mentioned that her kitchen garden production has gone up. They are not worried about the ever-increasing costs of LPG cylinder. The biogas plant at this location will fully work at least for 8 months in a year. The project spent Rs. 4200- on the plant and approx. Rs 3000 was spent by the beneficiary on transportation from roadside.

Use of Solar Energy

Use of Solar Energy in the rural areas is an innovative activity that has the potential to reduce pressure on natural resources and reduce consumption of fossil fuels. .Abundant sunlight is continuously available in the hills except during short spells in rainy season. .

Use of solar energy has a strategic advantage for several reasons. Staying outdoors in the dark in odd hours is a common requirement in hilly areas. A solar lantern can be a convenient way to overcome the fear of attacks by wild animals. Solar cookers reduce pressure on forests by cutting down fuelwood demand while providing a clean cooking environment.

The arrangements of public lighting in the villages of Uttarakhand are not sufficient to meet the needs of the people especially during odd hours. Interestingly, during the survey, in several cases women folk mentioned the use of solar lantern for the purpose of children out for nature's call during the dark. Also women feel safe to move around with solar lantern which can be operated without spending on kerosene oil, battery cells etc.

In many villages solar cookers were distributed to old and handicapped people who were unable to fetch fuel wood from forest. This was specially observed in some sample villages in Augustmuni Division during TERI team's field survey.

Table 28 Status of distribution of solar equipment in sampled GPs

Name of Divisions	GP	No. of Solar Equipment distributed/installed		
		Street light	Solar lantern	Solar cooker
Augustmuni	Kamsal	-	13	4
	Baniyari	1	14	-
	Giwala	1	15	3
	Agar	-	10	-
	Sari	3	11	-
	Kyudi	-	17	-
	Vora	-	14	-
	Kinjani	-	14	-
	Tewadi Sem	1	19	-
	Bhatwari Sunar	-	9	-
Tehri Garhwal	Pokhari	-	23	-
	Bhenti	-	46	-
	Gairnagun	-	35	-
	Indiyan	-	38	-
	Ghaun	-	50	-
	Majhkhet	-	64	-
Nainital	Digauli	1	27	
	Kukna	-	25	

Name of	GP	No. of Solar Equipment distributed/installed		
	Katna	1	26	3
	Mehtoliyagaon	2	33	1
	Majyuli	1	38	1
	Thaldi	1	40	1
	Thali	2	42	1
Bageshwar	Harsilla	4	-	-
	Sumati Baisani	9	125	-
	Gainar	2	30	-
Total		29	778	14

Source: Teri Primary Survey, 2013

Small Infrastructure facilities for marketing support

For marketing NTFP products SLEM project provided support to institutions and individuals engaged in the activities. The following table shows the various types of support provided in the sample GPs:

Table 29 Small infrastructure facilities for marketing support

(Cost in Rupees)

MWS	GP	Utensils		Kilta		Crate		Electric balance		Processing unit		Multi-utility Centre	
		No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost	No.	Cost
Baniyari gad	Kamsal			30	39840	6	2520						
Baniyari gad	Baniyari	2	5712	41	54448	18	7560	1	6526				
Baniyari gad	Giwala	2	4000	17	22576	21	8820	1	6526				
Pogta Gad	Aagar	1	2856	20	26570	8	3360						
Pogta Gad	Sari	4	11424	30	39900	14	5880						
Surgad	Kyudi	2	5712	30	39900								

MWS	GP	Utensils		Kilta		Crate		Electric balance		Processing unit		Multi-utility Centre	
Surgad	Vora	5	14280	11	14620					1	1290000		
Kyunjagad	Kinjani			25	33200	10	4200						
Kyunjagad	Tevadi Sem	1	2856	27	35856	12	5040						
Kyunjagad	Bhatwari Sunar	3	8568	54	71712	12	5040						
Sunkot	Katna											1	270000
Dolgad	Majyuli											1	270000
Kumgad	Harsila											1	266119
	Total	**20**	**55408**	**285**	**378622**	**101**	**42420**	**2**	**13052**	**1**	**1290000**	**3**	**806119**

Source: WMD/ TERI Survey 2013

The processing unit in Vora GP of Augustmuni Division is active and mostly processing the spices such as turmeric. Turmeric is being grown under the project as a medicinal plant and the crop was promoted during UDWDP by supplying improved variety seeds and is being continued in SLEM's MAP programme. . Other species like coriander, chilli, etc. are also been processed. The pine briquette mould machine provided to SHGs is also operating at the centre along with briquette marketing. This centre was visited by TERI team during survey for final impact assessment and was found operational.

Three multi-utility centres established in Katna and Majyuli GPs of Nainital and Harsilla GP of Bageshwar are aimed at collection and processing centres for various local products such as turmeric, coriander, chilli, etc. and grading and packaging of pulses. The centre at Majyuli is functional but Katna centre is yet to become operational. Harsilla centre is also operational.

Other items like electronic balance were provided to facilitate weighing material for marketing. Utensils were used in preparing, storing and packaging the pickles and seeds, etc. *Kilta* is a plastic carrying basket designed in the local style to carry agricultural produce. Crates are used as containers for storing and carrying ginger, turmeric and other products.

Some of the livelihood generation activities through SHGs, discussed in the next section have been greatly benefitted due to such infrastructural support.

Results

The implementation of above activities in sample GPs has resulted in the following:

- Dependence of at least 456 households on forests for firewood has been reduced due to pine briquettes. Similarly dependency of 15 households on forest firewood has been reduced by adopting Bio gas plants. Solar cookers have reduced the dependency on forest firewood of 14 households. Out of 4023 households in the 26

sampled GPs, 18 GPs have pine forests and comprise2522 households; out of these, total of 485 households have directly reduced their dependence on the forest firewood due to the described project interventions. In addition to it 843 pine briquette stoves have been distributed which would reduce the dependence on forest fuel wood in near future. This is about 12% of total households in sampled GPs as against the target of about 13% in the entire project area.

- 12 SHGs engaged in pine briquette making with 145 members (31.7% of concerned households) have entered the market with pine briquettes, and sold pine briquettes worth Rs 87,000 during the past one year. This meets the target of 20% households entering the market for pine briquettes.

Impact of livelihood opportunities on households

Several interventions are made in SLEM project to enhance the livelihood opportunities of the households. In the Result Framework the livelihood opportunities have been identified with an outcome indicator as follows:

10% increase in livelihood opportunities in treated areas (measured by increase in no. of person engaged in different livelihood opportunities)

Table 30 depicts the range of interventions undertaken during SLEM project to enhance the sustainable livelihood opportunities in the sampled GPs.

Table 30 Beneficiary households due to the local enterprise interventions

Livelihood activities	No. of beneficiaries (baseline as reported for 51 GPs selected for Baseline Survey)	No. of beneficiaries (final)
Dairy	205	81
medicinal plant processing	10	804
NTFP collection	20	20
Food / Fruit processing, preservation, pickle making	55	37
Handicraft	28	18
Sewing / Knitting / Embroidery	45	180
Sub-total	**363**	**1140**
Others*	**57**	
a - Gharat	5	134

Livelihood activities	No. of beneficiaries (baseline as reported for 51 GPs selected for Baseline Survey)	No. of beneficiaries (final)
Pine briquetting	24	456
b-Tent house*		223
c-Poultry*		20
Goatery*		189
Shops*	18	18
Traditional occupation*		73
Ata chakki	10	30
Cement casting		39
Grading, packaging		23
Nursery		20
Band		6
Sub-total	**57**	**1231**
Grand Total	**420**	**2371**

Source: TERI Primary Survey

*** These activities were captured during SLEM baseline survey but not separately reported.**

A number of smaller interventions in the form of shops, tent, band have also been extremely successful.

Water Mills or Gharats

Gharat renovation is the most important of the livelihood activities undertaken in SLEM project. *Gharat* is a traditional mill made out of local material and run by water of nearby perennial *nalas* or rivulets to grind flour for meeting day to day consumption needs. These are common in all the rural areas throughout the hills. Mostly they are individually owned and get water from channels or *Guls* which flow through forest land. The owner gets a share of grinded flour as rental of *Gharat* which is normally the same in all the villages. The use of these mills was largely discontinued, and was reduced to being a traditional livelihood of one or two families in a village. This was due to flooding of *nalas*, drying or diversion of water sources, damage of old *Gharats*, lack of interest of owners and coming up of diesel operated flour/rice/oil mills which work faster and operate all year round as against water

mills which are specific to grinding flour and are seasonal due to fluctuation of availability of water.

The *Gharats* in many villages are still relevant as the diesel operated mills are far away from the villages and are now very costly (Rs 3.50 per kg). The flour grinded in Gharats is very tasty and nutritious. . Under the SLEM project, rejuvenation of water mills or *Gharat* was funded. In some cases, the support was provided to individual and in other cases through SHGs.

The apparatus consists of local material such as stone mill (2 parts), basket for grain which hangs above the mills that pours the grain continuously, the shaft connected to the mill which rotates with the force of water that is made to fall through a hole in the wood that makes the mill to rotate and grind the grain. Traditionally *Gharats* are made from local material with *kutcha* walls in local stone with mud mortar and thatched roofs. They generally leak during rainy seasons and need repairs year after year. Under SLEM project, the walls were made with cement and even the roofs were renovated with RCC. For the poor mill owners the repair that was needed to be done every year previously would cost much more than their earnings. The operation of gharats in most cases was entrusted to SHGs who are operating and maintaining the *Gharats* and earning a regular income from them. This has also opened up possibilities for their technical upgradation to generate electricity on a small scale for which the GPs are in contact with UREDA.

Table 31 Status of upgradation of *Gharats* in sample GPs

Name of Division	GP	No. of Gharats renovated	No. of SHG members			Income generated (in Rs.)
			Male	Female	Total	
Nainital	Majhyuli	5	15	10	25	53,795
	Thali	1	5	0	5	32,187
	Kukuna	3	12	13	15	9,205
	Digauli	3	16	0	16	49,660
	Thaladi	3	15	0	15	17855
Bageshwar	SumatiBaisani	7	37	2	39	4,07,863
	Harsilla	3	7	7	14	2,43,410
	Gainar	1	4	1	5	23,170
Total		**26**	**111**	**33**	**134**	**837145**

Source: TERI Primary Survey, 2013

Box 4

Case Study of successful renovation of Gharats (Watermills) in Bageshwar Division

Water mills locally known as Gharats have been traditionally used in hills for grinding grains to make flour. These were essential till diesel operated small scale mills were not available. Along with the hand operated family *chakkis*, *Gharats* were operational in every village where there was a perennial water stream. They were neglected in recent past due to diesel *Chakkis* which had larger output. The frequent flooding of small streams damaged the channels which connected the *Gharats* and it was not considered economically viable to repair channels and operate *Gharats*.

One of the important activities supported through SHGs under SLEM was renovation of *Gharats*. Bageshwar and Nainital Divisions took up this activity wherein 11 and 15 *Gharats* were respectively renovated in these Divisions.

In Sumati- Baisani GP of Bageshwar Division 7 *Gharats* were renovated. These were being operated by a 39 (37 men, 2 women) member strong SHG. One more SHG *Hinwal* was engaged in packaging *Mandua* flour ground from *Gharats*. *Mandua* flour is popular with hill people living even outside Uttarakhand as it is rich in calcium and is consumed in the form of *Chapatis* especially during winter. All these *Gharats* were initially in thatched huts with temporary water channels and crude stone slabs and wooden shafts. The huts were replaced by cement concrete structures and RCC roofs, channels were modernized and equipment was also changed to make them more efficient. The output went up from 5-6 kg per hour to 10 kg per hour. The grinding charges are taken in the form of flour per unit of grain ground so the income is increased by almost double. It is also now possible to keep *Gharats* operative all through the year.

In one of the *Gharats* in Sumati RV, electric dynamo is also fitted to generate electricity in collaboration with UREDA and electric connection has been provided to a nearby school for operating computer system and in 3 households for light and television. Rent from these houses is being realized by the SHG. The total earning of all the 7 *Gharats* is Rs. 407863 in 2 years which is the highest in any of the sampled GPs where *Gharat* renovation has been done under the project.

SHG oriented model of livelihood development

SLEM is an extension of UDWDP. During UDWDP Self Help Groups were formed to enhance the livelihood of the households. The SHGs which remained active after completion of UDWDP were considered appropriate to support in order to enhance their entrepreneurial activities. Some of the activities undertaken for vulnerable groups in UDWDP were found successful in some of the villages and these activities were taken up in SLEM project as well while some new innovative activities which would be helpful from the environmental angle were introduced. Most important of the activities are renovation of Gharats, stitching and tailoring, cement castings, tent house and utensils for functions.

Table 32 Summary of SHG activities for sample GPs

S.No.	Name of Activity	SHGs involved	Male	Female	Total	Funding under SLEM (in lakhs Rs.)	Earning by SHGs (in Rs.)
1	Gharat	26	111	23	134	9.45	837145
2	Cement Casting	8	33	6	39	1.1	114828
3	Knitting	5	0	34	34	1	13100
4	Grading & Packaging	3	3	20	23	0.6	12400
5	Nursery	3	10	5	15	0.5	9940
6	Stitching & Tailoring	10	3	86	89	3.66	49580
7	Fiber processing	4	10	12	22	0.8	0
8	Poultry	3	12	8	20	0.9	0
9	Biodiversity awareness	1	2	3	5	0.25	1750
10	Medicinal plant nursery	1	0	5	5	0.25	0
11	Band	1	6	0	6	0.5	0
12	Goatery	6	0	69	69	3.213	14000
13	Flour Mill	1	0	19	19	0.8	26000

S.No.	Name of Activity	SHGs involved	Male	Female	Total	Funding under SLEM (in lakhs Rs.)	Earning by SHGs (in Rs.)
14	Tent House	22	20	203	223	7.847	98705
15	Fruit processing	1	0	12	12	0.25	0
	Total	**95**	**210**	**505**	**715**	**31.12**	**1177448**

Source: TERI Primary Survey, 2013

Gharat renovation was a new activity comprising of 26 SHGs with 135 members who were benefitted. More than one third of the total funding in livelihood support activities was spent on this component. During field survey all the Gharats had not become operative as work was still in progress. Bageshwar Division was leading in this activity where the results could be clearly seen and income to SHGs had started pouring in. Instead of cash charges for grinding fixed quantity of grain is collected as grinding charges.

Out of Rs.1177448 lakh income generated till March 2013 from all activities, Gharats alone account for 71% income generation. All other activities put together earned only 29% of the total income. In activities like knitting, basket making, poultry, medicinal plant sale, yarn making, Band and fruit processing no income generation was reported till the time of survey. SHGs in Bageshwar have collaborated with UREDA for generation of electricity at small scale for domestic use. In one of the gharats in Baisani village, electricity generation was seen to be already in progress and was being distributed to a few households.

Most of activities started in 2011 and 2012. Funding was also done as late as March 2013 for 19 out of 95 activities. Only 3 activities started in December 2010. In all 24 SHGs were provided funding. It will not be justified to predict their sustainability at this stage except the activities which have started income generation. Since the SHGs were formed during UDWDP period and only those SHGs were selected for funding which has been successfully operating therefore it can be assumed that most of them will be sustainable in the long run.

Conclusion

Despite fragile nature of hill areas, the dependence of local population on the natural resources especially forests is very high due to absence of alternatives. The project area is situated in the sub-tropical to temperate region where the natural growth of the forests is slow which does not match with the extent of exploitation leading to unsustainable status of the natural resources. The dominance of chir pine makes the forests vulnerable for forest fire and increases the risk of degradation. Hence, top priority was given for developing alternatives to forest fuelwood and reducing the fire hazards. Most important among these were the pine briquettes, biogas and use of solar energy for alternative cooking and heating energy. Availability of pine needles in 33 of 49 sample RVs in great abundance provides an opportunity to not only reduce fire hazards of pine forests but also contribute to livelihood of the rural women by making pine briquettes. The major impact of the pine briquette

making activity has been partial shift from fuelwood to pine briquettes for cooking and heating purposes, in turn reducing the amount of time spent in fetching fuelwood.

Bio gas is another activity to switch the choice of fuel from forest fuelwood to Bio gas. In the lower altitudinal zone Bio gas plants can work for 240 days in a year and hence can be useful in substantially reducing the pressure on forests. The limitation with this activity is reducing number of cattle which would produce Bio for the plant. The limited availability of fodder is also another limitation for feeding cattle.

Solar energy is yet another alternative source of energy and can be effectively used for switching choice of fuel from conventional to alternative one. The project has provided solar cookers, solar street lights and solar lanterns. The solar cookers are useful especially for the elderly citizens in the hills since they are not in a position to fetch fuelwood and can sustain on the technology except during rainy season. The solar street lights and lanterns are proving as convenient systems for villagers especially the women folk to go around in the villages.

Subsistence farming coupled with scattered landholding makes agriculture an unprofitable venture in the hills. The farmer cannot sustain more than 4-6 months based on the present productivity of the agriculture. Alternative livelihood option therefore is a necessity in such a situation. The high profits generated by Gharats suggests that the revival of traditional technologies could prove successful in addressing day to day needs, and could yield higher returns as compared to interventions based on markets, such as food processing. Similarly, the traditional occupations supported by the project such as blacksmith, barber have shown higher success in comparison with other enterprises.

The objective of reducing pressure on the natural forests by fostering markets for NTFPs has been achieved adequately. As discussed in the chapter, about 12% of households in the target area have benefitted from interventions for provision of alternative energy sources, and have reduced their dependency on fuelwood from forests. About 31% of concerned households have marketed briquettes, and this activity is very likely to pick up fast. Solar energy interventions, while reducing forest dependence, comes as a boon for old and infirm people who can now meet basic cooking needs without having to go through the drudgery of fuelwood collection.

The target of 10% increase in livelihood opportunities is also met. The success rates are however more for traditional occupations as compared with those that rely on external markets. The enhancement of livelihoods have impacted equity positively as the interventions are largely targeted at women and/or landless and socially backward households.

6. Enhancing biodiversity conservation and management through watershed planning and community participation

Introduction

The activity *Enhance biodiversity conservation and management through watershed management and community participation* is aimed at qualitatively and quantitatively enhancing biodiversity at watershed level. This has been done through specific interventions where the planned focus is on biodiversity conservation by identifying sustainable livelihood options. The soil and water conservation activities are also intended to directly and indirectly contribute to biodiversity conservation. This chapter presents the major impacts relating to this activity head.

Table 33 Result Framework for ''Enhance biodiversity conservation and management through watershed planning and community participation"

Project Development Objective	Result/Outcome Indicators	Baseline data / evaluation method	Baseline value	Final Value
Enhance biodiversity conservation and management through watershed planning and community participation	Increase in direct and indirect evidence of presence of key species of flora and fauna in 20 MWS	Vegetation assessment	Shannon Weiner Index: Trees: 2.02, Shrubs: 3.04Herbs: 3.59, Species richness Trees: 32, Shrubs: 73, Herbs: 38	Shannon Weiner Index: Trees: 2.02, Shrubs 3.57, Herbs: 2.6, Species richness Trees: 32, Shrubs: 79, Herbs: 28[11] Significantly higher diversity index and species richness values for shrubs, herbs and overall species richness of project site compared to control sites Significantly higher number of naturally regenerating seedlings in project than in control sites
	20% reduction in incidence of fire in treated MWS	Area affected by fire (based on surveys and FD records)	19.5 hectare affected, 11 incidents in 51 GPs 8 incidents and 15.5 ha area affected in	16 hectare affected in 51 GPs. 2 incidents in 26 GPs and 6 ha area affected that were sampled for the final

[11]The decrease in the richness and diversity of annual herbs was due to the timing of the assessments.The baseline survey was just after the monsoon while the final assessment was soon after the winter when many of the areas were covered by snow. However, a comparison of project and control sites show a statistically significant increase in herb species richness and diversity in project sites vs control sites.

Project Development Objective	Result/Outcome Indicators	Baseline data / evaluation method	Baseline value	Final Value
			26 GPs that were sampled for the final assessment (Compartments falling in the respective MWS plans) Baseline assessment year is 2010	assessment (26 GPs) so 75% reduction in # of incidents & 61.3% reduction in fire area Final assessment year is 2013
	Cultivation of at least 5 local MAPs (medicinal and aromatic plants) by communities in 20 microwatersheds.	Number of MAP species cultivated	Ginger and Turmeric grown as cash crops	*Zingiber officinale* (Ginger or adrak)*Curcuma longa*(Turmeric or haldi), *Aloevera (*Aloe, ghritkumari*), Rauvolfia serpentina*, (snake root or sarpgandha), *Amomum subulatum* (Black cardamom or badi elaichi), *Asparagus racemosus* (Asparagus or Satavar), *Cinnamomum tamala* (Indian bay leaf or Tejpatta) and *Phyllanthus emblica* (Indian gooseberry or amla)

About 65%percent of the total geographical area of Uttarakhand is recorded as forest area. The actual forest cover however is 45.80% of the state's geographical area (FSI, 2011). The altitude of the state ranges from 300 m to 7817 m, resulting in significant variations in flora and fauna. The predominant forest tree species in the state are Conifers, Oaks (e.g. *Quercus leucotrichophora*), *Rhododendron* spp., Maple (*Acer* spp.), Toon (*Toonaciliata)* and shrubs such as Kirmor (*Berberisaristata*), Hissar (*Rubusellipticus*), *Rosa* sp. etc., climbers and herbs including some important medicinal and aromatic species and orchids. In terms of jurisdiction, the forests of the state are classified as Reserve Forest, Civil Soyam forest and Van Panchayats. The state forest department has exclusive control over Reserve Forests, the Civil-Soyam forests fall under the jurisdiction of the revenue authorities of the state, while Van Panchayat forests are under the control of local communities. At present, there are over 12,000 Van Panchayats, managing 5400 km^2, which is approximately 11% of the total forest area of the state (Sarkar, 2008). In terms of watersheds, there are 8 catchments, 26 watersheds, 116 sub-watersheds and 1120 micro-watersheds spread throughout the state.

