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Assessment for Designing REDD Plus Projects in India

The Energy and Resources Institute

...towards global sustainable development

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Project Team

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List of Abbreviations

AGB	Above Ground Biomass
AGTB	Above Ground Tree Biomass
ANR	Assisted Natural Regeneration
BAP	Bali Action Plan
BDA	Biological Diversity Act
BEF	Biomass Expansion Factor
BGTB	Below Ground Tree Biomass
BPL	Below Poverty Line
CAI	Current Annual Increment
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CF	Conversion Factor
CFM	Community Forest Management
CFMC	Community Forest Management Committee
COP	Conference of Parties
C-Sink	Carbon Sink
CSR	Corporate Social Responsibility
DBH	Diameter at breast height
DFO	Divisional Forest Officer
DW	Deadwood
EC	Executive Committee
EMR	Electromagnetic Radiation
EPA	Environment Protection Act
EXIM	Export Import Policy

FAO	Food and Agriculture Organisation
FCA	Forest Conservation Act
FDCs	Forest Dependent Communities
FPC	Forest Protection Committee
FRA	Forest Rights Act
FSI	Forest Survey of India
FUGs	Forest User Groups
GB	General Body
GBH	Girth at Breast height
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GIM	Green India Mission
GIS	Geographic Information System
GPS	Global Positioning System
HHs	Households
IFA	Indian Forest Act
IFS	Indian Forest Service
IGA	Income Generating Activity
IMD	Indian Meteorological Department
IPCC	Intergovernmental Panel on Climate Change
IPF/IFF	Intergovernmental Panel on Forests/Intergovernmental Forum on Forests
IR	Infra Red
JFM	Joint Forest Management
JFMC	Joint Forest Management Committee
JICA	Japan International Cooperation agency
JPOI	Johannesburg Plan of Implementation
LANDSAT	Land Satellite

LL	Leaf Litter
LPG	Liquefied Petroleum Gas
MAB	Man and Biosphere
MAI	Mean Annual Increment
MDGs	Millennium Development Goals
MFP	Minor Forest Produce
MNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MoEF	Ministry of Environment & Forests
MoRD	Ministry of Rural Development
MOTA	Ministry of Tribal Affairs
MoU	Memorandum of Understanding
MP	Madhya Pradesh
MRV	Measurement, Reporting, and Verification
NAMAs	Nationally Appropriate Mitigation Actions
NDVI	Normalised Difference Vegetation Index
NFP	National Forest Policy
NGOs	Non-Governmental Organizations
NP	National Park
NTFPs	Non-Timber Forest Produce
OBCs	Other Backward Classes
OFSDP	Odisha Forestry and Sustainable Development Program
PRF	Proposed Reserve Forest
RED	Reducing Emissions from Deforestation
REDD	Reducing Emissions from Deforestation and Forest Degradation
REDD+	Reducing Emissions due to Deforestation and Forest Degradation Plus
RF	Reserve Forest

RS	Remote Sensing
SBSTA	Subsidiary Body for Scientific and Technological Advice
SCS	Severe Cyclonic Storm
SC	Scheduled Caste
SFM	Sustainable Forest Management
SHG	Self Help Group
SMF	Sustainable Management of Forests
SOC	Soil Organic Carbon
ST	Scheduled Tribes
tdm	Tons of dry mass
TERI	The Energy and Resources Institute
TM	Thematic Mapper
TV	Television
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNFF	United Nations Forum on Forests
UP	Uttar Pradesh
VCS	Voluntary Carbon Standard
VFC	Village Forest Committee
VSS	Van Sanrakshan Samiti (Forest Protection Committee)
WB	West Bengal
WC	Working Circle
WLPA	Wildlife Protection Act
WS	Wildlife Sanctuary

Executive Summary

Background

REDD (Reducing Emissions from Deforestation and Forest Degradation) is a global endeavour to incentivize developing countries to protect, sustainably manage, conserve and develop their forests resource and thereby, contribute to the global fight against climate change. REDD+ goes beyond checking deforestation and forest degradation, and includes incentives for ecosystem services, biodiversity conservation, sustainable forest management, and enhancement of carbon stocks.

This report provides an assessment of India's potential to implement a REDD+ Project at the ground level, based on a review of the current international architecture on REDD+, an analysis of response options and impacts at the national level and a field level assessment in five pilot locations across the country. While the outputs of the first two components have been consolidated into a separate study report, a series of policy briefs and workshop proceedings, the present report focuses on the field level assessment, providing a detailed methodology for carbon stock estimation, and reporting the results of the assessments of carbon stock changes, forest dependence, sustainability of forest resource extraction and institutional mechanisms at each pilot location. Wherever relevant, an analysis of gender issues and non-carbon ecosystem services is also provided.

Carbon stock assessment

The estimation of carbon stock is based on remote sensing technology coupled with ground truthing. Comparisons of the current carbon stock (2012) have been made with that of the baseline year (1990). For this study, five pools of carbon have been considered – Above Ground Biomass, Below Ground Biomass, Leaf Litter, Deadwood and Soil Organic Carbon. The first two pools have been used to compute the carbon stock increment from the base year, as it is not possible to have estimate of the latter three for the base year; moreover these account for a relatively small share of the total biomass. The increment in carbon stock in the five sites is presented in the table below:

Project site	Area (ha)	1990 (t/ha)	2012 (t/ha)	Change (t/ha)	Change (%)
Angul	200	83	91	8	10

Project site	Area (ha)	1990 (t/ha)	2012 (t/ha)	Change (t/ha)	Change (%)
Chhindwara	504	60	111	51	85
Mussourie	95	175	173	-2	-1
Renukoot	77	40	71	31	76
Sunderban	4420	147	197	50	34

Main results from the pilot sites

(Note: In this report, the sites have been referred by the Forest Divisions to which they belong for ease of identification, except in the case of the Sundarban. The details of the Block/Compartment/VFC area have been provided in the respective chapters.)

In the Renukoot site (Uttar Pradesh), the forest was found to be degraded on account of unsustainable harvest of fuelwood, fodder and minor forest produce. Due to poor economic conditions, a large section of households depend on the sale of fuelwood for meeting subsistence requirements. The degradation can be checked through enhancement of livelihoods options and provision of alternative employment, thereby reducing the dependence on forests to the extent of the sustainable limit.