The project area lies in the middle Himalayas ranging from 700-2000 m above sea level. The forests in this altitudinal zone are primarily of Chir pine (*Pinusroxburghii*) and Oak *(Quercusleucotrichophora*) as either pure stands or mixed with other species. Under the

project, a major emphasis was meeting the fuelwood, fodder, minor forest produce and timber demands of local people. Hence species of their choice were given preference while carrying out the plantation activities. Van Panchayats have been the nodal institutions for undertaking all the forestry interventions in the project. The Government issued an order on 2nd December, 2009 authorising the VP to treat the reserve forests area under any project, within a prescribed plan. Forestry activities such as afforestation and soil conservation works were carried out in Van Panchayat and Reserve Forests under the project. Funds were directly transferred in the project to Gram Panchayats which in turn were transferred to Van Panchayats to carry out watershed treatment in areas that lie outside the boundary of the Gram Panchayat but within the concerned Micro Watershed System (MWS). Under forestry activities, 830 ha (203 ha in RF and 627 ha in other areas) of afforestation has been carried out. Plantation activities have carried out in Bageshwar (207 ha), Haldwani (217 ha), Augustmuni (231) and Chinyalisaur (175 ha) and the key species have been *Grewia*, *Bauhinia*, *Alnus*, Oak spp. *Ficus* spp., *Albizia*, and *Toona*. Assisted Natural Regeneration (ANR) of Oak has been carried out in 115 ha of forest area - 60 ha in Haldwani and 55 ha in Augustmuni. Moreover, 68 nurseries were developed under the project; 42 in Bageshwar, 9 in Haldwani, 7 in Augustmuni and 10 in Chinyalisaur.

Methodology

The overall methodology has already been discussed in Chapter 2.

Vegetation surveys were carried out in sixteen sites from four blocks in four districts of Uttarakhand state.[12] All these sites were selected from the overall sample of 51 Gram Panchayats (GPs) in which the baseline survey was carried out under the SLEM project. Two blocks (Augustmuni, and Thauldhar) were from the Garhwal region, while two blocks (Okhalkanda and Kapkot) were from the Kumaon region. All the selected sites fall within an altitudinal range of 700 m to 2000 mm and have a subtropical to temperate climate and vegetation. Most of the plantations under SLEM were carried out in the community forests such as Van Panchayats and Reserve Forests. Details of the areas planted under each category are provided in (Annexure 1 and 2). Field data was collected from February to March, 2013.

[12]The GPS coordinates are provided in Annexure 4.

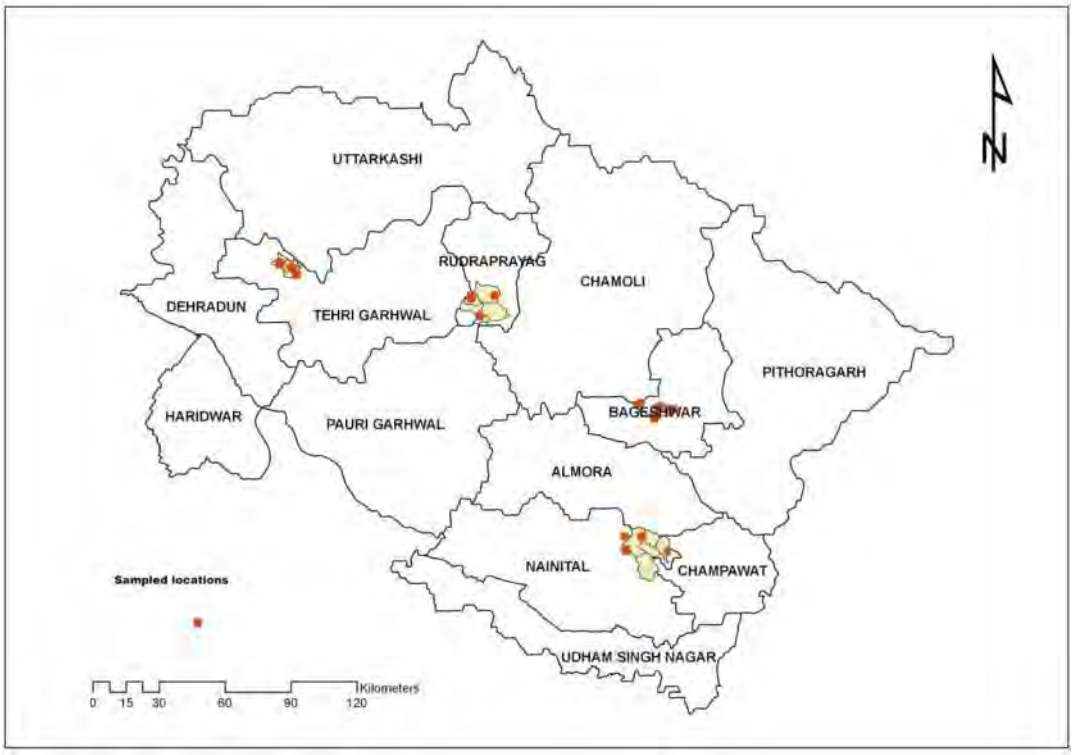


Figure 10 Locations of the vegetation survey

Species diversity and richness

To assess the vegetation composition of planted sites and the survival percentage of planted seedlings and saplings, nested quadrat sampling approach was used in all the selected sixteen sites. At all the selected sites, quadrats of size 20 x 20 m for trees, 10 x 10 m for shrubs (including tree seedlings and saplings), and 1 x 1 m for herb species were laid out. Depending upon the plantation area, 3 to 6 quadrats were laid within each treated plantation site. Three replicates were laid out in each 5 ha plantation area, while 6 quadrats were laid out for larger plantation areas of 10 ha. However, in Kwaidal, nine plots were laid in 15 ha of plantation areas that were under Assisted Natural Regeneration (ANR). GPS Co-ordinates of the sampled sites are provided in Annexure 3.

The seedlings/saplings assessed in the 10 x 10 m shrub quadrats included those planted under the SLEM project, as well as any natural regeneration that may have occurred. The total number of tree, shrub or herb species and their abundance was used to calculate a diversity index for each of these categories for each site. In addition, the total number of species of trees, shrubs and herbs were used to determine the species richness of each vegetation category, as well as to obtain the total plant species richness for each site. Diversity indices attempt to incorporate both richness and abundance into a single numerical value. To compare the vegetation diversity between the study sites with the control, the *Shannon-Weiner Diversity Index* was used.

Survival percentage

An important means of gauging the success of any plantation activity is to determine the number of surviving saplings. Survival percentage was calculated from the sixteen surveyed

sites within the project area. In each quadrat, the total number of planted saplings and number of dead saplings were counted separately. These figures were then extrapolated for individual project sites.

Importance Values

To determine the importance of each species to the vegetation composition of an area, an Importance Value Index (IVI) can be calculated. This IVI is a measure of the relative dominance of species in a forest community. Importance values rank species within a site based upon three criteria:

1. how commonly a species occurs across the entire forest;
2. the total number of individuals of the species; and
3. the total amount of forest area occupied by the species.

For this assessment, an IVI value was calculated separately for tree, shrub and herb vegetation categories, to determine the relative dominance of species in each of the 16 surveyed sites. This IVI can help provide information, for example, on whether a particular weed species dominates the vegetation composition as well as provide information on the dominant members of a community and their associates. In this report, we have only listed the IVI for the 4-5 species (in each category of tree, shrubs and herbs) with the highest values.

Vegetation analyses

Diversity index: Diversity index of the plants was calculated according to Shannon-Weiner Diversity Index.

$H' = -\sum p_i . \ln p_i$

where, $p_i = n_i / N$

= Number of individuals of one species /Total number of all individuals in the samples

'ln' is the natural logarithm to base e.

The Shannon Weiner Index takes both species richness and the relative abundance of each of these species in a community into account to determine the uncertainty that an individual picked at random will be of a given species. It provides a simple measure of the degree to which species in a community are represented.

To understand the impact of the project on the vegetation diversity of the project sites, we compared the diversity indices, species richness and regeneration status for control and treated sites to see if the differences detected were statistically significant. Because the data were not normal or violated the assumptions of homogeneity of variance, we used non-parametric Mann-Whitney tests to determine statistical significance. Furthermore, we assessed whether any changes had occurred in the vegetation diversity and species richness since the baseline biodiversity assessment. Since the data was not normal even after transformations, we used repeated measures Wilcoxon signed-rank test to assess if any changes had occurred in the above parameters.

Vegetation composition

To determine which species are the most important members of the community in terms of relative dominance, the Importance Value Index was calculated for each sampled site as well as each control plot.

Importance value Index = Relative frequency + Relative density + Relative dominance

These relative frequency, density and dominance values are calculated based on the frequency, density, and dominance of each species within the community.

Frequency: the percentage of inventory points occupied by a given species, a measure of species distribution across the site

Density: the average number of individuals per unit area (per hectare)

Dominance: the average dominance of each species within the study area is estimated by its total basal area per unit area (m^2 per hectare) or in the case of herbs and shrubs based on the abundance (total number of individuals of a species)

Basal Area (BA): The cross sectional area of each tree stem measured at (1.37 m) above the ground (girth at breast height or gbh). This value is normally obtained from girth or diameter (diameter at breast height or dbh) and can be calculated using the following equation:

BA in m^2 = dbh^2 (cm) * 0.00007854

To compare communities that may differ in size, or that were sampled at different intensities, importance values are calculated using relative rather than absolute values.

Relative frequency: Number of occurrences of one species as a percentage of the total number of occurrences of all species.

Relative density: Number of individuals of one species as a percentage of the total number of individuals of all species

Relative basal area: Total basal area of one species as a percentage of the total basal area of all species. For shrubs and herbs only the first two criteria were used to obtain a rough idea of the importance value of the species in the community based on its frequency of occurrence and abundance only. The maximum importance value for any one species is 300 (100 + 100 + 100) for trees and 200 (100 +100) for shrubs and herbs. After calculations are completed, species are ranked from high to low for comparison with other sites. Importance values were also calculated on a 200 scale for trees and a 100 scale for shrubs and herbs for each control plot. For this the frequency calculation was dropped and only relative dominance (where applicable) and relative density were included.

Results

Vegetation composition

Oak forest

The oak forests were dominated by several species of oak like *Quercus leucotricophora (incana), Q. semecarpifolia, Q. dilatata, and Q. glauca,* while *Rhododendron arboreum,*

*Myrica esculenta, Lyonia ovalifolia, Pyracantha crenulata, Randia tetrasperma, Lonicera parvifolia, Arundinaria falcata (Drepanostachyum falcatum), Skimmia laureola, and Symplocoscrata egoides were the most associated species. Alnus nitida, Persea odoratissima, Cornus capitata, Cedrus deodara, Picea smithiana, Aesculus indica, Taxus baccata, Cupressus torulosa, Viburnum cotinifolium*are other important co-associates of *Quercus* species.

Pine forest

In the Pine forest *Pinus roxburghii*is the dominant species, while *Carissa spinarum, Rhus parviflora, Woodfordia fruticosa, Indigofera heterantha, Berberis aristata* etc. are associated with *Pine sp*. The other associates of pine forest are*Pyrus pashia, Rubus ellipticus, Colebrookia oppositifolia, Mallotus phillipinensis, Sapium insigne, Euphorbia royleana,* and*Ficus sp.*

Species diversity and richness

Species diversity and richness were calculated separately for tree, shrub and herb species of treated sites in order to compare the vegetation status in the selected treated plantation sites. Details of the diversity index and species richness for project sites are provided in Annexure 5. It may be noted that the diversity index and species richness for tree, herb and shrub categories are not additive.

The study revealed that the shrub stratum has higher diversity values and species richness as compared to the tree and herb species strata. This is not surprising given that a) the shrub strata included saplings of tree species that had been planted or which had regenerated naturally under the SLEM project and b) the number of pre-existing adult trees were relatively low on account of biomass extraction and grazing prior to the project. Moreover, the lower diversity index and species richness of herbs compared to the baseline values was because this final assessment was carried out soon after the winter season, when areas were under snow and most of the annual herbs had died. In contrast, the baseline assessment had been carried out soon after the monsoon when all the annual herbs were flourishing. The strata that consequently gives the most valid signal of the success of the SLEM project is therefore any increases in the species richness and/or diversity index of shrubs.

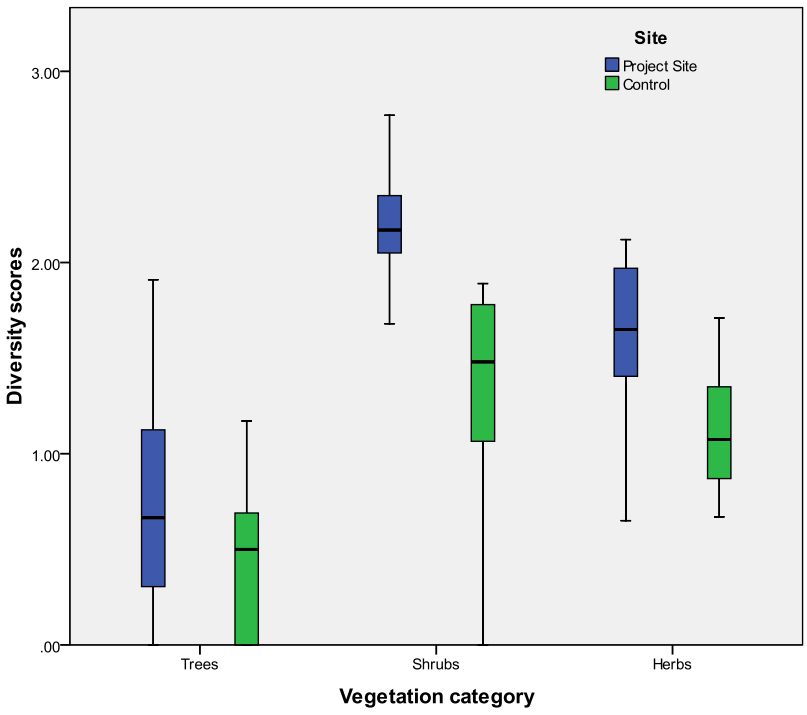
The highest diversity index for shrubs is from Majkhet, a site in Garhwal (2.77). From Kumaon, the highest diversity index of shrubs is from Pajaina (2.32). The highest diversity index (1.91) for trees is from Kwaidal in Kumaon. The next highest diversity index (1.47) for trees is from Ginwala in Garhwal.The highest species richness (38) was recorded from 2 sites; Majkhet in the Garhwal region and Gainar in the Kumaon region.

The species richness for all sites pooled together is 32 for trees, 79 for shrubs and 28 for herbs. This includes those tree species that are also found in the shrub category as saplings or young trees.. The unique total species richness for all sites pooled together excluding any repeated species is 112 for all the sites.

The full listing of all species recorded site-wise indicating their habit (annual/biennial/ perennial) is provided in Annexure 4.

Differences between project and control sites in diversity, species richness and regeneration

Except for the diversity index and species richness of trees (U=85.5, p=0.11; U=82, p=0.086), the project sites had significantly higher median diversity index values and species richness for shrubs (U=5, p<0.001, ; U=0, p<0.001), herbs (U=38.5, p<0.001; U=25.5, p<0.001) as well as the overall plant species richness (U=2.5, p<0.001, median of 23 for project sites versus 9.5 for the control) (Figure 11 & 12). The lack of significant values for trees (both in terms of richness and diversity) is not surprising, given that we cannot expect any changes in the richness or abundance of pre-existing adult tree species (height > 5m) within the short time frame of the project. ***However, given that tree seedlings and saplings are enumerated in the shrub category, the significantly higher median diversity index (median 2.17 for project sites versus 1.48 for the control) and species richness values (median 13.5 for project sites versus 5 for the control) for shrubs suggests the efficacy of project interventions in terms of tree seedling/sapling plantation***. This is corroborated by the overall significantly higher number of naturally regenerating seedlings and saplings in the project sites (median of 22) than the control areas (U=36.5, p<0.001, median 6.5) (Figure13) strongly suggesting that the project had a significant impact on the regeneration status of the project sites and that enhanced protection has been responsible for the increased numbers of naturally regenerating seedlings. Higher diversity index (median of 1.65 for project sites and 1.07 for control) and richness values (median of 8 for project sites versus 4 for control) also occurred for herbaceous plant species. Overall these results suggest the success of two factors 1) Tree seedling/sapling plantations under the project which has caused the higher observed diversity and species richness of shrubs and 2) the efficacy of protection activities by local communities which is suggested by a) the higher number of naturally regenerating seedlings in treated sites.



Source: TERI Primary Survey, 2013

Figure 11 Diversity index scores for project and control sites for each vegetation category (tree, shrub and herb)

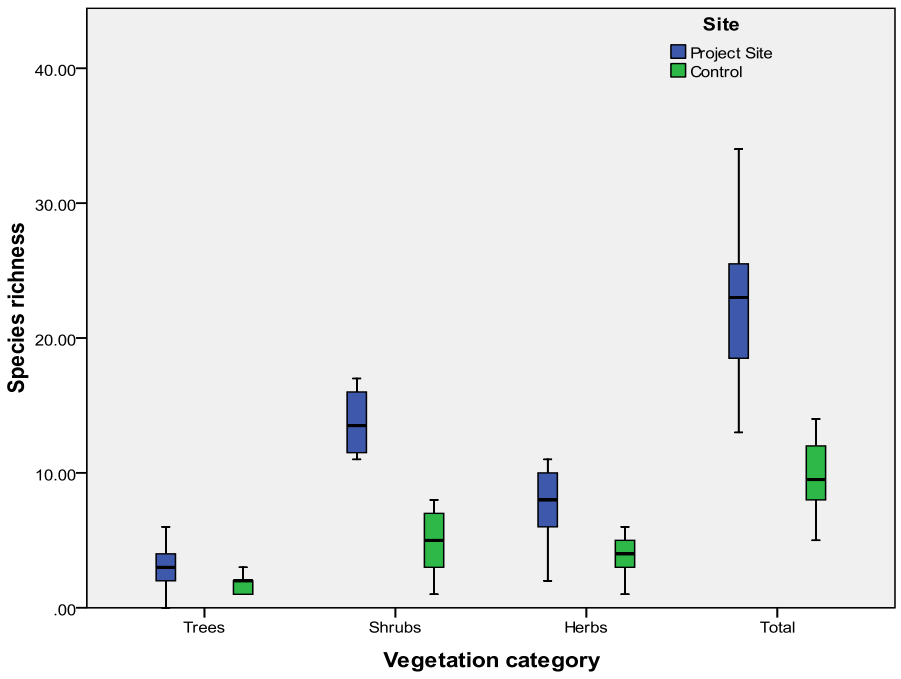
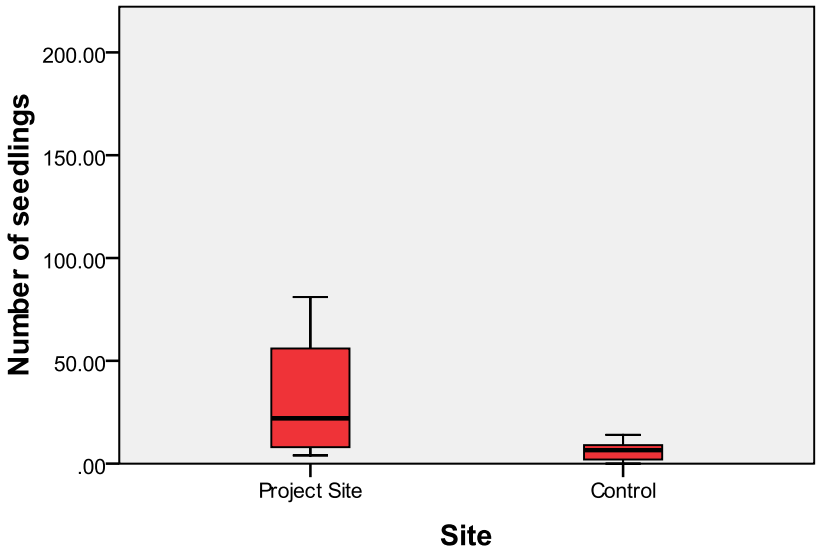


Figure 12 Species richness scores for project and control sites for each vegetation category (tree, shrub, herb and all categories together)

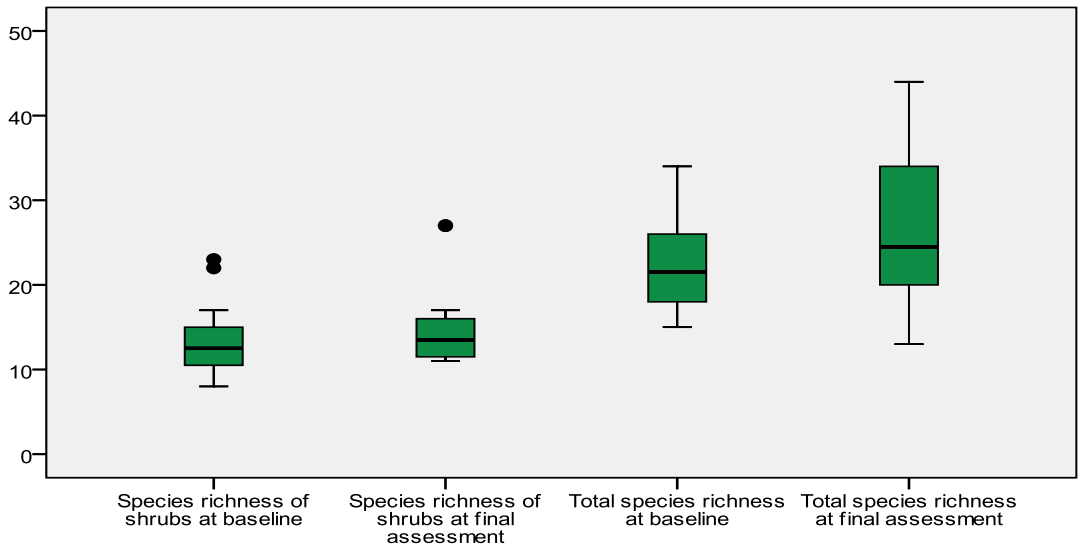


Source: TERI Primary Survey, 2013

Figure 13 Natural regeneration (number of seedlings regenerating naturally) for project and control sites

Differences in diversity and species richness between the baseline and final impact assessment (one year)

We also assessed whether significant changes had occurred in the diversity and richness of trees, shrubs and herbs in the one year period since the baseline assessment (Figure14). Given the short time frame we did not expect any significant changes in most of these parameters. However, we did find that the median species richness for shrubs (median of 12.5 versus 13.5 after one year) had increased significantly ($Z=-2.145$, $p<0.05$) as had the median values (median of 21.5 versus 24,5 after one year) for the total species richness (inclusive of trees, shrubs and herbs ($Z=--2.106$, $p<0.05$). Since the shrub category also includes tree seedlings and saplings, the increase in species richness for shrubs, in particular, suggests that the plantation of several tree species as well as enhanced protection from grazing and biomass collection has probably resulted in an increase in the species richness of the area. That significant positive changes have occurred in a short span of a year suggests that this project continues to be effective in enhancing regeneration and the biodiversity status of the area.



Source: TERI Primary Survey, 2013

Figure 14 Differences in species richness of shrubs and total richness at the baseline and at the final assessment one year later.

Overall, the tree species richness as expected has remained the same since the baseline assessment (32 species). The number of shrub species richness has increased from 73 to 79 indicating the success of plantation and protection activities. The overall number of herbs has decreased from 38 to 28 species in the final assessment. This is because many of the herbs are annuals and the timing of assessments varied from soon after the monsoon in the baseline survey, to February-March in the final assessment. Similar trends are visible with the diversity index. The value for trees remains the same at 2.0, for shrubs the diversity index increased to 3.6 while for herbs the diversity index dropped to 2.6.

Positive increases in relevant parameters for treated sites as compared with control plots, as well as enhanced species richness and diversity index of shrubs in the final assessment as compared with the baseline survey, clearly indicate the success of SLEM activities.

Importance valuesand species dominance

Pinusroxburghii dominated the tree stratum of several sampled sites including Baisani, Harsilla, Gainar, Purkuni, Majkhet, Loladi, Indiyan, Ginwala, Sari, etc. (Annexure 6). Amongst oaks, *Quercus leucotricophora* was also an important species in several sites such as Majkhet, Kontha, Thali, and Purkuni. Other important species included *Myrica esculenta* (Majkhet, Dholigaon, Thali) and *Rhododendron arboretum* (Kontha, Kwaidal, Thali).

Amongst shrubs (Annexure7), saplings of *Quercus leucotricophora*had high importance value indices in 9 of the 16 treated sites (56% of the sites), followed by *Pinus roxburghii* in 7

of the sampled sites and *Toona ciliata* and *Bauhinia variegata* in 6 sites. The importance of tree seedlings and saplings of species such as *Quercus leucotricophora, Toona ciliata* and *Bauhinia variegata* that had been planted during the project, again suggests the success of tree plantation activities under the GEF SLEM project. The importance of *Pinusroxburghii* as well, suggests that natural regeneration is also occurringdue to protection activities carried out as part of the SLEM project. Moreover, the dominance of tree seedlings that had been planted during the project in the regeneration strata of the forests suggests their key contribution to the composition of the forests in the future. This is because the regeneration stratum provides a template of what the composition of forests will be in the future.

Amongst herbs (Annexure8), the invasive species *Eupatorium* sp. dominated the herb layer in fifteen of the sixteen sampled sites, indicating its widespread invasion in forest areas located close to villages in the hills. The invasive *Ageratum conyzoides* was also dominant at six treated sites (Agar, Ginwala, Kontha, Indiyan, Gainar, Harsilla). The native herb *Anaphalis busua,* however, was also an important component of the herb stratum in 9 of the project sites. Amongst the herbaceous layer, the ferns *Cheilanthesanceps* and *Adiantumcapillus* were amongst the dominant species in 6 of the treated sites. *Reinwardtia trigyna* and *Artemisia nilagirica* had high importance values in 5 of the 16 sampled sites. Similarly, *Eupatorium sp.*, *Anaphalis busua* and*Cheilanthesanceps* dominated the control sites.

Presence of key species of flora in sampled MWS

As described earlier, the composition of the shrub layer which includes naturally regenerating or planted tree seedlings and saplings is particularly important in gauging the effectiveness of the project interventions in terms of increases in key species of flora through a) survival of planted species b) natural regeneration of native species. This is true because it is the tree seedlings and saplings that play a critical role in defining the future vegetation composition of the forests.

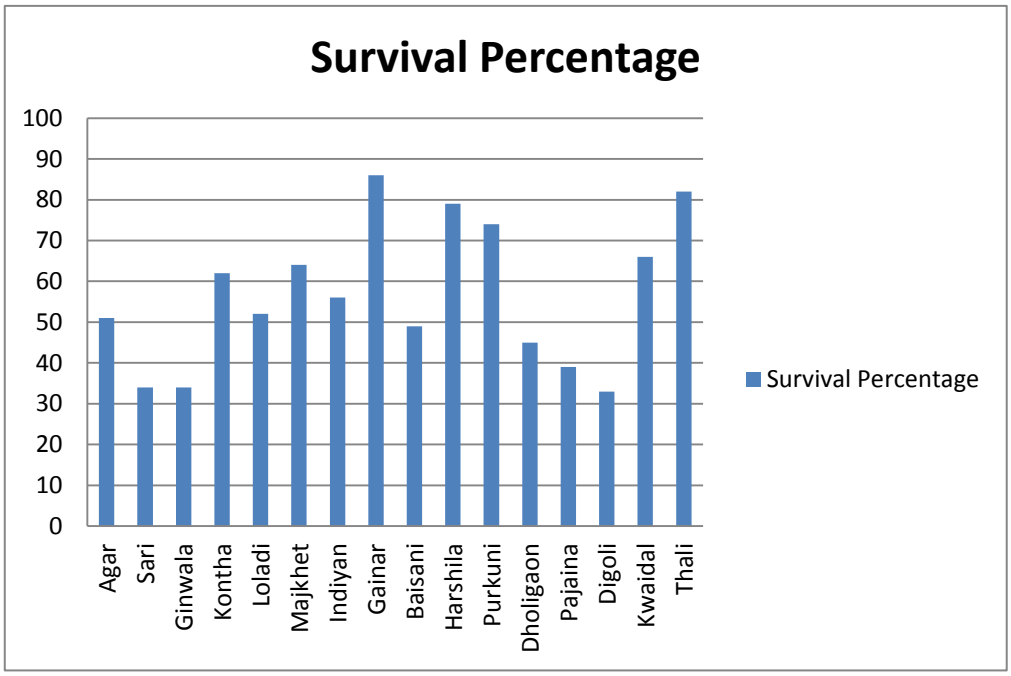
In Nainital division, *Quercus leucotricophorai* is the dominant species in the shrub layer, followed by *Quercus semecarpifolia*, *Pinus roxburghii* and then *Rhodendronarboreum* and *Berberis aristata.* This is in contrast to the tree layer which is dominated by *P. roxburghii.* In Bageshwar division, *Toona ciliata, Bauhinia variegata,Quercus leucotrichophora and Persea odoratissima* dominate the shrub layer followed by *Pinusroxburghii*. This is again in contrast to the tree layer which is dominated by *Pinus roxburghii.* In Rudraprayag Division, *Berberis aristata*, *Colebrookia oppositifolia, Toona ciliata, Quercus serrata and Rhus parviflora* dominate the shrub strata. In the tree layer, however, *P. roxburghii* was the second most dominant species. In Tehri Garhwal, although *Pinus roxburghii* has the highest importance values, it is closely followed by *Bauhinia variegata, Berberis aristata, Quercus leucotricophora and Toona ciliata*. (Annexure 9). It is the only division where *P. roxburghii* retains its dominance in both the tree and shrub layers. However, the importance values of Pine is much higher in the tree layer than in the shrub layer (Annexure 9)

The importance of species other than *Pinus roxburghii such as Quercus leucotrichophora, Berberis aristate, Toona ciliata and Bauhinia variegata* in the regeneration strata suggest that these species will likely dominate the future species composition of the forests in the MWS. Moreover, this dominance of species other than *Pinus roxburghii* suggests the transition to mixed type of forests in the future, rather than forests dominated solely by *Pinus roxburghii.*

Survival percentage of planted saplings

The average survival percentage varied from 33% (Digauli) to 86% (Gainar) within the sixteen surveyed sites (Figure15). The mean survival percentage within the surveyed sites was more than 56% indicating relatively high survival. The A few (25%) of the sites that had survival percentages less than 40%, namely Digauli (33%), Sari and Ginwala both with 34% and Pajaina with 39%. Forest fires which also caused damage to the young saplings occurred in Pajaina, Baisani, Thali, Loladi and Agar. Some areas like Bogora (Digauli), Dholigaon, Sari and Ginwala had heavy biotic pressure which adversely affected the plantations.

Climatic conditions and aspect are also important factors for vegetation growth. Dominance of Pine occurs in subtropical zones (1800-2000m), mostly on the southern aspect of hills with steep slopes and sunny, dry conditions. Northern or north-eastern aspects are one of the important factors for highest survival percentage in some sites due to increased availability of moisture regimes on these aspects and less steep slopes.



Source: TERI Primary Survey, 2013

Figure 15 Survival percentage of planted saplings across project sites

Significant increase in the species richness and diversity index as well as the higher number of regenerating saplings in treated sites were mainly due to a) significant survival of tree plantations b) effective dry stone fencing and watch and ward activities in many of the plantation sites. Conservation and protection activities in particular, allow for both the enhanced survival of planted species as well as facilitate natural regeneration of other native

species. Moreover, the construction of various soil and water conservation structures also lead to an increase in the moisture content of the soil, which could also result in increases of herb and shrub species within the treated area. However, in the control sites, which were not subject to plantation activities or protection from cattle grazing and were open to anthropogenic disturbances, significantly lower values of species richness and diversity is recorded. Moreover, the results also suggest that the overall regeneration status of the planted and protected project sites has further enhanced in the one year period since the baseline assessment of SLEM as illustrated by the higher species richness of shrubs and the overall species richness of the area.

Faunal biodiversity [13]

The entire project area falls in the Himalayan bio-geographical zone (Zone 2) and West Himalaya province (2B) as per the classification of Rogers and Panwar (1989). Except in the protected areas, wild animals occur at very low densities. However, the animals causing conflict with local people, such as monkeys, Hanuman langurs, wild pigs, leopards, bears and porcupines are common. Due to the presence of abundant forest cover, the leopard is common even in and around villages and townships. In areas where forest cover is low or where natural prey of the leopard is lacking, man-eating and cattle lifting is common. Due to such incidents leopards also suffer as the local people can poach, poison or trap them in snares.

When local communities were asked as part of this survey if there had been an increase in the incidents of human-animal conflicts, 78% of the villages replied in the negative, suggesting that over the timeframe of the SLEM project for the majority of the revenue villages, man-animal conflicts had not increased. In terms of which animals were responsible for these conflicts, 40% of the villages mentioned attacks by leopards on their animals, 50% mentioned crop depredations by monkeys and by wild boar (48%). Only 12% of the villages cited sambar to be a problem for crops. Overall, while these results suggest that man-animal conflicts did not increase during the duration of the project, leopards, wildboar and monkeys continued to cause problems for the villagers. The problem persists mainly because the number of cattle grazing in the villages seems to have decreased, and this has led to fewer disturbances around villages, and growth of more vegetative cover which shelters these animals during the day. Moreover, due to complete decimation of the prey base from these forests, conflicts with leopards continue.

The interval between the two surveys being short, and the terrain being highly disturbed by human activities, it was difficult to perceive any noticeable change in the faunal diversity. However, in the plantation sites, due to fencing, good growth of grasses, shrubs and herbs has been achieved due to which the presence of many insects particularly grasshoppers, beetles, butterflies and moths, dragon flies, as well as more bird activity was noticed. Small mammals like rats and hares and reptiles such as rock lizards, monitor lizards, snakes etc. were also reported from these sites by village women who visit these areas for collection of grass after the rainy season.

[13]This section refers to the project area as a whole and not to the sampled GPs in specific. Assessment of faunal diversity at the GP level has not been possible due to specific reasons. In hill areas, on account of the terrain, animals usually leave no visible identification marks such as pugmark and scat. Also, on account of high population density, sightings of animals are extremely rare except during the night.

Reduction in incidence of fire in treated MWS

Total area over which forest fire management has been carried out is 186 ha. The activities under this component consisted of fire line clearing and fire safety tools distribution. Another important component was capacity development (by training and awareness generation programmes) on forest fire management and safety issues.

In the project area the dominant tree species in the forests is chirpine which makes the forests fire prone. However, it has been observed that fire incidences are cyclical in nature, and are usually associated with high temperature for relatively longer spells, wind velocity and fuel load on the forest floor.

We have used the year 2010 as the baseline and 2013 as the final assessment year to assess a) the change in incidences of fire over this period and b) change in the area under fire during this period. There has been a change in the incidence of fire from 8 incidents and 15.5 ha area affected (in the 26 GPs sampled for the final assessment) (11 incidents in the 51 GPs sampled and 19.5 ha area affected) in 2010 to 2 incidents and 6 ha area affected in 2013 (75% reduction in the incidence of fire (Table 34) as well as a reduction in the area under fires of 61.3% over the base year 2010 (change from 15.5 ha in 2010 to 6 ha in 2013) (Table 35). In Nainital Division 8 ha of area (in the sampled sites) was covered under forest fire management, and no instances of fire were reported in 2013 in the sampled sites in this Division.

Table 34 provides division wise fire details of forest blocks and compartments falling in the MWS for which plans have been prepared under SLEM .

Table 34 Fire incidents recorded from 2010 to 2013 in Sampled MWS

Sr No.	Name of Forest Division	Name of DPD Division under SLEM Project	Year of fire	Compartment of fire incidence	Area (ha)	No. of incidences
1	Champawat	Nainital	2010	Debguru 5, Khujethi 8	3+ 3= 6	1+1= 2
2	Champawat	Nainital	2011	Nil		
3	Champawat	Nainital	2012	Debguru 5, Dansiri 3	2+3= 5	1+1= 2
4	Champawat	Nainital	2013	Nil		
5	Nainital	Nainital	2010	Raikuna 13	1.5	1
6	Nainital	Nainital	2011	Nil		

Sr No.	Name of Forest Division	Name of DPD Division under SLEM Project	Year of fire	Compartment of fire incidence	Area (ha)	No. of incidences
7	Nainital	Nainital	2012	Patlot 6, Anarpa 3,	1.5+ 0.2=1.52	2+ 1= 3
8	Nainital	Nainital	2013	Nil		
9	Rudraprayag	Rudraprayag (Augustmuni)	2010	Ragsi II4, Augustmuni 4b	1+0.5= 1.5	1
10	Rudraprayag	Rudraprayag (Augustmuni)	2011	Augustmuni 2, kakodakhal 2, Kakodakhal VP	3+ 0.5+ 3= 6.5	2+ 1+ 2= 5
11	Rudraprayag	Rudraprayag (Augustmuni)	2012	Sari 5, 13, Augustmuni 1, 3,	1+ 1+ 1+ 10= 13	1+1+ 1+ 1= 4
12	Rudraprayag	Rudraprayag (Augustmuni)	2013	Augustmuni 1, 2	1+5= 6	1+1= 2
13	Tehri	Chinaylisaur	2010	Kangra 3, Kangra 14 & 15, Kangra 20&21, Kangra 20	1.5+ 2+ 2+ 1= 6.5	1+ 1+1+1=4
14	Tehri	Chinaylisaur	2011	Nil		
15	Tehri	Chinaylisaur	2012	Nagunagad 15a, b, Mendkhal 1, 3, Dhikiyara, Kangda 30,	2+ 0.5+ 1+ 1+1+ 3= 8.5	1+1+1+1+1+2 = 7
16	Tehri	Chinaylisaur	2013	Nil		

Source: Uttarakhand Forest Department

Table 35 Forest fire area (ha) in respective Forest Divisions (sampled GPs)

Forest Division	2010 (Baseline assessment year)	2011	2012	2013 (Final assessment year)
	Area (ha)			
Champawat	6	0	5	0
Nainital	1.5	0	1.52	0
Rudraprayag	1.5	6.5	13	6
Tehri	6.5	0	8.5	0
Bageshwar	4	5.5	18	10
Total	19.5	12	46.02	16

Source: Uttarakhand Forest Department

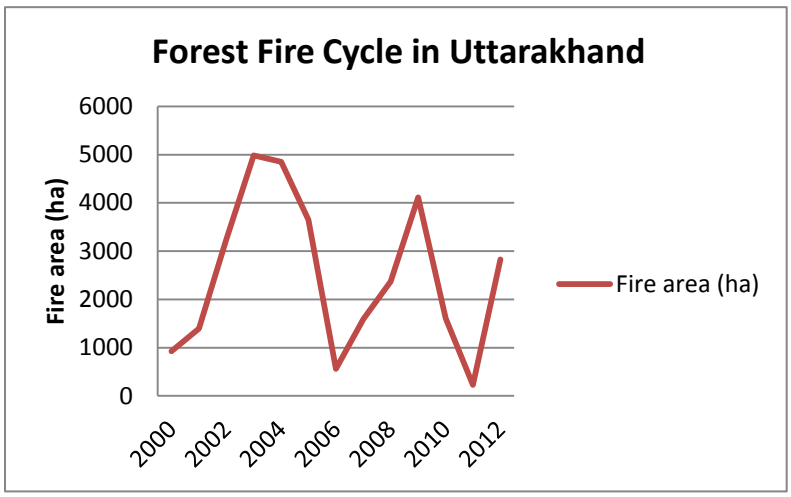
Table 36 Forest fire area (ha) in the Forest Divisions (Overall)

Forest Division	2010 (Baseline assessment year)	2011	2012	2013 (Final assessment year)
	Area(ha)			
Champawat	47	6	56	2
Nainital	60.9	0.25	67.4	0.1
Bageshwar	103.3	28.15	113.6	17
Tehri	93.7	24.25	131.3	42.45
Rudraprayag	30	11	93.7	39
Total	231.6	69.65	462	100.55

Source: Uttarakhand Forest Department

It may be noted that 2012 has been a high fire incidence year at the state level whereas 2011 has been a low fire incidence year. Therefore, it may be difficult to attribute fire reduction to

project interventions with complete certainty. Moreover, the fire cycle for the state of Uttarakhand (Figure16) clearly indicates the cyclic nature of the fires in the state with some years having a higher incidence of fire (related to high temperature years) than others. This cyclic nature of forest fires is also reflected in the sampled GPs as well as the forest divisions as a whole (Tables 35, 36, Figs 17 and 18).