In the Chhindwara site (Madhya Pradesh), there is heavy dependence on minor forest produce, specially achar, mahua, sal seeds and tendu leaves. The quantity of harvest of all these are beyond the sustainable limit, and the techniques of harvest are unsustainable too which is adversely impacting natural regeneration. Fuelwood collection is unsustainable as well. There is a need to enhance efficient fuel use and promote value-addition of minor forest produce.

In the Mussourie site (Uttarakhand), the extraction of fodder leaves and fuelwood is unsustainable, impacting forest productivity and causing degradation. To check the pressure on forests, a section of households could shift to alternative sources of fuel such as LPG, solar energy and biogas. Notably, the carbon stock of this site is currently 173 t/ha which indicates that the forest remains well stocked in spite of unsustainable harvest. Carbon stock can be further enhanced if harvest is maintained within the limit of sustainability.

In the Angul site (Odisha), the harvest of fuelwood and fodder is well within the sustainable limit, though techniques of harvest are unsustainable in some cases. The harvest of forest produce is largely for self-consumption and rarely for sale., and several alternative livelihood options are available. In the Sundarban site (West Bengal), mangrove forests are valued largely for their protective functions and direct forest dependence for fuelwood and minor forest produce is relatively limited. The economic value of the storm protection service of the forest is estimated at one-third of the total cash incomes of the households.

The estimation of carbon stock changes in the sites shows that there is an increment of about 50 t/ha in Sundarban and Chhindwara, an increment of 30 t/ha in Renukoot, an increment of 8 t/ha in Angul and a marginal decline in Mussourie. However, the Mussourie site had a relatively high baseline value of 175 t/ha and this stock has been maintained till the current period. If sustainable harvest is practiced and alternative livelihood options are provided, it is likely that higher increments will be achieved.

Observations and recommendations

It is evident that the full load of livelihoods of communities cannot be borne by forests in a majority of situations. There is therefore a need to provide alternative means of livelihoods through convergence with other rural development schemes.

However, estimation of sustainable harvest levels itself poses a challenge and demands adequate documentation at the ground level. It is essential that capacity be built among the communities to assess these limits as well as to use techniques of biomass assessment so that a monitoring of carbon stock changes is possible. It is imperative that field-level monitoring be coupled with Remote Sensing based techniques with technical support from the Forest Department and scientific institutions. Such assessments need to be part of the Working Plan preparation exercises.

It is important that appropriate financial arrangements be developed to incentivize the sustainable management of forests. The Warsaw Framework for REDD+ adopted at UNFCCC COP 19 (November 2013) addresses results-based finance for REDD+ with funding coming from multiple sources – public and private, bilateral and multilateral, provided drivers of forest degradation and safeguard issues are addressed. At the national level, emission reduction targets for the corporate sector could be set, and these could be met partly through the financing of REDD+ activities. Corporate Social Responsibility funds could also be used to enhance livelihood opportunities of forest-dependent communities and hence reduce pressure on forests, thus checking unsustainable extraction of forest

resources. With carbon stock increments estimated at four of the five pilot sites, there is also a potential to trade carbon in the voluntary market by developing REDD+ projects, using available methodologies such as the Voluntary Carbon Standard (VCS).

Finally, it is important that existing models of forest governance, including the provisions of the Forest Rights Act 2006, be synchronized with the REDD+ implementation process so that benefit-sharing arrangements for any carbon-based forest financing scheme is worked out appropriately at the community level.

Chapter 1 Introduction

Deforestation and forest degradation in tropical regions is the second largest source of greenhouse gases (GHGs), with different studies estimating its share in total global anthropogenic GHG emissions as 12–20 per cent (Ghazoul et al. 2010; IPCC 2007). With increased concern for climate change in recent decades, the emphasis on the reduction of GHG emission from deforestation and forest degradation has gained prominence as a climate change mitigation measure. However, the widespread prevalence of deforestation and forest degradation in many developing and underdeveloped countries located in the tropics poses a major challenge to this reduction. Among several other factors, the critical interlinkage between forest ecosystems and rural livelihood systems, as well as the competing land demands to further economic growth in these countries proliferate deforestation and forest degradation (Davidar et al. 2010; Chhatre and Agrawal 2009; Mahapatra and Kant 2005; Wunder 2001). Discourses on environmental conservation and economic growth have highlighted different aspects of the trade-offs involved, and tried to design solutions with win–win outcomes. REDD+, a popular word in the climate change lexicon, has emerged as one such solution to incentivize conservation and sustainable management of forests in the last few years. The concept of reducing emissions from deforestation (RED) was introduced in the 11th UNFCC Conference of Parties (COP 11) in 2005 as a compensation payment mechanism with potential win–win outcomes. Subsequently, its scope has been expanded to include forest degradation (REDD) and sustainable management of forest (REDD+). REDD+ is also understood to be a strategy with multiple advantages like carbon effectiveness, cost-efficiency and equity plus co-benefits—it is one of the most cost-effective climate change mitigation strategies (Wertz-Kanounnikoff and Kongphan-Apirak 2009).

REDD+ is a financial instrument to incentivize conservation and sustainable management of forests, and thereby reduce GHG emissions from deforestation and forest degradation. It aims at compensating forest owners in developing countries for conserving their forests by putting a value on the forest carbon stocks—one of the ecosystem services that forests provide. The notion of REDD+ is based on two basic premises. First, the countries conserving forests forgo the economic gain of harvesting them as well as the benefits from alternative land use, and hence need to be compensated for the same. Secondly, costs involved in conservation and sustainable management of forests need to be shared by other countries too, as forests provide a range of offsite ecosystem services that benefits all. Given the livelihood linkage of forests in many developing countries, forest conservation imposes several direct and indirect costs. Hence, any financial mechanism to compensate some of these costs by developed countries would encourage sustainable management of forest in developing countries—REDD+ has emerged primarily as the mechanism for such payments. There is a huge global market for carbon credits and all the developing countries with high forest cover have good potential to benefit from this through REDD+. The estimated value of transactions in the global forest carbon market in 2010 was $178 million. Carbon dioxide equivalent of 30.1 million metric tonnes has been transacted in 2010 (Diaz et al. 2011). The payments for carbon credits as co-benefits from the standing forest will discourage deforestation and forest degradation, and the money gained would be used effectively to address the drivers of such processes. For example, when the livelihood dependence of the local community results in forest degradation in any region, this money can be used to create alternative livelihood opportunities and reduce dependence on forest.