Source: Uttarakhand Forest Statistics (2012)

Figure 16 Forest fire cycle in Uttarakhand

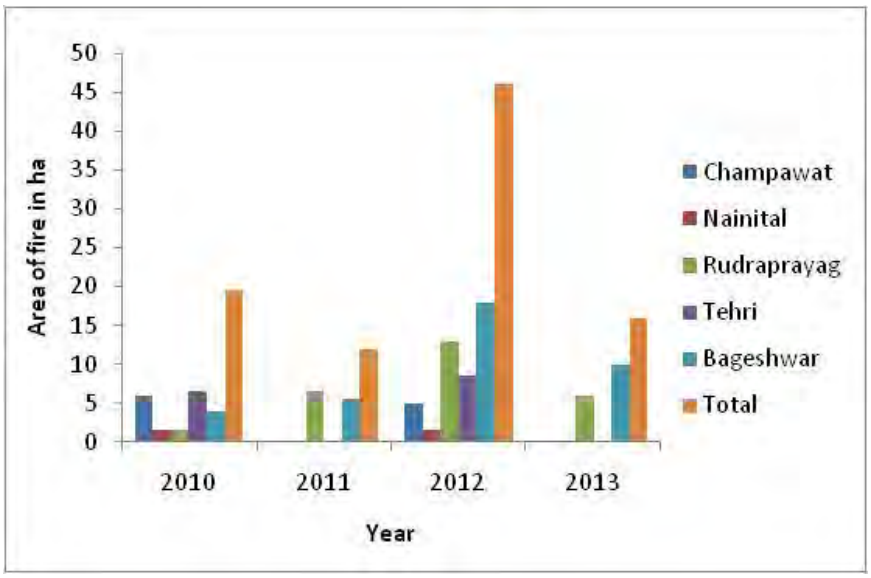


Figure 17 Cyclic nature of forest fires in sampled GPs in terms of area affected

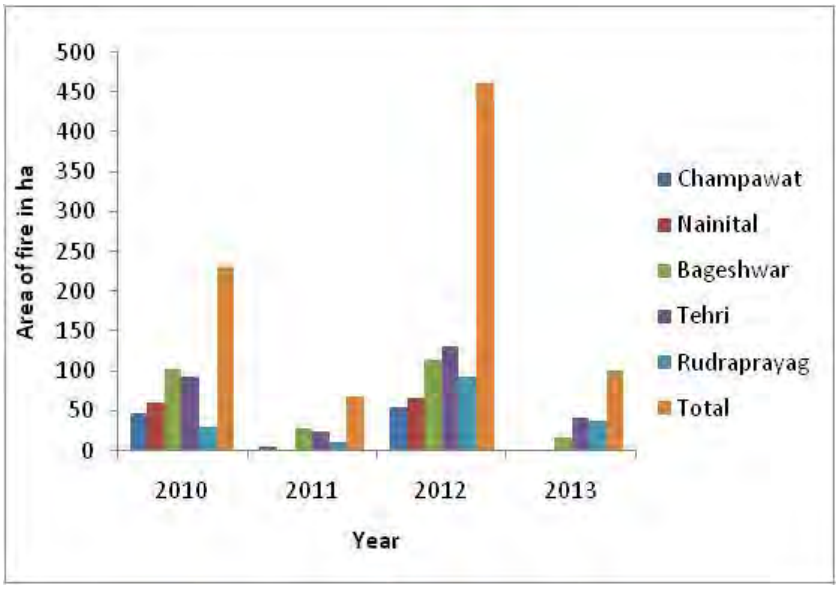


Figure 18 Cyclic nature of forest fires in the Forest Divisions (Overall) in terms of area affected

Longer term monitoring of fire instances may help in assessing impacts of fire management measures with greater confidence.

In the case of control GPs, associated RF areas are relatively less, and expectedly, there are no noticeable differences with respect to forest fire incidences over the baseline.

The cyclic nature of the fire cycle in Uttarakhand suggests that fire prevention with the help of participatory involvement of communities is critical particularly in high temperature years. Once a fire has started, control is very difficult. Instead as the GEF SLEM approach has shown various participatory approaches such as appointment of fire watchers or handing over fire watch responsibilities to SHGs, maintaining of fire lines and general education on the importance of fire reduction are effective ways to reduce the incidences of fire.

Cultivation of at least 5 local MAPs (medicinal and aromatic plants) by communities in 20 micro watersheds

Domestication and cultivation of at least 5 local medicinal and aromatic plants by communities in the project Micro watersheds was undertaken and a cluster approach was adopted to facilitate marketable quantums with viable linkages. Depending upon the suitability of site, the following species of MAPs were planted : *Aloe vera* (Aloe or ghritkumari), Rosmarinus officinalis (Rosemary), *Cymbopogan flexuosus* (Lemon grass), *Asparagus racemosus* (Asparagus or Satavar), Geranium, *Phyllanthus emblica* (Indian gooseberry or amla), *Amomum subulatum* (Black cardamom or badi elaichi), *Rauvolfia serpentina* (snake root or sarpgandha), *Bacopa monnieri* (Waterhyssop, Brahmi, *Withania somnifera* (Indian ginseng or Ashwagandha), *Ocimum sanctum* (Sacred Basil,Tulsi, *Stevia*

rebaudiana, (Stevia), *Cinnamomum tamala* (Cinnamon, Indian bay leaf or Tejpatta), *Zingiber officinale* (Ginger or adrak), *Curcuma longa* (Turmeric or haldi).[14]

MAP cultivation is new to farmers of the project area. Though isolated efforts were made in UDWDP to encourage farmers to grow MAPs, he success was somewhat limited. Training to farmers and WMD field functionaries was imparted under the project and planting material was made available. Polyhouse for demonstration of MAP nurseries were provided to Farmers Interest groups (FIGs) where planting material was raised. The plants raised in nurseries were planted in clusters by members of FIGs so that market linkages could be possible. Some plants like Amla and Tejpat were also raised in forest nurseries. Some of the nurseries were raised as Kisan/Mahila nurseries which were managed by women members of FIGs. The activity started in 2010 and it took some time to pick up. Ginger and Turmeric are also cash crops apart from being of medicinal value and FIGs were quick to adopt these species due to their marketing potential. These species were promoted during UDWDP and market linkages had also been established through FIGs. The success of marketing of MAP under the project can be attributed to these two species.

Other short rotation species which could be marketed within a year or two were Aloe vera and Stevia. Some FIGs also marketed planting material of Aloe vera, Satawar, Tulsi, Tejpat, Amla, Lemon grass, Sarpganda, Ashwagandha and Geranium in the neighbouring villages. During the project period WMD field functionaries also purchased planting material from farmers for demonstration in other villages/other farmers.

Difficulties in technicalities in raising plants, limitations of irrigation and climatic conditions did not allow the cluster approach to succeed to the desired extent. Many species such as Aloe vera, Stevia, Satawar and geranium were not successful in a majority of villages.

Table 37 Status of FIGs involved in medicinal plant activity

MWS	Name of GP	No. of Nurseries raised	FIGs involved				Marketing done (in Qtl.) during one year (2011-12)
			No.	M	F	Total	
Kumgad	Harsilla	1	2	21	2	23	Turmeric-67, Ginger-80
Gagnigad	Sumati Baisani	1	1	18	5	23	Turmeric-54, Ginger-100
Gainargad	Gainar	-	1	16	2	18	Turmeric-81, Ginger-71
Sunkot	Digauli	2	4	32	7	39	Turmeric- 165 Ginger-48
Sunkot	Kukna	-	-	-	-	-	-
Dantagad	Katna	-	5	73	1	74	Turmeric- 210 Ginger-55

[14]We have given the scientific names the first time the species is referred to in the text. Subsequently the most commonly used name of the plant is used throughout the text

MWS	Name of GP	No. of Nurseries	FIGs involved				Marketing done (in Qtl.) during one year (2011-
Dolgad	Mehtoliyagaon	-	3	40	0	40	Turmeric- 131 Ginger-37
Dolgad	Majyuli	-	4	52	2	54	Turmeric- 206 Ginger-42
Dolgad	Thaladi	-	2	23	0	23	Turmeric- 168 Ginger-76
Dolgad	Thali	-	-	-	-	-	-
Garigad	Pokhari	-	-	-	-	-	-
Garigad	Bhenti	-	2	16	5	21	Aloe vrea- 1000*
Garigad	Gairnagun	-	3	30	8	38	Aloe vera – 3000*
Malogigad	Indiyan	-	2	8	4	12	Aloevera-2000*
Chamargad	Ghaun	-	1	10	1	11	Aloevera-1000*
Ghattugad	Majkhet	1	3	24	6	30	Aloe vera -5000*
Baniyarigad	Kamsal	-	-	-	-	-	-
Baniyarigad	Baniyari		2	1	25	26	Turmeric-4.4, Ginger-16.58
Baniyarigad	Giwala	-	3	0	24	24	Turmeric-4.80, Ginger-12.57
Pogtagad	Agar	-	1	0	19	19	Ginger-3.43
Pogtagad	Sari	-	4	15	34	49	Turmeric-18, Ginger-10.19
Surgad	Kyudi	-	2	5	18	23	Turmeric-7.17, Ginger-14
Surgad	Vora	-	3	5	40	45	Turmeric-8.76, Ginger-11
Kyunjagad	Kinjani	1	6	39	46	85	Turmeric-1.18, Ginger-3.15
Kyunjagad	Tewadi Sem	2	5	7	58	65	Turmeric-17.3, Ginger-14.15
Kyunjagad	Bhatwari Sunar	-	6	0	57	57	Turmeric-43.01, Ginger-19.03
Grand Total	**26**	**6**	**65**	**440**	**364**	**804**	

***Aloe vera bulbils**

Source: WMD

Except for ginger and turmeric, marketing of MAP products have been done in a few GPs at a small scale. Cultivation of these two species had been an important activity undertaken in UDWDP with formation of FIGs, and market linkages had also been established in most GPs. Cultivation of these two species had been adopted on a cluster approach. During the field survey, it was found that FIGs are mostly active where turmeric and ginger have been grown. In Nainital Division marketing support was provided by CHEA, an NGO which facilitated the sale of both the crops to the farmers of Pithoragarh district under their Tribal Development Fund Project. Ground turmeric powder was also sold to different markets and in the SARAS fair in Mumbai. Market linkages for MAP products were made through Appropriate Technology Institute (ATI) and *Mandakini Khadya Prasanskaran Udyog Bhatwarisain* of Augustmuni Division. In Chinyalisaur Division market linkages were provided by Vedic Foods Dehradun, for Stevia, CAP for Lemon grass and Patanjali Yogpeeth and Shivdhara Foods Uttarkashi for Aloe vera. In Bageshwar market linkages were made through SARAS and local markets for Aloe vera. FIG in Sumati Baisani was found to be very successful in making Aloe vera products and also selling seedlings to other farmers. The processing was being successfully done by women members. In Nainital Division, farmer's registration with CAP and MOU with Dabur Industries was under process.

Sustainability in marketing is vital to the success of this programme and the chances of success seem to be higher for Aloe vera, Stevia, Satawar, Tejpat, Amla and Badi Elaichi, apart from ginger and turmeric which are established as cash crops in the hills.

Conclusion

The mixed temperate forests in the hills of Uttarakhand typically suffer from degradation due to high anthropogenic pressures, and consequent unsustainable use. The process leads to loss of species diversity and also disturbs the micro-climate . In GEF SLEM, the forests under plantations and ANR are closed to grazing and protected so as to reduce anthropogenic pressures and provide an *in-situ* opportunity for the natural flora to regenerate.

The mixed temperate forests meet livelihood needs better than the mono-dominant Pine forests. Hence, it is necessary to have suitable interventions in the VPs and RFs to create mixed-species forests in the near future which would reduce the chances of fire, support better moisture regimes and provide a number of ecosystem services to local people. At this stage, the recruited undergrowth of mixed species of seedlings and saplings suggests that if protection from fire, grazing and other anthropogenic pressures continues, the future forest composition could be of mixed species type and not Pine dominant.

On steep southern aspects, rocky outcrops support only chir pine forests due to deficiency of moisture and soil nutrients. The proportion of such pure chir pine forests in the project area is substantially high and it is these forests which are most vulnerable to fire. Due to total ban on green felling within the project area, chir areas cannot be worked for any new type of plantations including the regeneration of chir pine.

Some of the components of the project would have indirect positive impacts on biodiversity such as pine briquetting and biogas. Pine briquetting not only reduces the pressure on forests for fuelwood, it also clears the carpet of pine needles from the forest floor and

possibly provides an opportunity for non-pine species to regenerate. Similarly, biogas also reduces the demand for fuelwood and if stall feeding is carried out then grazing pressure is also reduced and regeneration is enhanced. But the impact of these activities is felt at a relatively micro scale.

The involvement of villagers in preventing and extinguishing fires has been an important feature of the project. This will encourage participatory approaches and would help in reviving traditional fire management mechanisms.

The cultivation of medicinal plants to serve as an alternative to the wild collection has been a widely accepted conservation strategy. But the quantities produced for supply on commercial scale have been limited. Though the cluster approach used in the project was not entirely successful (except for ginger and turmeric), it is the only possible way to develop a supply chain of medicinal plants for commercial purposes. The cluster approach could be enhanced by having tie ups like the one initiated with Dabur for a substitute of *Jatamansi (Valeriana jatamansi)*. In UDWDP, FIGs were federated to facilitate technical inputs for production of certain cash crops and their marketing. In the SLEM project, a large number of farmers are growing turmeric and ginger in marketable quantities and the federations so formed deserve credit for this.

In conclusion, the following points may be reiterated:

1. Changes in species composition of forests are determined by the composition of species that recruit in the undergrowth / shrub layer. The opportunity for key species such as *Quercus leucotrichophora, Toona ciliata* and *Bauhinia variegata* to survive and replace the existing pine-dominated tree layer over a period of time can only occur when non-pine tree species recruit in the undergrowth. The dominance of species such as *Quercus leucotrichophora, Toona ciliata* and *Bauhinia variegata* along with *Pinus roxburghii* suggests that the future possible species composition in the tree layer would be of mixed temperate type (rather than *Pinus roxburghii* dominated forests), provided the incidences of forest fire are controlled. Mixed species composition is important for sustenance of a range of ecosystem services.
2. Fire is a consequence of combination of climatic factors and anthropogenic interferences. In the hills, there has been a proven cycle of fire over a period of four years. In such a situation it becomes important to develop and revive participatory fire prevention mechanisms. Involvement of communities in fire management under SLEM has been a welcome initiative.
3. The cultivation of MAPs through a cluster approach has been successful only for ginger and turmeric which happen to be cash crops in the project area. The other species have been cultivated in relatively smaller quantities - Aloe vera, Rosemary, Lemon grass, Satawar, Geranium, Anwala, Cardamom, Sarpgandha, Brahmi, Ashwagandha, Tulsi, Stevia, Cinnamon (Tejpat), etc. The activity needs be continued with enhanced marketing support.

7. Community participation and Institutional development

Introduction

Watershed planning and enhancement of biodiversity conservation and management through community participation is emphasized and reflected as intermediate results in SLEM. SLEM being the extension of UDWDP in 20 of the 76MWSs, the foundation for community participation had already been laid during the planning and implementation phase of UDWDP. Facilitators and motivators were engaged to mobilize the community and create awareness among them towards project objectives and activities. In many cases, the facilitators and motivators working in UDWDP have worked in SLEM as well. The initial efforts needed to establish SHGs, FIGs, User Groups and implementing bodies such as RVCs and VPs had already been put, and benefitted from the UDWDP experience. A major difference with UDWDP was the inclusion of inter-GP areas or RFs in the project. In SLEM Van Panchayats (VPs) were the implementing agencies in RF areas and funds were directly given to VPs to avoid any delays. In a word, SLEM inherited enhanced capacities for project implementation at the grassroots level from UDWDP, and was building on this base.

Given the emphasis on the close involvement of the GPs, VPs and of the community in the project implementation, various interventions were made to provide institutional support to further enhance the participation of communities and community based groups in the project. In all 65 Farmer Interest Groups (FIGs) have been formed for cultivation of medicinal and aromatic plants, 33 SHGs have been formed for Pine Briquetting, and 95 SHGs have been given support to enhance their entrepreneurial activities in the sampled GPs.

General indicators of participation

The following table shows that the level of participation at the GP level has increased during the operation of the SLEM project. In specific, the participation of women in Gram Sabha meetings shows a sharp rise by about 11 percentage points. The significant involvement of women in SHG activities and the continued presence of women motivators/facilitators were noted as key factors contributing to this rise. The overall attendance percentage in Gram Sabha meetings also show an increase by 8 percentage points, and expectedly show higher values as compared to control GPs.

Table 38 Level of participation in meetings

	Treatment		Control	
	Before the project	After the project	Before the project	After the project
Average attendance in Gram Sabha (%)	40.76	48.8	24	39
Participation of women in Gram Sabha (%)	37.88	48.46	30	35
Average attendance in GP meetings (%)	54.88	73.30	49	68

Source: TERI Primary Survey, 2013

Participation of Community based Institutions in Micro-Watershed Plan Preparation.

During UDWDP, detailed GP level plans were prepared for each GP through a PRA exercise, involving all institutions and various sections of the community. These plans had all the details of the RVs and documented the development needs of the villages. During preparation of MWS plans for selected 20MWSs for the project, these plans were used. For finalising the activities in different RVs,a general consultation was done among GPs, VPs, RVs and User Groups of the MWSs to finalize the physical targets for different RVs. Targets for RF areas were finalized in consultation with concerned Forest Departments and VPs/GPs. Thus 20 MWS plans were prepared at the start of the project and were duly implemented.

Community Based Institutions formed under the Project

Two community based institutions, namely, Self Help Groups (SHGs), Farmer Interest Groups (FIGs) have been formed under the project. Strengthening of SHGs gives livelihood support to the community, including women and weaker sections of the society whereas FIGs focus on supporting farmers' groups in farming and marketing of produce. Van Panchayats which are constitutional bodies formed under Panchayati Raj Act were designated as agencies for implementing project activities in the Reserve Forest areas.

SHGs

SLEM activities can be seen as logical extensions of activities taken up under UDWDP. The SHGs that remained active at the completion of UDWDP were considered for support under SLEM with a view to enhancing their entrepreneurial activities. The activities taken up by the SHGs include several successful activities under UDWDP and some innovative actions important from the environmental angle. Key among the SHG activities (with the largest share of funding) under SLEM include the renovation of Gharats, stitching/tailoring, cement castings, tent house and loaning of utensils for functions, etc. Some of the SHGs were also formed during the SLEM project period such as pine briquetting, operating Gharats and some of other activities for which project financial support was provided to SHGs.

The details of community based institutions in sampled GPs formed or supported during the project are as under:

Table 39 Community based Institutions in sampled GPs

Institutions	Bageshwar				Nainital				Agustmuni				Chinyalisaur			
	No	M	F	T	No	M	F	Total	No	M	F	Total	No	M	F	Total
SHG (Pine briquetting)	7	-	58	58	8	-	98	98	11	-	152	152	9	-	138	138
SHG(Livelihood support)	20	65	54	119	46	147	105	252	12	-	150	15	15		190	190

Institutions	Bageshwar				Nainital				Agustmuni				Chinyalisaur			
FIG (Marketing support to MAP)	4	55	9	64	18	225	10	235	32	72	391	463	11	88	24	112
Van Panchayat (IA for RF)	3	23	4	27	9	60	11	71	2	14	1	15	6	44	6	50
Total	**34**	**143**	**125**	**268**	**51**	**432**	**224**	**656**	**57**	**86**	**694**	**780**	**41**	**132**	**358**	**490**

No: Number of Institutions; M: Male Members; F: Female Members; T:Total Members

Source: TERI Survey, 2013

35 SHGs are engaged in pine briquette making and one mould machine has been provided to each of the SHG. These are all Female SHGs with 456 members. Training and demonstration was given to all SHGs. Most of them have produced pine briquettes but most of the production has been consumed at home. Only 12 SHGs consisting of 145 members have marketed briquettes worth Rs 87,000 since the inception of the activity. Most of the production started after SLEM project was launched. Sustainability of these SHGs will depend on the marketing of pine briquetting for which efforts at various levels will be needed.

95 SHGs were supported for livelihood activities of different types. 26 of them relate to operating the traditional Gharats (Water Mills) renovated under the project. Other major activities were tent houses, cement casting, sewing machines and goatary. A total of 499 women and 212 men are engaged in these activities. Total earning from the beginning of the activities till the time of survey (March 2013) was Rs 11,77,448 out of which a major earning of Rs 8,37,145 was from Gharats alone. There was no earning from 6 activities. Most activities started in 2011 and 2012 whereas 19 activities started as late as March 2013.

Activities for supporting SHGs included those which are traditionally practiced by weaker sections of society. These included basket making (10 male and 7 female), yarn making (5 female), band (8 male), stitching and tailoring (3 males and 86 females) and Gharats (113 male & 22 female). New SHGs were formed for these activities wherever necessary, thus benefitting weaker sections of society specially SC families, and families with marginal land holdings.

65 FIGs were formed for MAP production in which 440 men and 434 women were engaged. 80% of these members were from Augustmuni and Nainital Divisions. In all these FIGs, marketing of Ginger and Turmeric (also treated as cash crops) were marketed. 1190 quintals of Turmeric and 610 quintals of Ginger was marketed for a sale value of Rs 15,45,2910. This performance was achieved in 3 Divisions namely Bageshwar, Nainital and Augustmuni with Nainital Division contributing the largest share (about 75%). FIGs in Chinyalisaur Division marketed only Aloe Vera planting material worth Rs. 24000.

In all, 20 VPs were involved with 20 female and 141 male members. These VPs were responsible for implementing soil and water conservation works in respective RF areas.

About 13% of the amount spent on soil and water conservation activities was spent through VPs.

Sustainability of SHGs and FIGs will largely depend on the economic returns in the long run. At this stage, only 10 SHGs for pine briquetting have entered the market. This activity will need further outside support, especially from the Forest Department.

Conclusion

Community participation in project planning and implementation had been emphasized in UDWDP and continued in SLEM. This was done through a network of women workers - motivators at RV level and facilitators at the higher level - by extensive village visits and regular monthly meetings of women involved in various institutions. Most SHGs have relatively higher representation of women Monthly subscription by members and inter loaning had been ensured during UDWDP which made most SHGs financially strong and independent, enabling women to influence family decisions. SLEM project gave the successful SHGs entrepreneurial support for livelihood activities to strengthen them.

Group Discussions at several villages revealed instances of women resuming studies or taking up entrepreneurial activities on getting involved with SHG activities. Several motivators and SHG members have successfully contested local elections, and were seen to be carrying out their responsibilities with distinction. Women remain the backbone of hill economy, and their financial independence had been significantly enhanced on account of successful operation of women-dominated community-based institutions.

8. Economic Analysis

Introduction

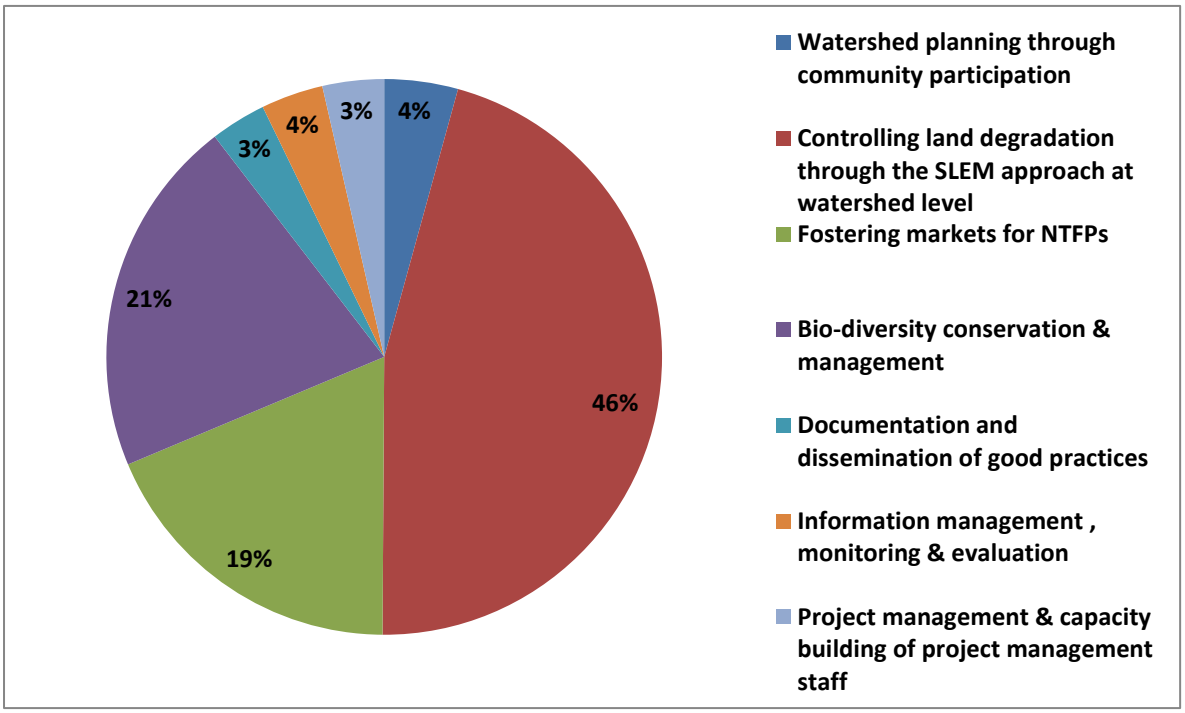
This chapter presents an economic analysis of the additional GEF financing of USD 7.49 million in the state of Uttarakhand that aims at scaling up and mainstreaming the outcome of the UDWDP. The economic return on investments under UDWDP was estimated at 16.9% (PAD 2009). The return in case of GEF-SLEM is expected to be lower as the interventions have been carried out in eroded areas and in areas adjoining agricultural areas. The benefits of the SLEM project would be relatively indirect, unlike in case of UDWDP where direct returns in terms of enhanced agricultural and livestock production; and enhanced incomes from IGAs were seen. It is likely that many of the benefits from GEF would not be amenable to direct monetization. Use of indirect methods for capturing the benefits lead to higher uncertainty, and it is a common practice to use estimates at the conservative end to make results comparable across projects. For example, while computing economic benefits from plantations, the ecosystem services provided by plantations have been ignored due to limitations of time and resources, though they constitute an important benefit of the project.

However, it is to be noted that indirect methods often take a wider view of benefits, since natural resource management projects are expected to generate benefits across a community of beneficiaries who cannot be individually distinguished from the point of view of analysis. Indeed this approach has been used in the present case, as a direct comparison of the project IRR is of limited significance. Rather a simplified benefit-cost analysis has been carried out to reflect the returns of the various project interventions. These have been aggregated based on the relative importance of the activities in terms of financial outlays.

Analysis of Costs

The cumulative financial achievement (till March 2013) has been Rs. 3,409.37 lakhs[15]. As Figure 17 below shows, the highest expenditure in this project has been done for controlling land degradation through soil and water conservation structures (46%), followed by biodiversity conservation and management (21%) and fostering markets for NTFPs (19%). The rest of the expenditure (15%) was largely in the nature of indirect costs and covers watershed planning through community participation, documentation and dissemination of good practices; information management, monitoring and evaluation; project management and capacity building of project staff.

[15]WMD.(2013). Financial Progress Report. Dehradun: Watershed Management Directorate, Uttarakhand.



Source: WMD .

Figure 19 Percentage share of various GEF-SLEM interventions in the total project outlay

Table 40 provides a summary of expenditure in the sampled GPs (Source: Deputy Project Directors). The expenditures in the three main direct cost heads match the overall cost distribution in the project, denoting a fairly even spread of the sample in terms of costs incurred. The spending in the sampled villages is approximately one fourth of the total spending in all project GPs on these heads, which matches reasonably well with the sampling intensity of 20% in terms of GPs selected for this assessment.

Table 40 Expenditure on GEF-SLEM interventions for sampled GPs

SLEM Interventions	Amount (in Rs. lakhs)
(A) Controlling land degradation through SLEM approach at watershed level	
Plantations	63.46
Oak ANR	5.19
Forest Fire Management	0.09
Soil Conservation Measures	288.49

SLEM Interventions	Amount (in Rs. lakhs)
Roof water harvesting tank	5.01
Irrigation tank	2.02
Village pond	46.34
Tal/naula/khaula rejuvenation	16.88
Total cost for (A)	**427.47**
(B) Biodiversity conservation and management	
Medicinal and Aromatic Plants Demo	68.67
Medicinal and Aromatic Plants Nursery	11.03
Polyhouse Demo	44.38
SHGs	32.61
Total cost for (B)	**156.69**
(C) Fostering markets for NTFPs	
Pine briquette moulding machine	28.23
Briquette stove demonstration	19.13
Solar lantern	28.88
Bio Gas	5.45
Solar Cooker	1.02
Solar street light	35.55
Marketing support	25.86
Total cost of (C)	144.12
TOTAL COST FOR ACTIVITIES (in sampled GPs) [(A)+(B)+(C)]	**728.28**

Source. WMD

Analysis of Benefits

Overall approach for the analysis of benefits under the SLEM project is based on the standard benefit-cost analysis techniques wherein benefit-cost streams are constructed for each activity head in the project. The analysis is presented in the most disaggregated manner possible; with benefits described activity wise. In case of soil conservation activities, the impact has been clubbed together for various kinds of soil conservation structures because the impacts of each structure are captured at the village level. It is assumed that benefits would sustain over a 10 year period and hence, the benefits estimated at the end of the project are extended to this period. In case of plantation activities, the benefits are captured over a period of 30 years corresponding to the rotation period of the dominant species, as per standard forestry practice. However for the sake of consistency, it has been assumed that these benefits accrue at the 10thyear; that is an equivalent benefit figure for the 10th year has been used. In all these cases the benefits are expected to be realized, at the collective level by the communities, and hence significant enhancements of direct incomes is not expected (or is difficult to attribute to the project), except in the case of livelihood support activities (through SHGs).

Component wise benefits

In this section, benefit-cost analysis is presented for the interventions related to the activity heads 'controlling land degradation through SLEM approach at watershed level; 'promoting biodiversity conservation and management'; and 'fostering markets for NTFPs'. The benefit-cost calculations in the following section have been made taking a discount rate of 6%. For the purpose of the analysis; all the unit costs for activity/interventions are based on schedule of rates of Watershed Management Directorate (WMD).

Controlling land degradation through the SLEM approach at watershed level

Roof Water Harvesting Tank (RWHT)

The benefit for roof water harvesting tanks is computed in terms of time saved in obtaining water from a relatively far off-water source. In our sample, an average household spends 0.7 hr/day to collect water in a dry season (based on primary survey). Assuming that water from a RWHT is used for 180 days/year, total time saved per household is 126 hours in a year (0.7 hr/day X 180 days/yr). Assuming a daily wage rate of Rs. 142 and an 8 hour day[16], the monetary value of time saved works out to be Rs. 2,236/yr for a household (this will add to the benefit arising from a single unit of RWHT). There are in total 125 RWHTs[17] constructed under as a part of SLEM interventions; and therefore for 125 beneficiary households of RWHTs, the total benefit on this account is Rs. 2,79,562/ yr.

Our field level estimates that these structures also have an additional irrigation potential of 1.25 ha (potential of 0.01 ha/structure); and the water from these RWHTs is typically for the purpose of kitchen gardening. Now to calculate the additional benefit to the beneficiary households, we assume a return of Rs. 20,000/ha from traditional agriculture without using RWHT; and a return of Rs 60,000/ha from vegetable cultivation using RWHT water in a year. The incremental benefit from RWHT works out to Rs. 40,000/ha/yr. As the total

[16]As per the wage rate stated for Uttarakhand in: MoRD.(2013, Januray). Gazette of India: News Bulletin. Ministryof Rural Development (MoRD), Government of India (GoI).
[17]WMD.(2013). Physical Progress Report. Dehradun: Watershed Managment Directorate, Uttarakhand.

irrigation potential is taken to be 1.25 ha, additional irrigation potential of all 125 RWHTs is calculated to be Rs. 50,000 (1.25 ha X Rs. 40,000/ha).

Adding the benefit in terms of monetary value of time saved and the additional irrigation benefits arising out of RWHTs, we get the total benefit from all RWHTs is Rs. 3,29,562/yr. The benefit-cost calculations are provided below:

Table 41 Benefit Cost Calculations for Roof Water Harvesting Tank (RWHT)

Benefit/yr	Rs. 3,29,562
Undiscounted benefit (10 years)	Rs. 32,95,620
Discounted benefit (10 years)	Rs. 25,71,145
Cost	Rs. 19,12,500
Benefit Cost Ratio	1.34

Village Pond

Village ponds constructed as a part of SLEM interventions have a capacity of 100 cum of water per structure. 314 such village pond structures were constructed under the project[18], with total water holding capacity of 31,400 cum. for all the structures. Considering there is a 25% evaporation loss, 23,550 cum. of water is available for groundwater recharge fillings. Now considering a 50% loss of this available water due to percolation, the final water available to augment the spring source is 11,775 cum. or 1,17,75,000 litre.
We have assumed that the average water requirement is 200 litre per household per year (based on field observations, a lower end value); and hence it is estimated that the spring water source could serve 58,875 households in a year. Benefits arising from village ponds have been calculated in terms of opportunity cost of collecting water from a relatively far off water source.

The primary survey reveals that an average household spends 0.7 hr/day to collect water in a dry season (primary survey). Considering a dry season is of 120 days, a total of 49,45,500 hours are saved across all households in a year. A daily wage rate of Rs 142 for an 8 hour day has been used for the analysis and considering that each household uses about one-fourth of the time saved for productive activities; the opportunity cost of time saved is Rs.2,19,45,656 for all beneficiary households.

The benefit-cost calculation for the village pond intervention of the GEF-SLEM project is provided below:

[18]WMD.(2013). Physical Progress Report. Dehradun: Watershed Managment Directorate, Uttarakhand.

Table 42 Benefit Cost Calculations for Village Pond

Benefit/yr	Rs. 2,19,45,656
Undiscounted benefit (10 years)	Rs. 21,94,56,560
Discounted benefit (10 years)	Rs. 17,12,13,257
Cost	Rs. 3,64,24,000
Benefit Cost Ratio	4.70

Irrigation tank with Delivery system

The irrigation tanks constructed as a part of SLEM are of the dimension 4m X 2.5m X 1.5m[19]; thus each tank has a volume of 15 cum. As per field observations, the irrigation potential of each structure is approximately 1.2 ha of land. There are in total 15 such structures[20], and thus the total irrigation potential is calculated to be 18 hectares of land. Benefit obtained from irrigation tanks has been calculated taking the difference between incomes generated in two scenarios – one, where cultivation is carried out without using the irrigation tank and the second, where water from irrigation tank is used for cultivation. Agricultural land not using water from irrigation tanks gives a return of Rs. 16,250 per ha of land (assumed on basis on field survey), whereas land on being irrigated using irrigation tank gives a benefit of Rs. 31,000 per ha of land (assumed on basis on field survey observations). Therefore, the additional benefit realized is Rs. 14,750 per ha of land. Since the total irrigation potential has been calculated to be 18 ha, this implies a total additional benefit of Rs. 2,65,500 for all the irrigation tanks in the project. The benefit-cost calculations are provided below:

Table 43 Benefit Cost Calculations for Irrigation Tank with Delivery System

Benefit/yr	Rs. 2,65,500
Undiscounted benefit (10 years)	Rs. 2,65,5000
Discounted benefit (10 years)	Rs. 20,71,350
Cost	Rs. 10,05,000
Benefit Cost Ratio	2.06

Plantations

The economic analysis for plantation activities is based on estimation of the benefit stream for timber and fuelwood over a 30 year period. Unlike other activities where benefits are calculated over a 10 year time horizon, plantation benefits are computed over this longer time horizon to correspond with the rotation cycle of the dominant species. It is assumed

[19] This is based on measurements and observations made during field surveys.
[20] WMD.(2013). Physical Progress Report. Dehradun: Watershed Management Directorate, Uttarakhand.

that timber will be harvested in the 30th year while fuelwood will be harvested in the 10th year in the first instance and subsequently, every fifth year.

The computation of harvestable timber in the 30th year is based on the number of standing individuals at the time of survey and the estimated number of years for each of them to reach exploitable diameter, using a Mean Annual Increment (MAI) of 2.5 t /ha. It is assumed that survival rate at maturity is 75%.Benefits are based on current round wood and fuelwood prices, while costs are based on a aggregation of plantation costs, maintenance costs for the first five years, and harvesting costs for timber and fuelwood in the respective years. The benefit-cost calculations are stated below:

Table 44 Benefit Cost Calculations for Plantations

Discounted Benefit (30 years)	Rs. 4,83,618
Discounted Cost (30 years)	Rs. 1,30,224
Benefit Cost Ratio	3.71

It is to be noted that plantations produce a range of environmental benefit, which if taken into account, would lead to a much higher estimate of the benefit-cost ratio. However, monetization of such benefit would need the application of indirect methods which are beyond the scope of this assignment. It can safely be concluded that the result derived here is a highly conservative estimate of the benefit of plantations. For the sake of consistency, in the overall calculations, the plantation benefit is assumed to have accrued in the 10^{th}year; that is the BCR has been projected back into the 10^{th} year.

Box 5

Ecosystem Services of Forests

The ecosystem services of forests have been notionally recognised for long; but their economic valuation is of recent origin. Costanza (1997) estimated that the value of 17 ecosystem services is about USD 33 trillion/ yr, double the value of the global GDP. However, such estimates normally do not enter mainstream economic accounting processes, leading to an under-valuation of the importance of ecosystem services. The key ecosystem services specially in the context of mountainous areas are downstream hydrological benefits, soil conservation benefits, recreational and aesthetic benefits, and reduction of the impacts of disasters. Many attempts have been made to value these in monetary terms, but the results vary on account of methodologies used and the specificities of the study locations. Madhu Verma (2002) has estimated the total value of the flow of goods and services from forests of Himachal Pradesh as Rs 7.43 lakh /ha/yr. About 70% of this value is attributed to watershed services, and only 1% to tangible forest goods. The rest is attributed to other ecosystem services like biodiversity, carbon sequestration, micro-climate, and recreational benefits. Many other studies in the context of mountainous states provide estimates on similar lines, though the actual values may vary. It can be safely concluded however that when valued in economic terms, the overwhelming share of values of forests are contributed by ecosystem services rather by the tangibles (that is forest goods like timber and fuelwood). The Supreme Court appointed committee on NPV (Kanchan Chopra Committee), the Central Empowered Committee and the 13th Finance Commission recommendations also recognise the importance of the ecosystem services of forests, indicating that valuation exercises now find reflection in decision-making processes. In the present assessment, only the flow of forest goods have been accounted for (due to limitations of time and resources), and these therefore represent a partial valuation attempt.

Soil conservation structures

The economic analysis for soil conservation measures is based on the areas impacted by various types of structures and the net economic return from these areas. In case of irrigated and barren land, this is based on the most plausible cropping pattern / use pattern based on field survey, and for forest land, this is based on per hectare values based on estimated plantation returns. An average net return (incremental) of Rs 5,000/ yr is assumed for irrigated agriculture and an average net return of Rs 1,000/ yr is assumed for barren land (grazing/grass production). In case of plantations, an estimated annual value (based on net return over a 30 year cycle is used) for simplicity.

The types of structures considered for the analysis include; vegetative checkdam, drystone checkdam, cratewire checkdams, cratewire spurs, contour bunds and trenches, retaining wall/ cross barrier, diversion drain, landslide treatment and roadside erosion control. The data for areas impacted is based on village level surveys, and the returns (as mentioned above) are based on average values for the entire sample. Costs are based on financial statements at the division level. The benefit-cost calculations are stated below:

Table 45 Benefit Cost Calculations for Soil Conservation Structures

Benefit/yr	Rs. 2,05,91,000
Undiscounted benefit (10 years)	Rs. 20,59,10,000
Discounted benefit (10 years)	Rs. 10,60,19,194
Discounted cost (10 years)	Rs. 2,88,49,023
Benefit Cost Ratio	3.67

Fostering markets for NTFPs

Pine Briquette Model Demonstration and Pine Briquette Stove

In the analysis, the benefit from pine briquette machines (PBM) and pine briquette stoves (PBS) has been calculated together. Single unit of PBM produces 150 kg of pine briquettes per day and since pine needles (used for processing in the PBM) are collected for 120 days in a year; it is assumed that the activity of PBM is also operational for 120 days in a year. Thus the yearly production of a PBM is calculated to be 18,000 kgs. These pine briquettes are sold Rs. 15 per kg and thus the yearly income generated from 1 PBM is Rs. 2,70,000 (18,000 kgs X Rs. 15/kg). As a part of the SLEM interventions, there are 203 such PBM units distributed and set up; thus the income earned from the whole activity of PBM (considering 203 units) is calculated to be Rs. 5,48,10,000.

Benefits from PBS are calculated in terms of money saved from expenditure on fuelwood. Field observations reveal that households using PBS have been able to save upto 10 kg of fuelwood per day. As noted earlier, pine needles are collected for 120 days in a year and thus PBS is also assumed to be operational for 120 days. Thus, the yearly savings in fuelwood is 1,200 kg. The market price of fuelwood is Rs 5/kg; and therefore the annual household savings arising from a single unit of PBS is Rs. 6,000. Under SLEM, in total 5,044 such PBS has been distributed across different villages. Thus, the benefit arising from all units of PBS comes out to be Rs. 3,02,64,000. Summing up the benefits arising from total units of PBM and PBS, the benefit amounts to be Rs. 8,50,74,000. The benefit-cost calculation for the PBM and PBS under the GEF-SLEM project is summarized below:

Table 46 Benefit Cost Calculations for Pine Briquette Model Demonstration and Pine Briquette Stove

Benefit/yr	Rs. 8,50,74,000
Undiscounted benefit (10 years)	Rs. 85,07,40,000
Discounted benefit (10 years)	Rs. 6,63,72,1169
Undiscounted cost (10 years)*	Rs. 26,26,37,748
Discounted cost (10 years)*	Rs. 21,12,29,003
Benefit Cost Ratio	3.14

*Includes a variable cost of Rs. 1,15,200 per unit of PBM.