The increased conviction among the scientific and policy communities across the world that the conservation and sustainable management of forest could be an effective mitigation strategy to fight climate change has resulted in the widespread acceptance of REDD+. REDD+ in its earlier version as RED (reducing emissions from deforestation) came into the discourse during COP 11 in Montreal in 2005, in the form of a submission from the Coalition for Rainforest Nations led by Papua New Guinea. The concept was well received among several stakeholders in COP 11, and was officially adopted during COP 13 held in Bali with further detailed elaboration and expansion to include forest degradation along with deforestation, as in some developing countries forest degradation is as damaging as deforestation. With the addition of forest degradation in COP 13 in 2007, RED became reducing emissions from deforestation and forest degradation (REDD). The scope of RED was limited only to changes from 'non-forest' to 'forest' land cover types, whereas with the inclusion of forest degradation in REDD, the scope has increased to include the changes in forest from 'lower' to 'higher' carbon stock densities.

Subsequently, REDD has evolved to REDD+ to expand the scope of this compensatory financial instrument to accommodate the concerns of diverse stakeholders. 'REDD+ goes beyond merely checking deforestation and forest degradation, and includes incentives for positive elements of conservation, sustainable management of forests and enhancement of forest carbon stocks' (MoEF, undated, p. 2). It includes reforestation, sustainable management, and benefits such as biodiversity conservation, improving livelihood for local communities, and food security into the scope of this compensatory framework. REDD+ was also a key point of discussion during the 15th COP in 2009 in Copenhagen. The Copenhagen Accord—a non-binding international instrument having a broad political consensus outlining the measures to control global warming to 2 C—also acknowledged the importance of protecting natural forests for reducing emissions and recognized REDD+, though it does not refer to any binding emission reduction targets and specific mechanisms for the implementation and governance of REDD+. REDD+ got prominence in international climate negotiations with its due acknowledgement in the Copenhagen Accord in 2009, and all subsequent COPs have seen its significant evolution. The notion of REDD++, which is yet to formalized and enter international negotiations, advocates further increasing the scope of REDD by including all land cover changes that affect carbon storage.

These evolutions in terms of expanding the scope of REDD are due to differential trends and drivers of land-use change or change in tree cover across the countries. The trends and drivers could also vary across the regions within any specific country with diverse agro-ecosystems and differential socio-economic conditions. Therefore, the suitability of any such compensatory conservation programme depends largely on the drivers of forest cover change, sources of emission, and the technical and economic mitigation potential of the region or country (Minang et al. 2009). Though there is greater clarity on conceptual issues of REDD+ among the international community, REDD+ as a mechanism to avoid deforestation and forest degradation is still evolving.

REDD+ in its current avatar is significantly different from the initial notion of RED when it was introduced at COP 11 in 2005. It is not only that it has alpha-symbolical (one more D and +) expansions, but it has also undergone changes in terms of 'how it its perceived and what it has become in practice' (Angelson et al. 2012, p. 32). Along with the changes in REDD nomenclature, as discussed in the previous section, there has also been changes in terms of its objectives, policies, approaches, scale of implementation, and funding prospects. Given the multi-lateral nature of REDD+ mechanisms, evolution of its architecture involves engagement of a diverse set of actors with varied interests. Though political and financial

agendas have shaped the changing architecture of REDD+, different ideological narratives like green growth approach of market liberals, governance concern of institutionalists, ecological value of forests put forth by bio-environmentalists, and the rights over resources concern of social greens have influenced this path of transition (Hiraldo and Tanner 2011).

The idea of REDD was formally introduced in COP 11 in 2005—yet, the philosophical basis of it can be traced back to the Kyoto Protocol. The genesis of REDD+ lies in the notion of carbon trading and clean development mechanism (CDM) that were initiated in COP 3 held in Kyoto in 1997. The global treaty that emerged out of this COP is popularly known as the Kyoto Protocol and it laid down the mechanisms for carbon trading among the nations. Among the different market mechanisms, CDM created opportunities for developing countries to trade their Certified Emission Reductions (CER) credits with Annex 1 countries. However, the CDM recognized only a very limited role of forests as carbon sink, and allowed only afforestation and reforestation under its ambit. The CDM as a market instrument has limited scope to address the drivers of deforestation and forest degradation and this has led to the emergence of RED(D) in subsequent negotiations. The major issues that are being debated in all these multilateral forums are the institutional architecture, the payment mechanism that includes crediting criteria, measurement, reporting, and verification (MRV) issues, and the safeguards.

As mentioned earlier, the global discourse on RED started with a proposal by the Coalition of Rain Forest Nations to consider financial incentives to reduce deforestation under the Kyoto Protocol in line with other carbon credit mechanisms. This proposal was taken up by the UNFCCC, and it was agreed to initiate consideration of this at the 24th session of the Subsidiary Body for Scientific and Technological Advice (SBSTA) held at Bonn in 2006. The SBSTA considered RED favourably and the idea was discussed in greater depth in several workshops involving different stakeholders. These stakeholder consultations have made SBSTA consider the inclusion of 'forest degradation' along with deforestation in the incentive payment mechanism in COP 13. The inclusion came about after much pressure from countries with low deforestation but high forest degradation.

The COP 13 held in Bali, Indonesia, in 2007 has recognized the contribution of emissions from deforestation as well as forest degradation. They have also recognized the urgent need to reduce these emissions in developing countries by halting forest cover loss by 2030 at the latest, and reducing gross deforestation by at least 50 per cent by 2020, as compared to the current levels. This has resulted in the emergence of REDD and the Bali Action Plan (BAP); the outcome of UNFCCC's COP 13 has provided a further road map for its development. The BAP has also recognized the 'the complexity of the problem, different national circumstances and multiples drivers of deforestation and forest degradation' and emphasized that 'needs of local and indigenous communities should be addressed' while implementing the measure (UNFCCC 2007, p. 8). However, there has been no consensus in many operational and technical aspects of REDD+, and five main issues that remain contentious are (*i*) scope and definition of REDD; (*ii*) MRV; (*iii*) the rights of indigenous people; (*iv*) financing options; and (*v*) operational scales and institutional arrangements in implementing countries (Holloway and Giandomenico 2009). Two ad hoc working groups and a SBSTA were established to further discuss these contentious and other related issues.

The 29th session of SBSTA held at Poznan in December 2008 had in-depth discussions on the definition and scope of REDD, as that was very critical for addressing other contentious issues. Some countries, such as India, advocated for the expansion of the scope of REDD to

recognize the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in reducing emissions in developing countries. This has been duly accepted by the SBSTA in its report and REDD with this expanded scope became 'REDD+'. Other countries like USA, Canada, New Zealand, and Australia blocked the inclusion of reference to 'indigenous people' and the 'explicit mention of rights'. This along with other contentious issues were further discussed in several meetings of the ad hoc working groups in Bonn and Barcelona in 2009, and a negotiating text was prepared without much consensus among different parties. As a result, the negotiating text for COP 15 had increased from 56 pages to around 200 pages to include all the issues and interests (Holloway and Giandomenico 2009).

REDD+ got prominence with its due acknowledgment in the Copenhagen Accord in 2009. The Cancun Agreement of COP 16 in 2010 emphasized the role of REDD+ not only as a mechanism for reducing emission, but also for halting and reversing the loss of forests. It also encouraged countries to explore effective ways to slow, halt, and reverse forest cover in their respective territories by identifying the drivers and addressing them through appropriate measures. The Cancun REDD+ text further delineates details about the readiness guidance for countries seeking implementation of REDD+. The readiness activities include the national plan, institutional reform for governance, national reference emission level, and mechanism for MRV. There have also been references to the principles and safeguards that all the actors implementing REDD as well as providing finance need to follow for effective REDD+ programmes.

The negotiations at COP 17 held at Durban in December 2012 also marked some progress on REDD+, though there are several unresolved issues concerning the implementation of REDD+. The major issues include lack of clarity on definitions of terms like 'forest degradation', 'sustainable management of forests', and 'conservation'; inadequate and imprecise guidelines on reference emission levels, safeguards, and linkages with Nationally Appropriate Mitigation Actions (NAMAs); and uncertainty over finance as well as the institutional mechanism for financing REDD programmes at a global scale (Daviet 2010, 2011). All the parties are yet to have a consensus on the source of finance, with some countries favouring a market-based approach, while others advocating a fund-based approach; some are in favour of a mixed approach (Dooley 2008). The funding sources as well as its institutional mechanism have strong implications on REDD design and outcomes.

The UN-REDD programme and World Bank's Forest Carbon Partnership Facility are the two REDD payment programmes in operation. The current approach for REDD+ initiatives has three phases of implementation. Phase 1 is characterized as the 'readiness' phase where the countries prepare their national REDD+ strategies; Phase 2 involves development of implementing polices and recognizing emission reduction in national strategies which is the advanced readiness phase; and Phase 3 is called the compliance phase where the forest-owning countries are compensated for quantified reduced carbon emission and removals due to reduction in deforestation and forest degradation or due to sustainable forest management.

The major contentious issue concerning REDD+ implementation globally is lack of consensus on MRV methodologies and the reference baseline for the emission measurement along with the financial mechanism. Some countries argue for a country-specific (historical) baseline, whereas others advocate using a global baseline (Dooley 2008). Along with these issues, implementation of REDD faces a host of ethical and operational challenges which need to be addressed for its effective implementation. Some of these operational challenges can be resolved with more clarity on REDD+ governance in future COPs. It is also important

that the implementation of REDD+ draws lessons from the discourses on existing forest governance in different parts of the world. Understanding the mechanisms that focus on enabling the implementation of already-agreed upon requirements on forest certification as well as other PES schemes may provide important insights and lessons to address similar challenges for REDD+ implementation (Kanowski et al. 2011).

However, at the national level, there are the major challenges of REDD+ implementation. These include lack of financial resources, inadequate technical capacity for the implementation of sustainable forest management and inadequate administrative capacity to design and implement REDD+ projects. India does have policy, legal and institutional mechanisms to implement the concept of REDD+ but there remain several gaps such as unresolved issues of forest governance, unsustainable harvest of forest produce, forest degradation. inadequate monitoring and evaluation, and mechanisms for assessment of carbon stock.

References

Angelsen, A., Brockhaus, M., Sunderlin, W.D. and Verchot, L.V. (eds). 2012. *Analysing* REDD+: Challenges and Choices. CIFOR, Bogor, Indonesia.

Chhatre, A and A. Agrawal. 2009. Trade-off and Synergies between Carbon Storage and Livelihood Benefits from Forest Commons. *PNAS*, 106 (42): 17667–17670.

Davidar, P., S. Sahoo, P.C. Mammen, P. Acharya, J-P. Puyravaud, M. Arjunn, J.P. Garrigues, and K. Roessingh. 2010. Assessing the Extent and Causes of Forest Degradation in India: Where do we Stand? *Biological Conservation*, 143: 2937–2944.

Daviet, F. 2010. From Copenhagen to Cancun: Forests and REDD. Available at http://www.wri.org/stories/2010/05/copenhagen-cancun-forests-and-redd (accessed on February 22, 2012).

———. 2011. Forests and REDD+ in COP17 Durban. Available at http://insights.wri.org/news/2011/11/forests-and-redd-cop17-durban (accessed on February 22, 2012).

Diaz, D., K. Hamilton, and E. Johnson. 2011. State of the Forest Carbon Markets 2011: From Canopy to Currency, Ecosystem Market Place. Available at http://www.forest-trends.org/documents/files/doc_2963.pdf (accessed on June 28, 2012)

Dooley, K. 2008. An Overview of Selected REDD Proposals. Brussels: FERN. Available at http://www.fern.org/sites/fern.org/files/media/documents/document_4314_4315.pdf (accessed on January 15, 2012).

Ghazoul J., R.A. Butler, J. Mateo-Vega, L. Pin Koh. 2010. REDD: A Reckoning of Environment and Development Implications. *Trends on Ecology and Evolution* 25: 396–402.

Holloway, V. and E. Giandomenico. 2009. The History of REDD Policy, Carbon Planet White Paper, p. 20. Available at http://unfccc.int/files/methods_science/redd/application/pdf/the_history_of_redd_carbon_planet.pdf (accessed on July 15, 2012).

Hiraldo. R and T. Tanner. 2011. The Global Political Economy of REDD+: Engaging Social Dimensions in the Emerging Green Economy, Occasional Paper 4, UNRISD and FES.