Miscellaneous innovative activities for promotion of non-conventional energy use

Solar lantern

Benefit arising from a single unit of solar lantern is calculated in terms of money saved in lighting a bulb of 40 watt for 4 hours in a day. This implies that the benefit from 1 unit of solar lantern is the savings of 160 Wh of electricity per day (consumed in lighting 1 bulb). It has been observed that a solar lantern is being used for 11 months (or 330 days) in a year; thus a single unit of solar lantern helps in savings of 52,800 Wh or 52.8 kWh. The price of electricity is Rs. 4 per unit, and thus the monetary benefits arising out a single unit of solar lantern is Rs. 211.

Here, we assume that use of single unit of solar lantern helps in increasing the productivity of 1 hour each day for each household beneficiary for 100 days. The monetary value of the increased productivity from a single unit of solar lantern is estimated at Rs 1,775. This implies benefit arising from 1 unit of solar lantern is calculated to be Rs. 2125.

Under the SLEM interventions, a total of 3,120 solar lanterns[21] have been distributed. Hence, the total savings or benefits from all the solar lanterns are calculated to be Rs. 66,31,248. The benefit-cost calculation is provided below:

Table 47 Benefit Cost Calculations for Solar Lantern

Benefit/yr	Rs. 66,31,248
Undiscounted benefit (10 years)	Rs. 6,63,12,480
Discounted benefit (10 years)	Rs. 5,17,34,956
Undiscounted cost (10 years)*	Rs. 1,54,12,800
Discounted cost (10 years)*	Rs. 1,43,15,405
Benefit Cost Ratio	3.61

*** Includes maintenance cost of Rs. 160 per year per unit of solar lantern**

Biogas plant

The benefit from a biogas plant is calculated in terms of money saved previously spent on fuelwood usage and the benefit arising from savings from electricity consumed to light a bulb from the biogas plant. Field observations reveal that a household of 5 members saves 10 kg of fuelwood per day with the usage of biogas plant. Assuming that a biogas plant is successfully operated for 240 days in a year, the annual savings of fuelwood per household comes out to be 2,400 kgs. The market price of fuelwood is Rs 5/kg; thus the annual money savings from fuelwoood expenditure for a household is calculated to be Rs. 12,000.
Also, the bio gas being produced is used by households to light a bulb of 40 watts for 4 hours every day. This implies that there are per day savings of 160 kWh of electricity or annual savings of 38,400 Wh (or 38.4 kWh or 38.4 units) of electricity by each household; with the assumption that a biogas plant is operational for 240 days in a year. Thus, the annual monetary savings in terms of electricity savings incurred with the use of biogas plant

[21]WMD.(2013). Physical Progress Report. Dehradun: Watershed Management Directorate, Uttarakhand.

is calculated to be Rs. 153.6 for each unit of biogas plant.

Now, summing the fuelwood savings and electricity savings, the benefit from single unit of biogas plant is estimated to be Rs. 12,154. Under the project, there are a total of 61 such units of biogas plant installed and hence, the total benefit for all units of biogas plants is computed to be Rs. 7,41,370. The benefit-cost calculation for the overall activity of biogas is stated below:

Table 48 Benefit Cost Calculation for Biogas Plant

Benefit/yr	Rs. 7,41,370
Undiscounted benefit (10 years)	Rs.74,13,700
Discounted benefit (10 years)	Rs. 57,83,938
Discounted Cost (10 years)	Rs. 16,89,700
Benefit Cost Ratio	3.42

Solar Street Light

The benefit of a solar street light is calculated in terms of money saved from electricity consumption, using a conventional source of lighting. Prior to using the solar street light, a bulb of 100 watts was used to light for 8 hours using the grid supply of electricity. Hence, a single unit installed of a solar street light helps in saving electricity consumption of 800 Wh per day. Assuming that a solar street light is successfully operated for 11 months in a year or 330 days in year, a single unit of solar street light leads to savings of 2,64,000 Wh (264 KWh or 264 units) of electricity annually. Thus, yearly savings from use single unit of solar street light is Rs. 1,056; electricity costing Rs 4/unit.

There are a total of 165 units of solar street lights installed[22], and thus the monetary benefits for all the units is calculated to be Rs. 1,74,240. The benefit-cost calculation for the overall intervention of solar street light under the GEF-SLEM project is stated below:

Table 49 Benefit Cost Calculations for Solar Street Light

Benefit/yr	Rs. 1,74,240
Undiscounted benefit (10 years)	Rs. 17,42,400
Discounted benefit (10 years)	Rs. 13,59,367
Undiscounted cost (10 years)*	Rs. 76,64,910
Discounted cost (10 years)*	Rs. 69,39,468
Benefit Cost Ratio	0.20

*** Includes maintenance cost of Rs 2,000 per year per unit**

[22]WMD.(2013). Physical Progress Report. Dehradun: Watershed Management Directorate, Uttarakhand.

The villagers also perceive several benefits with the installation of solar street lights; these include increased access to the markets as the roads remain better lit after the installation of solar street lights. The units which have been installed near the community grounds have helped the villagers to organize several cultural programmes and conduct *panchayat* meetings. These benefits cannot be monetized and hence, the relatively low BCR in this case is only a partial estimate of the economic returns from this activity.

Solar cooker

Benefits from solar cooker are calculated in terms of fuel savings as a result of less usage of fuelwood with the availability of solar cooker. While using solar cooker, a household of 5 members saves about 5 kg of fuelwood every day. Field observations reveal that solar cooker is used for approximately 240 days in a year. This implies that a household saves 1,200 kgs of fuelwood each year, leading to annual monetary savings of Rs. 6,000 (as fuelwood is obtained at the rate of Rs.5/kg). Under SLEM, 89 such units have been distributed; thus the benefits for all units of solar cooker amount to Rs. 5,34,000. The benefit-cost calculation for the overall activity of solar cookers under the GEF-SLEM project is shown below:

Table 50 Benefit Cost Calculations for Solar Cooker

Benefit/yr	Rs. 5,34,000
Undiscounted benefit (10 years)	Rs.53,40,000
Discounted benefit (10 years)	Rs. 41,66,104
Cost	Rs. 3,33,305
Benefit Cost Ratio	12.50

Majority of solar cookers have been distributed amongst the old and handicapped people across the villages and the solar cookers are considered to have long-term benefits with zero maintenance cost.

Bio-diversity conservation & management through watershed planning & community participation

Medicinal and Aromatic Plants Demonstration & Nursery Demonstration and Nursery

The estimated return on a per hectare basis has been calculated based on field observations. For overall computation, weighted average of the BCRs has been taken, and 50% survival rate has been assumed.

Table 51 Benefit Cost Calculations for Medicinal and Aromatic Plants Nursery

Name of species	Discounted Benefit (per ha) (10 years)	Discounted Cost (per ha) (10 years)	Benefit Cost Ratio
Aloe Vera	1,68,876	35,424	4.77
Tejpata (*Cinnamomum tamala)*	3,69,694	2,29,311	1.61
Brahmi (*Bacopa monnieri)*	3,41,324	1,96,867	1.73
Lemon grass (*Cymbopogan flexuosus)*	5,31,568	1,36,004	3.91
Bach (*Quercusleucotrichophora*)	21,06,457	11,32,306	1.86
Ginger (*Zingiber officinale)*	18,72,406	8,19,178	2.29
Turmeric (*Curcuma longa)*	11,70,254	6,78,747	1.72

Source: TERI

Under SLEM, a total of 17 units of nursery have been set up and the average sale price is Rs 10 per plant and with 10,000 plants per nursery, the total benefit is estimated at Rs 17,00,000. The cost incurred for setting up 17 units of nursery demonstrations is Rs 30,60,000 thus the BCR for the nursery demonstration is calculated to be 0.55.

Demonstration of polyhouse

The polyhouses constructed under SLEM are of two dimensions: 25m X 15m and 60m X 20m. Benefit arising out of polyhouse activity has been calculated taking an average mix of vegetables (cabbage, cauliflower, tomato and capsicum). The benefit-cost calculations for a single unit of polyhouse of both sizes are shown below:

Table 52 Benefit Cost Calculations for Polyhouse (for a single unit)

Type of polyhouse	Discounted Benefit (10 years)	Discounted Cost (10 years)	Benefit Cost Ratio
Type 1 (25m X 15m)	Rs. 1,95,042	Rs. 38,736	5.04
Type 2 (60m X 20m)	Rs. 5,85,127	Rs. 1,43,736	4.07

In total there have been a total of 237 polyhouses constructed under GEF-SLEM; out of which 178 have been of Type 1 and 59 for Type 2. The overall benefit cost ratio for the polyhouse activity works out to 4.79.

Capacity building of SHGs

A total of 20 SHG activities have been reported in the sampled GPs. As mentioned earlier, not all of them have reported an income at the time of survey. Some activities started rather late in the project, and are expected to yield a return in the near future. Taking into account the amount of project support to these activities and the benefit accrued at the time of survey, the BCR for this activity is estimated at 2.86.

Table 53 Benefit Cost Calculations for SHGs

Discounted Benefit (10 years)	Rs. 89,15,626
Discounted Cost (10 years)	Rs. 31,12,000
Benefit Cost Ratio	2.86

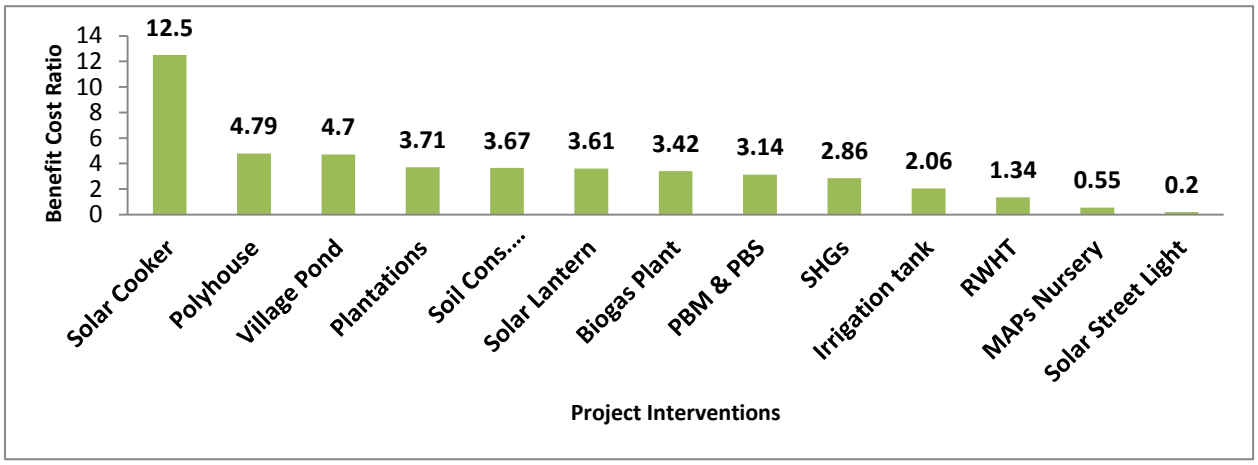


Figure 20 Compartive Benefit Cost Ratio of Project Interventions

Aggregated analysis

The previous section has presented disaggregated benefit-cost analysis for SLEM activities, to the extent feasible. The benefit and cost streams have been pooled to the project level, using the unit costs for each activity, and proportion of the costs for each sub-activity within budget heads in the sampled GPs.

The results have been reported in terms of BCR and NPV.

The following table provides sensitivity analysis for Benefit Cost Ratio

Table 54 Sensitivity Analysis for Benefit-Cost Ratio

Years	Discount Rate		
	4%	6%	8%
5	2.56	2.44	2.38
10	3.29	3.14	3.04

The following table provides a sensitivity analysis for NPV.

Table 55 Sensitivity Analysis for NPV

Years	Discount Rate		
	4%	6%	8%
5	78,82,19,322	71,60,38,960	67,40,70,628
10	1,63,68,07,572	1,45,99,97,127	1,32,83,66,381

Conclusion

Based on overall analysis, the project returns a benefit-cost ratio in the range 3.29 to 2.38. The ratio has to be, however, interpreted with some caution as the analysis is subject to several limitations (on account of time/resource constraints, and the very nature of the project). These include:

- Use of indirect measures to assess benefits in many cases where the output is not a marketed product. For example, time saved to fetch water is used as a proxy for the benefits of water conservation structures, and the time is valued at the opportunity cost of productive labour.
- Only tangible benefits of forestry activities are computed, while it is an established fact that forestry activities produce a large range of ecosystem services that are economically important. The monetisation of these benefits needs studies involving considerable additional resources.
- The benefits of solar lights have been captured partially as it is not possible to monetize full benefits of interventions of this nature. Several benefits of this and similar activities have been described qualitatively elsewhere in this report.

The overall analysis reveals that the project returns a favorable BCR under all considered scenarios. It is possible that some benefits will be realized beyond the 10 year horizon, or may be realised over shorter time periods, but this is subject to performance of the project interventions. Plantation benefits will be fully realised beyond the 10 year horizon, but for the sake of consistency, these have been pegged at the 10 year point.

Finally, it may be noted that the project of this nature is expected to have several multiplier impacts, which could magnify the benefit-cost ratio; these have not been explicitly analysed. Hence, it would be fair to say that the analysis here uses a conservative scenario, and the results should be considered indicative rather than conclusive.

9. Recommendations

- Reserve Forest land or the inter GP area was taken up under SLEM participatory mechanism to carry out soil and water conservation activities. The implementing agency was Van Panchayat or Gram Panchayat. It was a progressive step forward. Despite hitch at lower levels in Forest Department the activities could be successfully completed in most Divisions. This needs to be carried forward in all future projects of integrated watershed development.
- For measuring the impacts of SLEM activities in augmenting water discharge in springs and streams, a system of hydrological monitoring at the field level is recommended. This could be done in some selected springs and streams all over the state.
- Natural calamities like cloudbursts, incessant rains and draughts are common features of hills in Uttarakhand. It is highly desirable that a historical record of these is maintained at the project level so that field activities are better planned.
- Considering the scale and spread of soil and water conservation activities in different MWSs undertaken under SLEM project, technical inputs during planning and execution will make the approach and impacts more affective.
- The afforestation component needs to be strengthened as this is among the cheapest methods of holding soils in place while at the same time resulting in growth of vegetative biomass. Involvement of local institutions like SHGs during implementation and maintenance phase will be more helpful.
- Switching over to alternative fuels like pine briquettes, biogas and solar cookers is a positive step, but their scale has to be enhanced. Pine briquetting can become a major livelihood activity with an efficient marketing system. Hence, to enhance the impact of the technology on livelihoods and also on the forests (in terms of reduced fire hazards), the marketing system should be attractive enough for people to get involved in the making pine briquettes in larger quantities.
- The animal husbandry programme conducted during UDWDP, under which improvement of breed and stall feeding was stressed, has been helpful in successful implementation of biogas programme under SLEM. Similar approach should be continued where biogas technology is implemented with the support for livestock management and fodder development programmes.
- There is ample opportunity to harness solar energy by using solar water heaters as hot water is a permanent requirement in the hills. There could be possibilities of developing enterprise based models, where solar lanterns are rented out and the solar based charging stations are operated by small entrepreneurs.
- In Uttarakhand, as per local perception, pine is becoming locally invasive species. The existence of a pine needle carpet inhibits the regeneration of species other than pine. Hence, the areas where pine needles are being removed need to be monitored for the changes in the regeneration of vegetation with respect to the species other than pine. The villages involved in making pine briquettes could be also monitored for fire evidences especially the areas from where the pine needles are collected.

- The State Medicinal Plant Board (SMPB) is an umbrella body for cultivation of medicinal plants in the State. Convergence with this body with regard to MAP interventions is highly desirable.
- Participatory approach to prevent fire in the forest areas was an appropriate step under SELM. The decreasing interest of communities in preventing and fighting forest fires is a cause of worry and is the main reason for degradation of forest. It is only through involvement of communities that forest fires can be controlled.

10. Conclusion

The Project Development Objective (PDO) of SLEM is "to restore and maintain ecosystem functions and biodiversity while simultaneously enhancing income and livelihood functions, and generating lessons learned in these respects that can be upscaled and mainstreamed at state and national levels"

A community-based participatory approach to watershed planning is a key feature of the project. Participatory planning processes was already in vogue under UDWDP, and the microplanning process under SLEM benefitted significantly from the capacities built in the previous phase. The inclusion of inter GP areas has been an important feature of the project, and van panchayats were designated implementing bodies for activities in these areas.

Our study shows that about 21% of the eligible area under the selected MWSs has been brought under SLEM techniques using this approach. About 97 ha of land in the sampled GPs have been saved from degradation and about 14 ha of additional land have been brought under irrigation. There also has been a reduction in the time taken for fetching water for domestic uses, and a reduction in fuelwood dependence from forests due to promotion of alternative sources of energy.

The report has attempted to address the results framework, and estimate impacts corresponding to various components. The following paragraphs address some of the cross-cutting issues, as required by the ToR.

- Project impacts on management of natural resources, livelihoods/ incomes and empowerment have been discussed in various sections. A 7% increase in household incomes in real terms has been reported. Areas saved from degradation or brought under cultivation have been estimated and reported. There has been significant involvement of women in community-based organizations such as SHGs.
- The use of a truly participatory approach from the planning to the implementation stage has been a hallmark of the project. Technological approaches for water and soil conservation have also been successful, and have been coupled with more conventional approaches in terms of forestry interventions. Reduction of fuelwood dependence on forests has been a major impact, largely on account of promotion of alternative energy sources such as pine briquettes, biogas and solar cookers.. The revival of traditional *gharats* has also been a major success and has yielded high economic return. MAP demonstration has yielded mixed results, and greater convergence with activities of the State Medicinal Plants Board would have been desirable.
- The SLEM project has actively addressed equity issues. Soil / water conservation works have benefitted all categories of land owners, and has also enhanced access to water. IGAs have been dominated by women in several cases, and group activities like pine briquetting, sewing/knitting/tailoring and food processing have typically been women's preserve. *Gharat* renovation has been a men's activity; however the beneficiaries belonged to weaker sections of society, including many landless households. There has been significant employment generation at the local level, especially for implementation of activities on government land / common property land. This has benefitted socially backward groups, and the landless. The main poverty impact, indeed, has been through wage employment generation. It is estimated that approximately 2 lakh man-days of employment has been created in

the sampled villages – with an engagement of 80 persons per month per village on an average at a wage rate of Rs 250/day.

- In the hills the common property resources play a paramount role in the subsistence of the households, productivity of agriculture/ livestock and provision of several ecosystems services. In SLEM, inter GP areas have been treated for soil conservation, and RF/VP land associated with GPs have also been included. Plantations and ANR have been implemented on Civil Soyam lands, Van Panchayat lands and Reserve Forests. The main activities implemented on private lands have been irrigation tanks, Roof Water Harvesting structures, demonstration of medicinal plant cultivation and poly houses. The activities which have been partly done on private lands are landslip treatment, roadside erosion control and river bank protection. The benefits of the activities have been diffuse due to the very nature of the activity, and the topographical location of land. In typical DLT and soil conservation work, the increased water is available for everyone who could access, but the benefit of enhanced soil moisture is restricted to the lands on the banks of the streams.
- The capacities of Gram Panchayats were strengthened during UDWDP by providing them financial autonomy, and the services of account assistants and motivators. At the same time various institutions were constituted such as WWC, RVC, FIG. SHG, User Group and Federations. These local institutions were broad based representing all the socio-economic strata and/or specific stakeholders. In SLEM all the institutional mechanisms formed during UDWDP were continued. Plans were prepared for each of the 20 MWS, utilizing the PRA exercise conducted during UDWDP, buttressed by further consultations, For RF areas, Forest Department was consulted for the respective activities. In addition all the successful SHGs were provided entrepreneurial support in the project along with formation of new SHGs and FIGs wherever required. The existing Van Panchayats were made implementing agencies for works in RF. In the absence of VP, the GP was authorized to implement work in RF areas. These mechanisms have collectively enhanced the quality of participatory processes.
- Adequate care was taken to ensure that natural systems were not disturbed due to project interventions. For soil conservation works, the use of earth moving equipment was avoided.
- Innovative technological interventions and introduction of alternative energy sources have impacted the project areas positively. The alternative energy sources such as pine briquettes, Bio gas and solar cookers are finding a high level of acceptance. Promotion of pine briquetting as a women dominant SHG activity is serving the additional purpose of women empowerment. Enhancement of market penetration of briquettes could further increase the economic returns, which are modest at this stage.
- Economic analysis at the aggregate level returns a Benefit-Cost ratio in the range of 2.38 to 3.29 (Low: r=8%; t=5yr, High: r=4%, t=10yr). As indirect methods are employed for estimation of several benefits, the values are to be taken as indicative, rather than conclusive.

References

The Energy and Resources Institute, 2012. **Final impact Evaluation of UDWDP.** Watershed Management Directorate, Indira Nagar Colony, Dehradun (Uttarakhand)

The Energy and Resources Institute, 2012**. GEF SLEM Baseline Survey.** Watershed Management Directorate, Indira Nagar Colony, Dehradun (Uttarakhand)

Global Environment facility (GEF) trust Fund (TF 094443). **Status Report, March 2013.** Watershed Management Directorate, Indira Nagar Colony, Dehradun (Uttarakhand)

Global Environment facility (GEF) trust Fund (TF 094443). **Status Report, February 2013.** Watershed Management Directorate, Indira Nagar Colony, Dehradun (Uttarakhand)

MoRD. (2013, Januray). Gazette of India: **News Bulletin**. Ministry of Rural Development(MoRD), Government of India (GoI).

WMD. (2013). ***Financial Report FY 2012-13***. Uttarakhand: Watershed ManagementDirectorate.

WMD. (2013). ***Physical Progress Report***. Dehradun: Watershed Management Directorate, Uttarakhand

Global Environment facility (GEF) trust Fund (TF 094443). **Sustainable land, water and biodiversity conservation and management for improved livelihoods in Uttarakhand watershed sector.** Watershed Management Directorate, Indira Nagar Forest Colony, Dehradun (Uttarakhand)

Mishra, R. 1968. **Ecology Work Book**. Oxford and IBH Publishing Company, New Delhi, 244pp.

Sarkar R. 2008. **Decentralized forest governance in central Himalayas: A re- evaluation of outcomes.** Economic and Political Weekly43: 54-61.

Forest Survey of India, 2011. **State of Forest report 2011.** Ministry of Environment and Forest, Government of India

List of Annexures

Annexure: 1 Details of afforestation activities in project sites

Name of Division (GP)	Area planted (ha)			Species Planted
	Reserve Forest	VP and Civil Soyam	Total	*Grewia, Bauhinia, Alnus, Oak, Ficus, Albizia, Toona* and others
Bageshwar	47	160	207	As above
Haldwani	108	109	217	As above
Augustmuni	48	183	231	As above
Chinyalisaur		175	175	As above
Total	203	627	830	

Annexure 2: Details of Assisted Natural Regeneration (ANR) of Oak

Name of Division (GP)	Reserve Forest (ha)	Other (ha)	Total (ha)
Haldwani	10	45	55
Augustmuni	33	27	60
Total	**43**	**72**	**115**

Annexure 3. GPS Coordinates of Sampled Plots

Bageshwar

Site 1 Gainar		Site 2 Baisani		Site 3 Harsilla		Site 4 Purkuni	
Plot-1	**Altitude:** 1170m	Plot-1	**Altitude:** 1346 m	Plot-1	**Altitude:** 1141 m	Plot-1	**Altitude:**1990 m
	GPS Location: N 29 94 299 E 079 87 264		**GPS Location:** N 29 97 038 E 079 74 811		**GPS Location:** N 29 91 284 E 079 80 797		**GPS Location:** N29 95 425 E 079 82 678
Plot-2	Altitude: 1170 m	Plot-2	**Altitude:1367 m**	Plot-2	**Altitude:** 1124 m	Plot-2	**Altitude:**2006 m
	GPS Location:N 29 94 299E 079 87 264		**GPS Location:** N 29 97 069 E079 74 793		**GPS Location:** N 29 91 229 E 079 80 750		**GPS Location:** N 29 95 594 E 079 82 668
Plot-3	**Altitude:** 1243m	Plot-3	**Altitude: 1377 m**	Plot-3	**Altitude**1128 **m**	Plot-3	**Altitude:** 2018m
	GPS Location: N 29 94 488 E 079 87 268		**GPS Location:** N 29 97121 E 079 74 766		**GPS Location:** N 29 91 177 E 079 80769		**GPS Location:** N 29 95 671 E 079 82 582
Plot-4	**Altitude**: 1264 m	Plot-4	**Altitude:** 1405 m	Plot-4	**Altitude:** 1117 m	Plot-4	**Altitude:** 2066**m**

Site 1 Gainar		Site 2 Baisani		Site 3 Harsilla		Site 4 Purkuni	
	GPS Location: N 29 94 496 E 079 87 317		**GPS Location:** N 29 07 082 E 079 74 846		**GPS Location:** N 29 91 137 E 079 80 848		**GPS Location:** N 29 95 688 E 079 82 731
Plot-5	**Altitude:** 1268 m	Plot-5	**Altitude:1436** m	Plot-5	**Altitude:** 1115 m	Plot-5	**Altitude:** 2062m
	GPS Location: N 29 94 411 E 079 87 362		**GPS Location:** N 29 97 103 E 079 74 864		**GPS Location:** N 29 91 092 E 079 80 904		**GPS Location:** N 29 95 602 E 079 82 749
Plot-6	**Altitude:** 1274 m	Plot-6	**Altitude:** 1427 m	Plot-6	**Altitude:** 1089 m	Plot-6	**Altitude:** 2072m
	GPS Location: N 29 94 516 E 079 87 377		**GPS Location:** N 29 97 083 E 079 74 917		**GPS Location:** N 29 91 106 E 079 80 954		**GPS Location:** N 29 95 535 E 079 82 774

Nainital

Site 1 Dholigaon		Site 2 Pajaina		Site 3 Bogora (Digoli)		Site 4 Kwaidal (ANR)		Site-5 Thali	
Plot-1	**Altitude:** 1519m	Plot-1	**Altitude:** 1705m	Plot-1	**Altitude:** 1416m	Plot-1	**Altitude:** 2198m	Plot-1	**Altitude:** 2067m
	GPS Location: N 29 36 243 E 079 85 772		**GPS Location:** N 29 36 559 E 079 86 501		**GPS Location:** N 29 36 442 E 079 88 314		**GPS Location:** N 29 37 068 E 079 69 756		**GPS Location:** N 29 42 554 E 079 75 652
Plot-2	**Altitude:** 1545m	Plot-2	**Altitude:** 1664m	Plot-2	**Altitude:** 1396m	Plot-2	**Altitude:** 2209m	Plot-2	**Altitude:** 2060m
	GPS Location: N 29 36 760 E 079 85 803		**GPS Location:** N 29 36 582 E 079 86 559		**GPS Location:** N 29 36 528 E 079 88 303		**N 29 37 063** E 079 69 711		**GPS Location:** N 29 42 553 E 079 75 552
Plot-3	**Altitude:** 1553	Plot-3	**Altitude:** 1654	Plot-3	**Altitude:** 1365m	Plot-3	**Altitude:**2238m	Plot-3	**Altitude:** 2061m
	GPS Location: N 29 36 308 E 079 85 774		**GPS Location:** N 29 36 654 E 079 86 609		**GPS Location:** N 29 36 621 E 079 88 309		**GPS Location:** N 29 36 949 E 079 69 724		**GPS Location:** N 29 42 605 E 079 75 478
						Plot 4	**Altitude:** 2228m		
							GPS Location: N 29 36 978 E 079 69 804		
						Plot 5	**Altitude:** 2223m		
							GPS Location:		

Site 1 Dholigaon	Site 2 Pajaina	Site 3 Bogora (Digoli)	Site 4 Kwaidal (ANR)		Site-5 Thali
				N 29 36 948 E 079 69 899	
			Plot 6	**Altitude:** 2189m	
				GPS Location:	
				N 29 36 968 E 079 69 040	
			Plot 7	**Altitude:** 2195m	
				GPS Location:	
				N 29 36 887 E 079 69 064	
			Plot 8	**Altitude:** 2191m	
				GPS Location:	
				N 29 37 206 E 079 69 057	
			Plot 9	**Altitude:** 2208m	
				GPS Location:	
				N 29 37 010 E 079 69 662	

Rudraprayag

Site 1 Agar		Site 2 Sari		Site 3 Ginwala		Site 4 Kontha	
Plot 1	**Altitude:** 2067m **GPS Location:** N 30 32 874 E 079 09 250	Plot 1	**Altitude:** 808m **GPS Location:** N 30 30 047 E 079 14 334	Plot 1	**Altitude:** 998m **GPS Location:** N 30 40 347E 079 05 636	Plot 1	**Altitude:** 1989m **GPS Location:** N 30 41 264 E 079 15 311
Plot 2	**Altitude:** 2053m **GPS Location:** N 30 32849 E 079 09 347	Plot 2	**Altitude:** 860m **GPS Location:** N 30 30 040 E 079 14 414	Plot 2	**Altitude:** 993 **GPS Location:** N 30 40 296 E 079 05 743	Plot 2	**Altitude:** 2024m **GPS Location:** N 30 41 267 E 079 15 456
Plot 3	**Altitude:** 2072m **GPS Location:** N 30 32 891 E 079 09 334	Plot 3	**Altitude:** 874m **GPS Location:** N 30 30 109 E 079 14 420	Plot 3	**Altitude:** 1006m **GPS Location:** N 30 40 292 E 079 05 846	Plot 3	**Altitude:** 1964m **GPS Location:** N 30 41 171 E 079 15 372

Tehri

Site 1 Loladi		Site 2 Indiyan		Site 3 Majkhet	
Plot 1	**Altitude:** 1388m	Plot 1	**Altitude:** 1602m	Plot 1	**Altitude:** 1430m
	GPS Location: N30 52 849 E 078 32 198		**GPS Location:** N 30 49 820 E 078 34 327		**GPS Location:** N 30 54 613 E 078 27 815
Plot 2	**Altitude:** 1366m	Plot 2	**Altitude:** 1560m	Plot 2	**Altitude:** 1450m
	GPS Location: N 30 52 842 E 078 32 234		**GPS Location:** N 30 49 888 E 078 34 354		**GPS Location:** N 30 54 587 E 078 27 779
Plot 3	**Altitude:** 1407m	Plot 3	**Altitude:** 1609m	Plot 3	**Altitude:** 1462m
	GPS Location: N 30 52 750 078 32 291		**GPS Location:** N 30 49 866 E 078 34 399		**GPS Location:** N 30 54 506 E 078 27 763
				Plot 4	**Altitude:** 1441m
					GPS Location: N 30 54 464 E 078 27 706
				Plot 5	**Altitude:** 1438m
					GPS Location: N 30 54 476 E 078 27 746
				Plot 6	**Altitude:** 1398m
					GPS Location: N 30 54 527 E 078 27 824

Annexure 4.Species recorded in sampled sites

Bageshwar

Species	Habit (Annual/Biennial/Perennial)
Gainar	
Pinus roxburghii	P
Quercus leucotrichophora	P
Syzygium cumini	P
Melia azedarach	P
Ficus roxburghii	P
Sapindus mukurossi	P
Toona ciliata	P
Morus alba	P
Grewia optiva	P
Rhamnus procumbens	P
Leptodermis lanceolata	P
Callicarpum macrophylla	P
Leucena leucocephala	P
Bombax ceiba	P
Bauhinia variegata	P
Populus ciliata	P
Glochidion velutinum	P
Lyonia ovalifolia	P
Cinnamomum tamala	P
Strobilanthes wallichii	B/P
Myrica esculenta	P
Terminalia chebula	P

Species	Habit (Annual/Biennial/Perennial)
Eupatorium sp.	A
Ageratum conyzoides	A
Oxalis occidentalis	A
Fragaria indica	A
Bidens pilosa	A
Centella asiatica	A
Thymus serphyllum	A
Cheilanthes anceps	A
Anaphalis busua	A
Murraya koenigii	P
Viola serpens	A
Baisani	
Pinus roxburghii	P
Sapium insigne	P
Terminalia chebula	P
Ficus roxburghii	P
Bauhinia variegata	P
Emblica officinalis	P
Bauhinia purpurea	P
Leptodermis lanceolata	P
Ficus religiosa	P
Woodfordia fruticosa	P
Rubus ellipticus	P
Ougenia oojenensis	P
Callicarpum microphylla	P
Cheilanthus anceps	A

Species	Habit (Annual/Biennial/Perennial)
Ageratum conyzoides	A
Oxalis occidentalis	A
Bidens pilosa	A
Adiantum capillus	A
Strobilanthes wallichii	B/P
Phyllanthus niruri	A
Diplazium esculentum	A
Desmodium microphyllum	A/B
Cissampelos pareira	A
Euphorbia hirta	A
Harsilla	
Pinus roxburghii	P
Bauhinia variegata	P
Quercus leucotrichophora	P
Syzygium cumini	P
Bauhinia purpurea	P
Ficus roxburghii	P
Terminalia chebula	P
Morus alba	P
Oujenia oojensis	P
Indigofera heterantha	A/B
Toona ciliata	P
Sapindus mukurossi	P
Berberis aristata	P
Adiantum capillus	A
Cheilanthus anceps	A

Species	Habit (Annual/Biennial/Perennial)
Eupatorium sp.	A
Anaphalis busua	A
Desmodium microphyllum	A/B
Oxalis occidentalis	A
Fragaria indica	A
Ageratum conyzoides	A
Cissampelos pareira	A
Viola serpens	A
Diplazium esculentum	A
Dioscorea deltoidea	A
Purkuni	
Pinus roxburghii	P
Lyonia ovalifolia	P
Quercus leucotrichophora	P
Alnus nitida	P
Persea odoratissima	P
Rhododendron arboreum	P
Berberis aristata	P
Pyrus pashia	P
Typha angustifolia	P
Morus alba	P
Rubus ellipticus	P
Leucena leucocephala	P
Prunus persica	P
Desmodium microphyllum	A/B
Potentilla fulgens	A

Species	Habit (Annual/Biennial/Perennial)
Thymus serphyllum	A
Centella asiatica	A
Indigofera heterantha	A/B
Anaphalis busua	A
Fragaria indica	A
Oxalis occidentalis	A
Cyperus sp.	A
Eupatorium sp.	A

Nainital

Species	Habit (Annual/Biennial/Perennial)
Dholigaon	
Pinus roxburghii	P
Myrica esculenta	P
Glochidion velutinum	P
Cinnamomum tamala	P
Syzygium cumini	P
Quercus leucotrichophora	P
Alnus nitida	P
Bauhinia variegata	P
Acacia sp	P
Rubus ellipticus	P
Indigofera heterantha	A/B
Eupatorium sp.	A
Anaphalis busua	A
Thymus serphyllum	A

Species	Habit (Annual/Biennial/Perennial)
Artemisia nilagirica	A
Pajaina	
Pinus roxburghii	P
Grewia optiva	P
Bauhinia variegata	P
Myrica esculenta	P
Pyrus pashia	P
Glochidion velutinum	P
Berberis aristata	P
Rhus parviflora	P
Rubus ellipticus	P
Pyracantha crenulata	P
Themeda anathera	A
Pennisetum orientale	A
Heteropogon contortus	A
Artemisia nilagarica	A
Chrysopogon gryllus	A
Crotalaria sericea	A
Thymus serphyllum	A
Desmodium microphyllum	A/B
Bogora	
Pinus roxburghii	P
Alnus nitida	P
Bauhinia variegata	P
Grewia optiva	P
Myrica esculenta	P
Syzygium cumini	P

Species	Habit (Annual/Biennial/Perennial)
Pyracantha crenulata	P
Sapium insigne	P
Pyrus pashia	P
Berberis aristata	P
Glochidion velutinum	P
Emblica officinalis	P
Rubus ellipticus	P
Cornus capitata	P
Artemisia nilagirica	A
Indigofera heterantha	A/B
Eupatorium sp.	A
Anaphalis busua	A
Thymus serphyllum	A
Kwaidal	
Quercus semecarpifolia	P
Rhododendron arboreum	P
Quercus leucotrichophora	P
Lyonia ovalifolia	P
Quercus dilatata	P
Lonicera quinquelacularis	P
Viburnum cotinifolium	P
Picea smithiana	P
Persea odoratissima	P
Aesculus indica	P
Symplocos crataegoides	P
Premna latifolia	P
Taxus baccata	P

Species	Habit (Annual/Biennial/Perennial)
Berberis aristata	P
Skimmia laureola	P
Zanthoxylum armatum	P
Anaphalis busua	A
Potentilla fulgens	A
Diplazium esculentum	A
Habenaria intermedia	A
Thymus serphyllum	A
Gerbera lanuginose	A
Arundinaria falcata	P
Viola serpens	A
Artemisia nilagirica	A
Eupatorium sp.	A
Thali	
Pinus roxburghii	P
Myrica esculenta	P
Rhododendron arboreum	P
Quercus leucotrichophora	P
Alnus nitida	P
Pyracantha crenulata	P
Berberis aristata	P
Aesculus indica	P
Cupressus torulosa	P
Acacia sp	P
Diplazium esculentum	A
Thymus serphyllum	A
Oxalis occidentalis	A

Species	Habit (Annual/Biennial/Perennial)
Viola serpens	A
Habenaria intermedia	A
Anaphalis busua	A
Desmodium microphyllum	A/B

Rudraprayag

Species	Habit (Annual/Biennial/Perennial)
Agar	
Cedrus deodara	P
Pinus roxburghii	P
Cupressus torulosa	P
Rhus parviflora	P
Emblica officinalis	P
Quercus serrata	P
Leucena leucocephala	P
Melia azedarach	P
Berberis aristata	P
Colebrookia oppositifolia	P
Rubus ellipticus	P
Anaphalis busua	A
Verbascum thepsus	A
Bidens pilosa	A
Ageratum conyzoides	A
Eupatorium sp.	A
Sari	
Pinus roxburghii	P

Species	Habit (Annual/Biennial/Perennial)
Morus alba	P
Melia azedarach	P
Emblica officinalis	P
Grevillea robusta	P
Leucena leucocephala	P
Bauhinia variegata	P
Rhus parviflora	P
Carissa spinarum	P
Mallotus phillipinensis	P
Celtis australis	P
Juglans regia	P
Berberis aristata	P
Ageratum conyzoides	A
Eupatorium sp.	A
Chrysanthemum cinerariaefolium	A
Oxalis occidentalis	A
Cissampelos pareira	A
Boerhavia diffusa	A
Cassia tora	A
Euphorbia hirta	A
Ginwala	
Cinnamomum tamala	P
Toona ciliata	P
Pinus roxburghii	P
Bombax ceiba	P
Callistemon viminalis	P
Melia azedarach	P

Species	Habit (Annual/Biennial/Perennial)
Dalbergia sissoo	P
Salix tetrasperma	P
Vitex negundo	P
Bauhinia variegata	P
Emblica officinalis	P
Fraxinus micrantha	P
Dendrocalamus strictus	P
Callicarpum microphylla	P
Carissa spinarum	P
Colebrookia oppositifolia	P
Quercus serrata	P
Jatropha curcas	P
Sapium insigne	P
Pyrus pashia	P
Berberis aristata	P
Woodfordia fruticosa	P
Sapindus mukurossii	P
Centella asiatica	A
Ageratum conyzoides	A
Eupatorium sp.	A
Euphorbia hirta	A
Artemisia sp.	A
Adiantum capillus	A
Anaphalis busua	A
Kontha	
Quercus leucotrichophora	P
Rhododendron arboreum	P

Species	Habit (Annual/Biennial/Perennial)
Alnus nitida	P
Quercus serrata	P
Fraxinus micrantha	P
Bauhinia variegata	P
Morus alba	P
Berberis aristata	P
Rubus ellipticus	P
Randia tetrasperma	P
Cedrus deodara	P
Robinia pseudoacacia	P
Sapindus mukurossi	P
Pyrus pashia	P
Pyracantha crenulata	P
Anaphalis busua	A
Eupatorium sp.	A
Bidens pilosa	A

Tehri

Species	Habit (Annual/Biennial/Perennial)
Loladi	
Pyrus pashia	P
Pinus roxburghii	P
Bauhinia variegata	P
Albizia lebbek	P

Species	Habit (Annual/Biennial/Perennial)
Bauhinia purpurea	P
Carissa spinarum	P
Rhus parviflora	P
Woodfordia fruticosa	P
Rhus cotinus	P
Dalbergia sissoo	P
Lantana camara	P
Glochidion velutinum	P
Emblica officinalis	P
Bidens pilosa	A
Anaphalis busua	A
Adiantum capillus	A
Eupatorium sp.	A
Cissampelos pareira	A
Ageratum conyzoides	A
Strobilanthes wallichii	B/P
Oxalis occidentalis	A
Cheilanthus anceps	A
Indiyan	
Pinus roxburghii	P
Cupressus torulosa	P
Quercus leucotrichophora	P
Bauhinia variegata	P
Sapindus mukurossi	P
Emblica officinalis	P
Melia azedarach	P
Berberis aristata	P

Species	Habit (Annual/Biennial/Perennial)
Pyrus pashia	P
Rhus cotinus	P
Rubus ellipticus	P
Ageratum conyzoides	A
Eupatorium sp.	A
Viola serpens	A
Bidens pilosa	A
Anaphalis busua	A
Fragaria indica	A
Potentilla fulgens	A
Indigofera heterantha	A/B
Argemone mexicana	A
Majkhet	
Pinus roxburghii	P
Myrica esculenta	P
Robinia pseudoacacia	P
Alnus nitida	P
Prunus cerasoides	P
Quercus leucotrichophora	P
Bauhinia variegata	P
Prunus armeniaca	P
Grewia optiva	P
Melia azedarach	P
Strobilanthes wallichii	B/P
Myrica esculenta	P
Dendrocalamus strictus	P
Dalbergia sissoo	P

Species	Habit (Annual/Biennial/Perennial)
Berberis aristata	P
Woodfordia fruticosa	P
Rhus parviflora	P
Pyrus pashia	P
Cedrus deodara	P
Bauhinia purpurea	P
Glochidion velutinum	P
Coriarea nepalensis	P
Ficus roxburghii	P
Woodfordia fruticosa	P
Phoenix sylvestris	P
Asparagus adscendens	P
Bombax ceiba	P
Sida acuta	P
Anaphalis busua	A
Eupatorium sp.	A
Cissampelos pareira	A
Strobilanthes wallichii	A
Bidens pilosa	A
Cheilanthus anceps	A
Artemisia nilagirica	A