IPCC. 2007. Climate Change 2007: IPCC Fourth Assessment Synthesis Report.

Kanowski , P.J., C.L. McDermott, B.W. Cashore. 2011. Implementing REDD+: Lessons from Analysis of Forest Governance. *Environmental Science and Policy* 14: 111–117.

Mahapatra, K and S. Kant. 2005. Tropical Deforestation: A Multinomial Logistic Model and Some Country-specific Policy Prescriptions. *Forest Policy and Economics* 7: 1–24.

Minang, P.A., S. Jungcurt, V. Meadu, D. Murphy. 2009. *The REDD Negotiations: Moving into Copenhagen*. Manitoba: International Institute for Sustainable Development.

Ministry of Environment and Forests (MoEF). undated. India's Forests and REDD+. Available at http://moef.nic.in/downloads/public-information/REDD-report.pdf (accessed on February 12, 2012).

Environmental Science and Policy, 14: 100–110.

UNFCCC. 2007. Report of the Conference of Parties on its Thirteen Session, held in Bali from 3 to 15 December 2007, Decisions adopted by the Conference of the Parties. Available at http://unfccc.int/resource/docs/2007/cop13/eng/06a01.pdf (accessed on July 18, 2012).

———. 2011. Submission by India to SBSTA. Available at http://unfccc.int/files/methods_science/redd/submissions/application/pdf/india_driversdeforestationdegrdn_sbsta.pdf (accessed on February 12, 2012).

Wertz-Kanounnikoff S. and M. Kongphan-apirak. 2009. Emerging REDD+: A Preliminary Survey of Demonstration and Readiness Activities, CIFOR Working Paper 46. Bogor: CIFOR.

Wunder, S. 2001. Poverty Alleviation and Tropical Forests: What Scope for Synergies. *World Development* 29 (11): 1817–1833.

Chapter 2 Methodology

The overall objective of this study is to examine the potential of REDD+ implementation in India through a comprehensive assessment. The following tasks have been identified to achieve the assigned mandate:

1. Analyzing International Architecture for REDD plus and its relevance to India
2. Studying potential impacts and response options for REDD plus
3. Undertaking a comprehensive assessment for designing a REDD plus project in the field

This report is based on the outputs of Task 3 above, though it draws upon the outputs of Tasks 1 and 2. Detailed reports for Task 1 and 2 are available separately.

The task wise methodologies adopted for achieving the assigned mandate are as under:

Analyzing International Architecture for REDD Plus and its relevance to India

The forest related international instruments, processes and agreements with respect to sustainable forest management such as International Forest Policy, Forest Principles, IPF/IFF, UNFF, CBD, UNCCD, UNFCC, MDGs, JPOI, Agenda 21, IAF, COFO, ITTA, Regional Forestry Commission have been reviewed with the purpose of establishing linkage with climate change mitigation and adaptation. The literature related to the evolution of REDD+ under the umbrella of UNFCCC was studied in detail. A study of international architecture cannot be complete without linking it to the institutional mechanism in the developing countries. A national level consultation process has therefore been initiated with multiple stakeholders such as state forest department officials, MoEF, international organizations with presence in India, NGOs and experts . The consultations have focussed on the following themes:

1. Sustainable Management of Forests in context of different forest related international instruments and its relevance to REDD+

a) Key issues, Challenges and Opportunities

b) Institutional arrangement for implementing REDD plus

2. Assessment of Carbon under REDD+

a) MRV issues for REDD Plus – Linkages with alternative approaches

b) Methodological framework for REDD plus- Learning from CDM A/R

3. Field level observations on SFM and REDD Plus in India

4. Introduction to and a brief update on the current debate on REDD plus in international climate change negotiations- where are we heading?

a) Evolution of REDD+ under UNFCCC

b) International forest policy

c) India's position on REDD+

5. Voluntary markets for carbon trading in the context of REDD Plus

The subject was also discussed in an international consultation during COP-11 of CBD where representatives of more than 20 countries participated and discussed issues related to international REDD+ architecture and its relevance for developing countries. The South Asian perspective of REDD+ was discussed by experts from more than 10 countries in a workshop during the Delhi Sustainable Development Summit 2013. Proceedings of all consultations were uploaded on the website of MoEF. On the basis of consultations and review of literature a report on International Architecture of REDD+ and its relevance for India was prepared.

Studying potential impacts and response options for REDD Plus

The literature under the following elements was reviewed to understand the policy and legal framework needed for the implementation of REDD+ in India.

Drivers of Deforestation and Forest degradation:

- Economic Growth and Development
- Poverty
- Unemployment
- Livelihood dependence on forests
- Livestock population
- Agriculture Growth

Policies impacting Forests:

- NFP, 1988
- NEP, 2006
- Agriculture Policy
- Energy Policy
- Water Policy
- Tribal Policy
- EXIM policy

Legal Framework impacting Forests:

- IFA, 1927 and its amendments
- FCA,1980
- FRA, 2006
- WLPA,1972
- BDA,2002
- EPA,1986
- Regulation for felling of trees on private land

- Judicial activism

Assessment of Forests and Contribution towards GDP:

- Review of existing mechanism for MRV
- Development of methodology for MRV in future
- Review of existing mechanism of assessing contribution of forestry sector to GDP
- Policy recommendations for estimation of true contribution of forests into GDP

Green India Mission (GIM) and REDD+:

- Implementation issues in GIM
- Enhancement of carbon sink in sustainably managed forests and other ecosystems
- Adaptation of vulnerable species/ecosystems to climate change
- Adaptation of Forest Dependent Communities

National, regional, state, district and village level consultations with state forest department officials, MOEF, MOTA, MORD, international organizations, NGOs and independent experts were organized on the following elements to understand the existing policy and legal framework needed for REDD+ in India and the kind of policy interventions that are needed to implement REDD+ in India. The consultations were organised around the following broad themes:

1. REDD+ and its relevance to India
2. Forest governance in India & REDD+
3. Forest and livelihood issues in the context of REDD+
4. Forest Management (SFM) and Working Plans
5. Methodologies for Carbon Assessment, Leakages and Additionality of carbon
6. Discussion on setting of Baseline Data, Reference Levels for carbon assessment
7. Biodiversity Conservation in the context of REDD+

The issue of forest governance is very important for the implementation of REDD+ , and this was discussed in a separate national level consultation. The proceedings of these consultations were uploaded on the website of MoEF to get wider readership and comments. On the basis of extensive literature review and the views of different stakeholders (as expressed in the consultations) , a report on potential impacts and response options for REDD plus in India was prepared, suggesting many policy interventions. In addition six policy briefs and a full-length book on REDD+ and SFM in India were produced. These are listed below:

Book

Sustainable Forest Management and REDD+ in India (TERI 2013)

Policy Briefs

- International REDD+ architecture and its relevance for India.
- Institutional framework for implementing REDD+ in India.

- Forest governance and implementation of REDD+ in India.
- Livelihood of local communities and forest degradation in India.
- Conservation of biodiversity and ecosystem services by REDD+ project in India.
- Methodology for assessing carbon stock for REDD+ project in India.

Undertaking a comprehensive assessment for designing a REDD plus project in the field

As mentioned earlier, the objective of REDD+ is to reduce emissions from deforestation and forest degradation and enhance carbon stock with maintenance of ecosystem service, livelihood of the forest dependent communities (FDCs) and biodiversity conservation for compensating conservation efforts of the community through payment for enhanced carbon stock. There is no problem of deforestation in India, but forest degradation is a major hindrance to get benefits from REDD+. The cause of the forest degradation lies largely outside the forestry sector. The members of the FDCs depend on forests for their livelihood and often recourse to unsustainable harvest of minor forest produce . fodder and fuel wood. It is important to understand the dependence on forests for subsistence or livelihood needs through detailed socio-economic survey. There were many underlying research questions that led to the identification of the pilot sites: :

1. What are the major reasons for forest degradation?
2. How much is the dependence of the community for their livelihood and subsistence needs?
3. What is the sustainable quantity of minor forest produce, fodder and fuel wood?
4. How can the enhancement of carbon could be measured which are acceptable to global scientific community?

Representativeness of the pilot sites was also a consideration. Due to resources constraints , five pilots were identified in Uttarakhand, Uttar Pradesh, MP, Odisha and WB representing temperate forest ecosystem, tropical forest ecosystem and mangrove forest ecosystems. The criteria for identifying particular sites with these areas are as follows:

1. High dependence of FDCs on forests for their livelihood and subsistence
2. Scope of enhancing carbon stock with conservation effort
3. Existence of JFM mechanism
4. Recognition of rights of the FDCs.

Figure 2.1 below shows the location of the sites alongwith their key characteristics.

Once sites were identified, it was necessary to have workshops in the respective villages to make the community members understand the concept of REDD+ and the means through which they can contribute towards enhancement of carbon stock without compromising their dependence on the forest and without infringement of their rights. After village level consultations and physical visits of the forests, site-specific questionnaires were prepared to assess the dependence on the forest. Local NGOs were involved in this process, and in a few cases, they were directly involved in the conduct of the survey. The data collected through the socio-economic survey was analyzed and shared with villagers for primary validation, as far as practicable. The sustainable limit of fuel wood, fodder and various MFPs were estimated on the basis of working plans, research papers and discussions with community

and forest officials. The detailed methodology for estimating sustainable limit has been given in the respective chapters. . The level of unsustainable harvest has been estimated by deducting sustainable quantity from the total harvest as deduced from the survey.

The most important element under REDD+ is the enhancement in the carbon stock. Five pools of carbon (viz Above Ground Biomass, Below Ground Biomass, and Soil Organic Carbon, Leaf Litter and Deadwood) have been considered for this exercise in line with UNFCC guidelines The detailed methodology for this component is provided in Chapter 3.

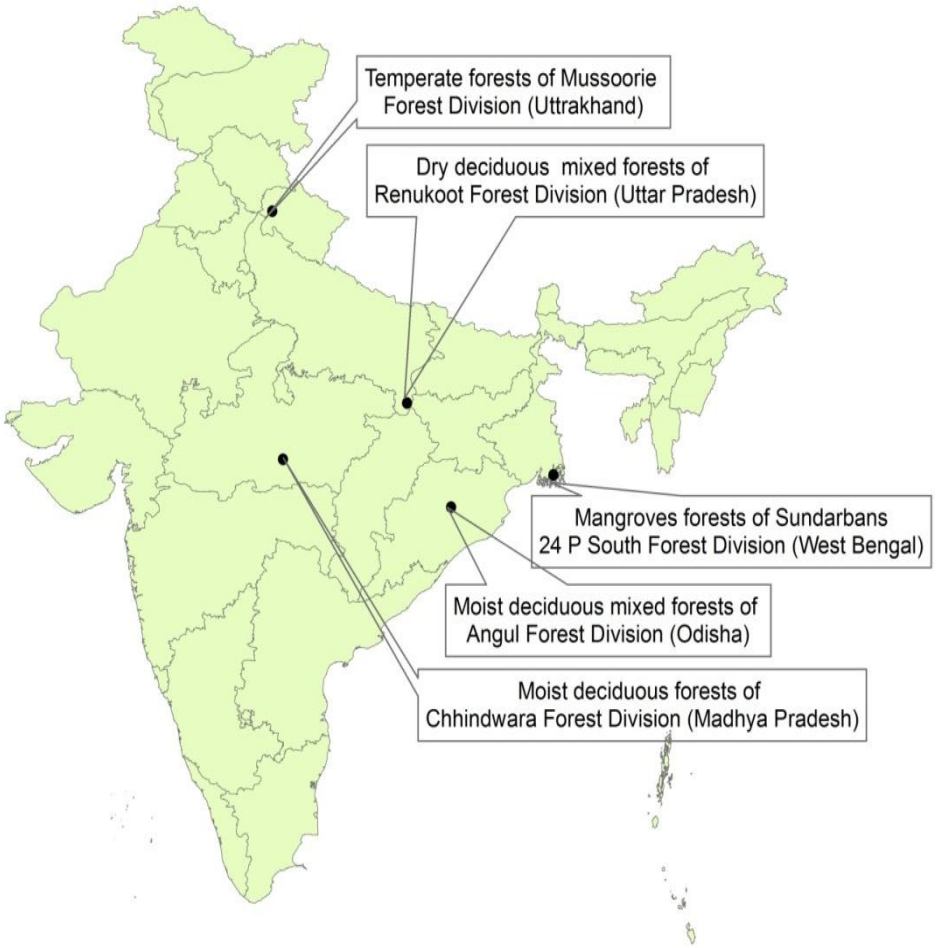


Figure 2.1 Location of the pilot sites

Chapter 3 Carbon stock assessment for REDD plus pilot project sites in India

Brief description of the selected sites

Five pilot sites – one each from Odisha, Madhya Pradesh, Uttarakhand, Uttar Pradesh and West Bengal - were selected for undertaking a comprehensive assessment in designing a REDD Plus project at the field level in India. These sites represent temperate, tropical moist deciduous, sub-tropical dry deciduous, dry deciduous and mangrove forest types. Basic criteria adopted to select these sites were a range of existing drivers of deforestation and degradation, availability of secondary data, willingness of the local communities to participate in the project activities, different topography and varied climatic zones. Details of each site are provided in the socio economic report of this project. Brief description of each site is given below