Annexure 5 Species Richness and Diversity Index

Revenue villages	Division	Blocks	Micro watershed	Habit	Climatic zone	Forest type	Diversity index Baseline	Diversity index Final		Species richness Baseline	Species richness Final	
							Treated	Treated	Control	Treated	Treated	Control
Agar	Rudraprayag	Agastmuni	Chhinkagad	Tree	Temperate	Himalayan moist temperate	0.763	0.76	0.69	3	3	2
Agar	Rudraprayag	Agastmuni	Chhinkagad	Shrub			2.005	2.36	1.79	10	16	8
Agar	Rudraprayag	Agastmuni	Chhinkagad	Herb			1.436	1.97	0.87	5	8	3
Agar	Rudraprayag	Agastmuni	Chhinkagad	Total						**16**	**24**	**12**
Sari	Rudraprayag	Agastmuni	Pogtagad	Tree	Subtropical	Subtropical chirpine	0	0	0	1	1	1
Sari	Rudraprayag	Agastmuni	Pogtagad	Shrub			2.258	2.04	1.51	14	13	5
Sari	Rudraprayag	Agastmuni	Pogtagad	Herb			1.764	1.65	1.43	8	8	6
Sari	Rudraprayag	Agastmuni	Pogtagad	Total						**21**	**22**	**12**
Ginwala	Rudraprayag	Agastmuni	Baniyarigad	Tree	Subtropical	Subtropical chirpine	1.457	1.47	1.09	9	9	3

Revenue villages	Division	Blocks	Micro watershed	Habit	Climatic zone	Forest type	Diversity index Baseline	Diversity index Final		Species richness Baseline	Species richness Final	
Ginwala	Rudraprayag	Agastmuni	Baniyarigad	Shrub			3.022	2.37	1.36	15	17	6
Ginwala	Rudraprayag	Agastmuni	Baniyarigad	Herb			1.497	2.06	1.41	7	10	6
Ginwala	Rudraprayag	Agastmuni	Baniyarigad	Total						**31**	**34**	**14**
Kontha	Rudraprayag	Agastmuni	Kyunjagad	Tree	Temperate	Himalayan moist temperate	0.595	0.6	0	3	3	1
Kontha	Rudraprayag	Agastmuni	Kyunjagad	Shrub			2.499	2.27	1.11	13	12	4
Kontha	Rudraprayag	Agastmuni	Kyunjagad	Herb			0.813	2.12	1.52	3	10	5
Kontha	Rudraprayag	Agastmuni	Kyunjagad	Total						**18**	**23**	**9**
Loladi	Tehri	Thauldhar	Gairgad	Tree	Subtropical	Subtropical chirpine	0	0.33	0	1	2	1
Loladi	Tehri	Thauldhar	Gairgad	Shrub			2.446	2.34	1.49	15	15	6
Loladi	Tehri	Thauldhar	Gairgad	Herb			1.957	1.69	1.06	10	10	4
Loladi	Tehri	Thauldhar	Gairgad	Total						22	**25**	11
Indiyan	Tehri	Thauldhar	Malogigad	Tree	Subtropical	Subtropical chirpine	0.561	0.56	0	2	2	1
Indiyan	Tehri	Thauldhar	Malogigad	Shrub			2.205	2.17	0	12	11	1

Revenue villages	Division	Blocks	Micro watershed	Habit	Climatic zone	Forest type	Diversity index Baseline	Diversity index Final		Species richness Baseline	Species richness Final	
Indiyan	Tehri	Thauldhar	Malogigad	Herb			1.601	1.65	1.21	9	8	4
Indiyan	Tehri	Thauldhar	Malogigad	Total						20	**19**	5
Majkhet	Tehri	Thauldhar	Ghattugad	Tree	Subtropical	Subtropical chirpine	0.819	0.92	0.35	6	6	2
Majkhet	Tehri	Thauldhar	Ghattugad	Shrub			2.697	2.77	0.79	23	27	3
Majkhet	Tehri	Thauldhar	Ghattugad	Herb			1.789	1.97	1.29	8	9	5
Majkhet	Tehri	Thauldhar	Ghattugad	Total						34	**38**	9
Gainar	Bageshwar	Kafkot	Ginargad	Tree	Subtropical	Subtropical chirpine	0.2126	**0.04**	0.56	3	2	2
Gainar	Bageshwar	Kafkot	Ginargad	Shrub			2.4844	**2.4**	1.77	22	27	7
Gainar	Bageshwar	Kafkot	Ginargad	Herb			1.9029	1.96	1.71	11	11	6
Gainar	Bageshwar	Kafkot	Ginargad	Total						**33**	**38**	**14**
Baisani	Bageshwar	Kafkot	Gaganigad	Tree	Subtropical	Subtropical chirpine	1.0022	1.01	0	4	3	1
Baisani	Bageshwar	Kafkot	Gaganigad	Shrub			1.6135	2.17	1.47	12	15	5
Baisani	Bageshwar	Kafkot	Gaganigad	Herb			1.9585	1.18	0.79	12	7	3

Revenue villages	Division	Blocks	Micro watershed	Habit	Climatic zone	Forest type	Diversity index Baseline	Diversity index Final		Species richness Baseline	Species richness Final	
Baisani	Bageshwar	Kafkot	Gaganigad	Total						25	23	8
Harsilla	Bageshwar	Kafkot	Kumgad	Tree	Subtropical	Subtropical chirpine	0.7267	0.73	0.5	3	3	2
Harsilla	Bageshwar	Kafkot	Kumgad	Shrub			1.7651	1.68	1.89	12	11	8
Harsilla	Bageshwar	Kafkot	Kumgad	Herb			2.0557	1.53	1.09	12	9	4
Harsilla	Bageshwar	Kafkot	Kumgad	Total						**25**	**21**	**13**
Purkuni	Bageshwar	Kafkot	Kumgad	Tree	Temperate	Himalayan moist temperate	1.2379	1.24	0.69	4	4	2
Purkuni	Bageshwar	Kafkot	Kumgad	Shrub			1.6976	2.12	1.02	10	14	3
Purkuni	Bageshwar	Kafkot	Kumgad	Herb			1.9412	2.1	0.74	9	11	3
Purkuni	Bageshwar	Kafkot	Kumgad	Total						**23**	**26**	**7**
Dholigaon	Nainital	Okhalkanda	Dantagad	Tree	Subtropical	Subtropical chirpine	0.499	**0.41**	0.5	2	2	2
Dholigaon	Nainital	Okhalkanda	Dantagad	Shrub			1.879	1.98	1.58	9	11	7
Dholigaon	Nainital	Okhalkanda	Dantagad	Herb			1.206	0.65	1.24	4	2	4
Dholigaon	Nainital	Okhalkanda	Dantagad	Total						**15**	**13**	**11**

Revenue villages	Division	Blocks	Micro watershed	Habit	Climatic zone	Forest type	Diversity index Baseline	Diversity index Final		Species richness Baseline	Species richness Final	
Pajaina	Nainital	Okhalkanda	Sunkot	Tree	Subtropical	Subtropical chirpine	0	0.28	0	1	1	1
Pajaina	Nainital	Okhalkanda	Sunkot	Shrub			2.158	2.32	1.83	11	13	7
Pajaina	Nainital	Okhalkanda	Sunkot	Herb			1.465	1.53	0.67	9	5	2
Pajaina	Nainital	Okhalkanda	Sunkot	Total						**18**	**18**	**9**
Bogora (Digoli)	Nainital	Okhalkanda	Sunkot	Tree	Subtropical	Subtropical chirpine	1.039	0	0.69	2	0	2
Bogora (Digoli)	Nainital	Okhalkanda	Sunkot	Shrub			1.809	2.12	0.83	13	11	3
Bogora (Digoli)	Nainital	Okhalkanda	Sunkot	Herb			1.405	1.34	1	5	5	4
Bogora (Digoli)	Nainital	Okhalkanda	Sunkot	Total						**19**	**16**	**8**
Kwaidal	Nainital	Okhalkanda	Pashyagad	Tree	Temperate	Himalayan moist temperate	1.874	1.91	1.171	12	12	4
Kwaidal	Nainital	Okhalkanda	Pashyagad	Shrub			1.868	2.06	1.25	17	16	5
Kwaidal	Nainital	Okhalkanda	Pashyagad	Herb			1.781	1.47	1.03	9	6	3
Kwaidal	Nainital	Okhalkanda	Pashyagad	Total						**27**	**25**	**10**

Revenue villages	Division	Blocks	Micro watershed	Habit	Climatic zone	Forest type	Diversity index Baseline	Diversity index Final		Species richness Baseline	Species richness Final	
Thali	Nainital	Okhalkanda	Pashyagad	Tree	Temperate	Himalayan moist temperate	1.197	1.24	1.73	4	4	7
Thali	Nainital	Okhalkanda	Pashyagad	Shrub			1.827	1.98	0.56	8	12	2
Thali	Nainital	Okhalkanda	Pashyagad	Herb			1.455	1.29	0	7	6	1
Thali	Nainital	Okhalkanda	Pashyagad	Total						**17**	**18**	**8**
ALL SITES POOLED*				Tree			**2**	**2**		**32**	**32**	
				Shrub			**3.04**	**3.57**		**73**	**79**	
				Herb			**3.59**	**2.6**		**38**	**28**	

** The Diversity Index and Species Richness figures are not additive for tree, herb and shrub species. The overall species richness for each site could be less than the sum of species richness of tree, herb and shrub as repeated species would be dropped in the overall computation. Overall for the project, the number of unique species is 112.*

Annexure 6 Importance Value Index for Trees

	Agar		Sari		Ginwala		Kontha		Loladi		Majkhet		Indiyan		Gainar		Baisani		Harsilla		Purkuni		Dholigaon		Pajaina		Digoli		Kwaidal		Thali	
Trees	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C
Pinusroxburghii	49	106	300	200	147	92			250	200	214	189	224	200	280	174	197	200	212		177	129	228	174	300	200					123	24
Terminaliachebula																	66			22												
Ficusroxburghii																	18															
Sapium																	18															
Quercusleucotrichophora							236	200			10.	22							74	178	57								11		63	11
Bauhinia variegata																			15													
Syzygiumcumini															20																	
Pistaciaintegerrima																26																
Lyoniaovalifolia																					47	71							57	56		7
Alnusnitida							31				10										19											
Myricaesculenta											45												71	26				77			36	60

	Agar		Sari		Ginwala		Kontha		Loladi		Majkhet		Indiyan		Gainar		Baisani		Harsilla		Purkuni		Dholigaon		Pajaina		Digoli		Kwaidal		Thali	
Cornuscapitata																											123					
Piceasmithiana																												83				
Rhododendronarboretum							33																					61	112	78	66	
Viburnum cotinifolium																												23				
Quercus Dilatata																												17	11			
Quercus Semecarpifolia																												14			6	
Persea Odoratissima																												7	21			
Pyrus Pashia									50																						25	
Cedrus Deodara	188																															
Cupressus Torulosa	63												76																			
Acacia sp.		84				53																										
Callistemon viminalis					23																											

	Agar		Sari		Ginwala		Kontha		Loladi		Majkhet		Indiyan		Gainar		Baisani		Harsilla		Purkuni		Dholigaon		Pajaina		Digoli		Kwaidal		Thali	
Bombaxceiba					23																											
Dalbergiasissoo					20																											
Meliaazedarach					19																											
Mallotusphillipinensis						55																										
Prunuscerasoides											10																					
Ravinia pseudo acacia											11																					

Annexure 7 Importance Value Index of shrubs

	Agar		Sari		Ginwala		Kontha		Loladi		Majkhet		Indiyan		Gainar		Baisani		Harsilla		Purkuni		Dholigaon		Pajaina		Digoli		Kwaidal		Thali	
Shrub species	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C
Woodfordia fruticosa						16.7				3.7						9.1	35.7	35.3														
Bauhinia variegata									24.4				17.7				34.7		45.1						20.2		33.5					
Leptodermis lanceolata																	22.1															
Phyllanthus emblica													21.5				25.9															
Terminalia chebula																	11.7	23.5		14.3												
Ougenia oojensis										7.4								23.5		14.3												
Pinus roxburghii									26.2		21.3	23.1	24.9	100.0		27.3		11.8			24.3		43	34.6				57.1			49.6	
Rosa macrophylla																		5.8														
Toona ciliate			21.7	17.9	28.4						22				50	22.7			59.4	28.6												
Bauhinia purpurea																			18													
Quercus leucotrichophora							34	40			20.8		22.6						17.5		27.3		24.6						39.8	40.6	16.3	25
Indigofera																			11.5													

	Agar		Sari		Ginwala		Kontha		Loladi		Majkhet		Indiyan		Gainar		Baisani		Harsilla		Purkuni		Dholigaon		Pajaina		Digoli		Kwaidal		Thali	
heterantha																																
Berberis aristata							23.2	45			14.6		37.1			13.6				9.5									21.7			
Quercus incana															20.2																	
Syzygium cumini															14				11.3				25.8	7.7								
Callicarpum macrophylla															11.7																	
Melia azedarach																																
Psidium guajava																18.2																
Persea odoratissima																					47											
Rhododendron arboreum																					21.2	52.9							29.8	40.6	26.4	
Leucena leucocephala																					13.5											
Pyrus pashia							16	10.0														23.5			16.1	15						
Lyonia ovalifolia																						23.5										
Glochidion velutinum																							37.3		23.2	20.0	25.5					
Rubus ellipticus		12.8					24.9	5															12.8	7.7	31.4	15		4.8				
Myrica esculenta																							12.9	34.6	24.2	20.0	23.3	38.1				75

	Agar		Sari		Ginwala		Kontha		Loladi		Majkhet		Indiyan		Gainar		Baisani		Harsilla		Purkuni		Dholigaon		Pajaina		Digoli		Kwaidal		Thali	
Pyracantha crenulata																								7.7		20.0	20.1					
Grewia optiva																											29.2					
Arundinaria falcata (bamboo)	20.1																															
Quercus semecarpifolia																													37.7			
Lonicera parvifolia																														6.25		
Quercus dilatata																													16.1	6.25		
Aesculus indica	24.8																														29.2	
Pistacia integerrima																																
Acacia molyssima	14.4																															
Colebrookia oppositifolia	36.3	23.1		7.7																												
Populus ciliate	19.2																															
Rhus parviflora		25.6	46	33.3		12.5			23.4	22.2																						
Cupressus torulosa		20.5																														
Randia tetrasperma		10.3																														

	Agar		Sari		Ginwala		Kontha		Loladi		Majkhet		Indiyan		Gainar		Baisani		Harsilla		Purkuni		Dholigaon		Pajaina		Digoli		Kwaidal		Thali	
Carissa spinarum			25.3	15.4	18.9	54.1			21.6	29.6																						
Morus alba			27.8																													
Mallotus phillipinensis			24.7	33.3		4.1																										
Jatropha curcas					22.7																											
Cinnamomum tamla					20.9																											
Quercus serrate					21.2																											
Euphorbia royleana						8.3																										
Fraxinus micrantha							20.7																									
Robinia pseudo acacia											17.8	69.2																				
Ficus roxburghii												7.7																				
Lantana camara									22.5	33.3																						

Annexure 8 Importance Value Index of herbs

	Agar		Sari		Ginwala		Kontha		Loladi		Majkhet		Indiyan		Gainar		Baisani		Harshila		Purkuni		Dholigaon		Paijana		Digoli		Kwaidal		Thali	
Species	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C
Cheilanthes anceps	33.3			3.8		6.3			51.7	52.2	29.3	54.5		50.0	33.5	20.0	73.9	23.1	62.4	61.1					24.3	40.0						
Adiantum capillus			52.5	34.6		15.6			54.0		49.7				19.1	20	64.8	69.2	40.7													
Eupatorium sp,		16.7	18.3	11.5	36.4	53.1	38.2	30.8	11.9	34.8	26.8	18.2	70.6		47.8	20.0	18.6		41.5	11.1	38.1	12.5	115.4	42.9	30.1		58.6	4.3	34.6	50.0	52.2	
Reinwardtia trigyna							33.2	7.7			22.8	9.1			34.5	8.0	18.6		24.7	11.1												
Ageratum conyzoides	29.6				24.6	12.5		23.1		8.7			15.4		18.2		12.9		25.1													
Artemisia nilagirica					17.9								23.7							16.7				21.4			67.1	8.7	18.0			
Bidense pilosa						6.3			19.3		16.4																					
Anaphalis busua	33.3	16.7					16.8	23				9.1		12.5	17	24.0		7.7			41.0	12.5	84.6	28.6	66.9	60.0	45.7	60.9	69.2	30.0	85.6	100.0
Centella asiatica					24.6																26.9											

	Agar		Sari		Ginwala		Kontha		Loladi		Majkhet		Indiyan		Gainar		Baisani		Harshila		Purkuni		Dholigaon		Paijana		Digoli		Kwaidal		Thali	
Thymus serphyllum							30.9	15.4													24.0				54.4						17.4	
Potentilla fulgens																					22.1	75.0							48			
Argemone maxicana	18.5																							7.1								
Fragaria indica			32.1						11.9				36.0												24.3		15.7	26.1	23.1	20.0		
Oxalis occidentalis			47.5	7.7	25.9																						12.9				17.4	
Viola serpens													17.1			8														13.7	
Rumex dentatus	29.6	66.7																														
Chrysanthemum cinerariaefolium			23.3																													
Cissampelos pariera				38.5								9.1		12.5																		
Tagetis minuta							25.9																									
Aster peduncularis																															13.7	
Verbascum thepsus										4.3																						
Bergenia ciliata														25																		

Annexure 9. Importance Values and Relative Density of dominant species (Division-wise)

Nainital Division	Relative Density	IVI	Bageshwar	Relative Density	IVI	Rudraprayag	Relative Density	IVI	Tehri	Relative Density	IVI
Tree layer											
Pinus roxburghii	31.1	76.0	*Pinus roxburghii*	75	229.5	*Quercus leucotricophora*	28.1	83.7	*Pinus roxburghii*	76.9	219.2
Picea smithiana	20.7	51.5	*Quercus leucotrichophora*	13.9	30.0	*Pinus roxburghii*	31.3	77.4	*Myrica esculenta*	9.6	32.4
Rhododendron arboreum	13.3	49.7	*Terminalia chebula*	4.6	13.7	*Cedrus deodara*	17.2	36.2	*Cupressus torulosa*	3.8	10.7
Lyonia ovalifolia	8.1	31.5	*Lyonia ovalifolia*	2. 8	9.7	*Toona ciliata*	1.6	20.3	*Pyrus phasia*	1.9	8.1
Quercus leucotricophora	6.7	20.7	*Alnus nitida*	0.9	4.3	*Rhododendron arboreum*	3.1	10.7	*Robinia pseudo acacia*	1.9	8.1
Undergrowth / Shrub layer											
Quercus leucotricophora	13.5	23.3	*Toona ciliata*	22.2	31.1	*Berberis aristata*	6.1	14.5	*Pinus roxburghii*	13.7	23.6

Nainital Division	Relative Density	IVI	Bageshwar	Relative Density	IVI	Rudraprayag	Relative Density	IVI	Tehri	Relative Density	IVI
Pinus roxburghii	11.2	18.2	*Bauhinia variegata*	10.9	39.6	*Colebrookia oppositifolia*	7.4	13.8	*Bauhinia variegata*	8.8	17.1
Quercus semecarpifolia	12.5	18.1	*Quercus leucotrichophora*	10.3	34.2	*Toona ciliata*	7.0	13.3	*Berberis aristata*	9.6	16.2
Rhododendron arboreum	9.5	17.2	*Persea odoratissima*	8. 8	28.8	*Quercus serrata*	6.1	11.4	*Quercus leucotrichophora*	8.5	16.0
Berberis aristata	5.8	13.4	*Pinus roxburghii*	4.3	25.40	*Rhus parviflora*	7.9	10.0	*Toona ciliata*	7.2	11.4
Herb layer											
Anaphalis busua	39.6	69.1	*Cheilanthes anceps*	29.9	47.1	*Oxalis occidentalis*	17.1	27.1	*Adiantum capillus*	25.9	40.2
Eupatorium sp	23.8	50.0	*Eupatorium sp*	17.6	38.1	*Eupatorium sp*	11.7	25.0	*Eupatorium sp*	17.5	33.9
Potentilla fulgens	12.4	22.2	*Adiantum capillus*	17.6	27.3	*Adiantum capillus*	14	22.3	*Cheilanthes anceps*	17.5	31.8
Artemisia nilagirica	9.9	19.7	*Reinwardtia trigyna*	7.7	21.7	*Anaphalis busua*	4.1	14.1	*Fragaria indica*	9.2	19.4
Fragaria indica	5.9	15.8	*Anaphalis busua*	7.2	15.8	*Ageratum conyzoides*	6.3	13.0	*Bidense pilosa*	6.6	16.8