1. Jereng Budhipahad village forest and Parha and Katada Reserve forest of Angul Forest Division in Odisha, which is a tropical moist deciduous forest.
2. Compartment no. 164 and 165 of Delakhari Forest Range of West Chhindwara Forest Division in Madhya Pradesh, which is subtropical dry deciduous forest.
3. Maghra - 5 Forest Beat in Jaunpur Forest Range of Mussourie Forest Division in Uttarakhand, comprising temperate Chir pine and Oak forests.
4. Gardawa Forest Beat in Dudhi Range of Renukoot Forest Division in Uttar Pradesh, consists of dry deciduous forest type and
5. Compartment no. 4,5,6,7 and 8 of Herobhanga Beat of Matla Forest Range of 24 Parganas South Forest Division (Sunderban) in West Bengal, comprising of mangrove forest type.

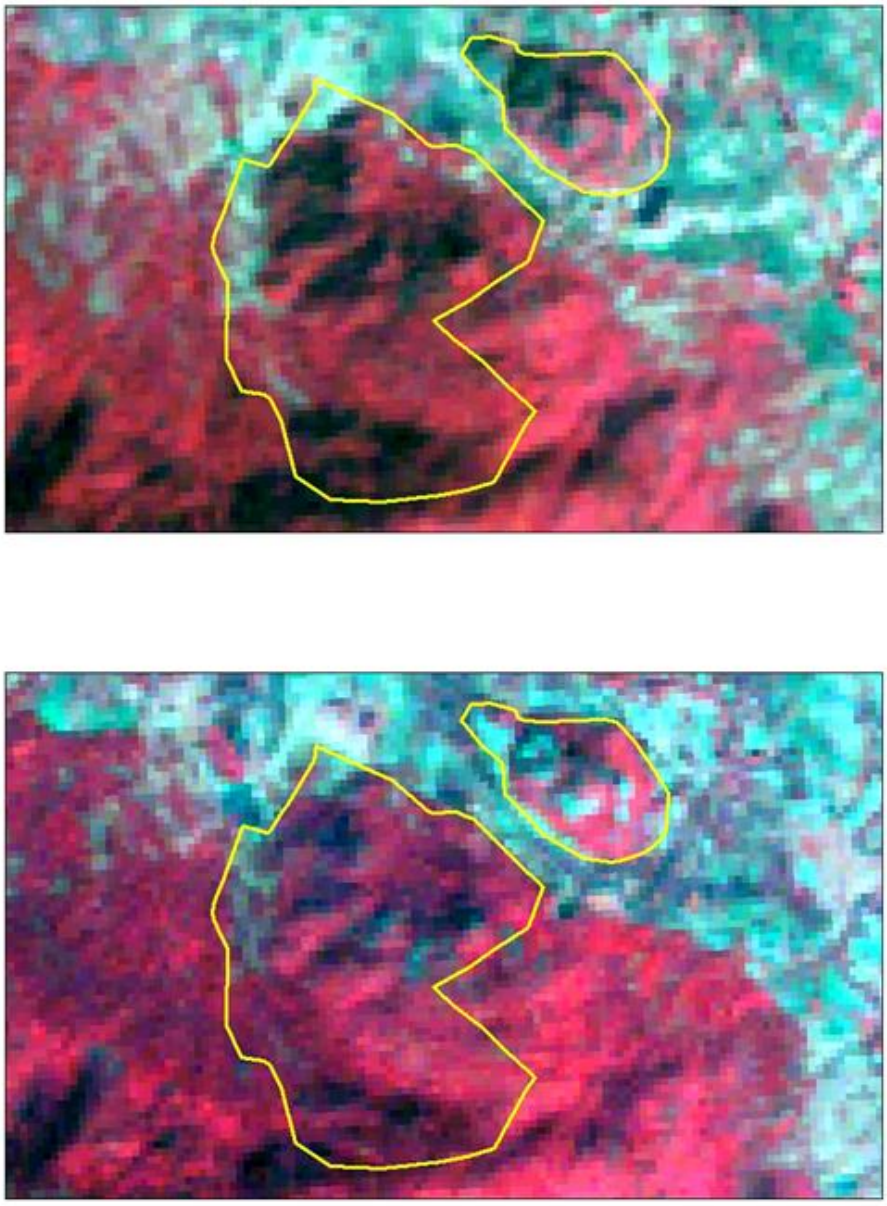


Figure 3.1 Satellite imageries of the project area in Angul for the year 1990 (above) and 2012 (below)

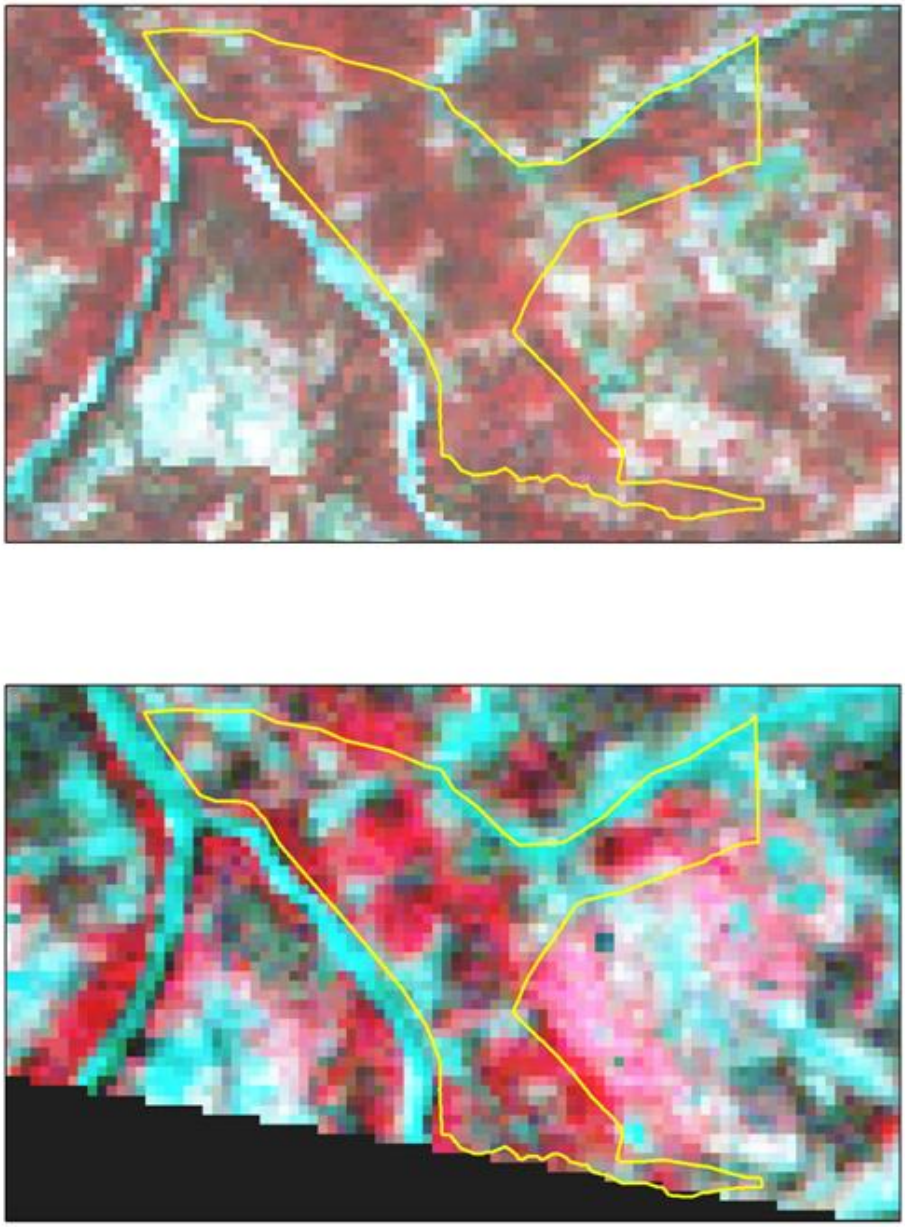


Figure 3.2 Satellite imageries of the project area in Chhindwara for the year 1990 (above) and 2012 (below)

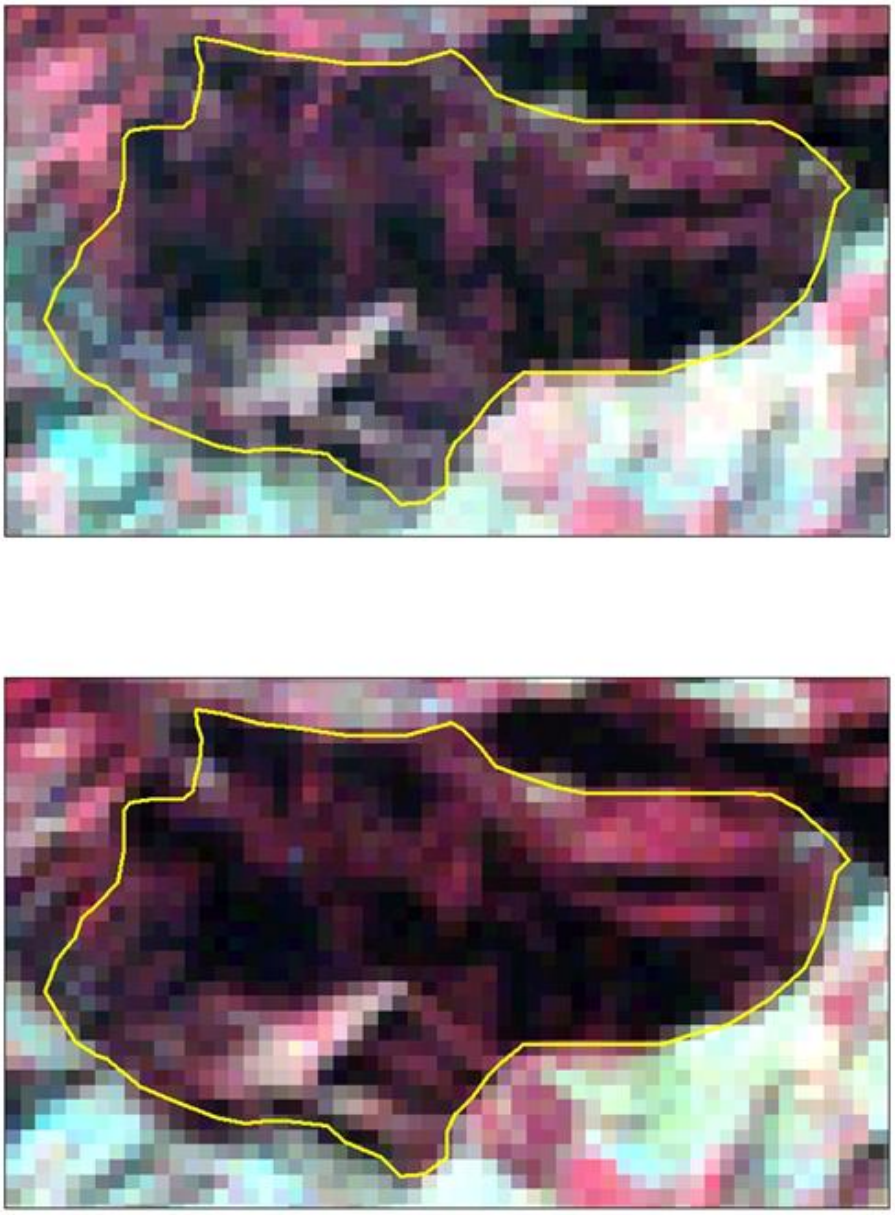


Figure 3.3 Satellite imageries of the project area in Mussourie for the year 1990 (above) and 2012 (below).

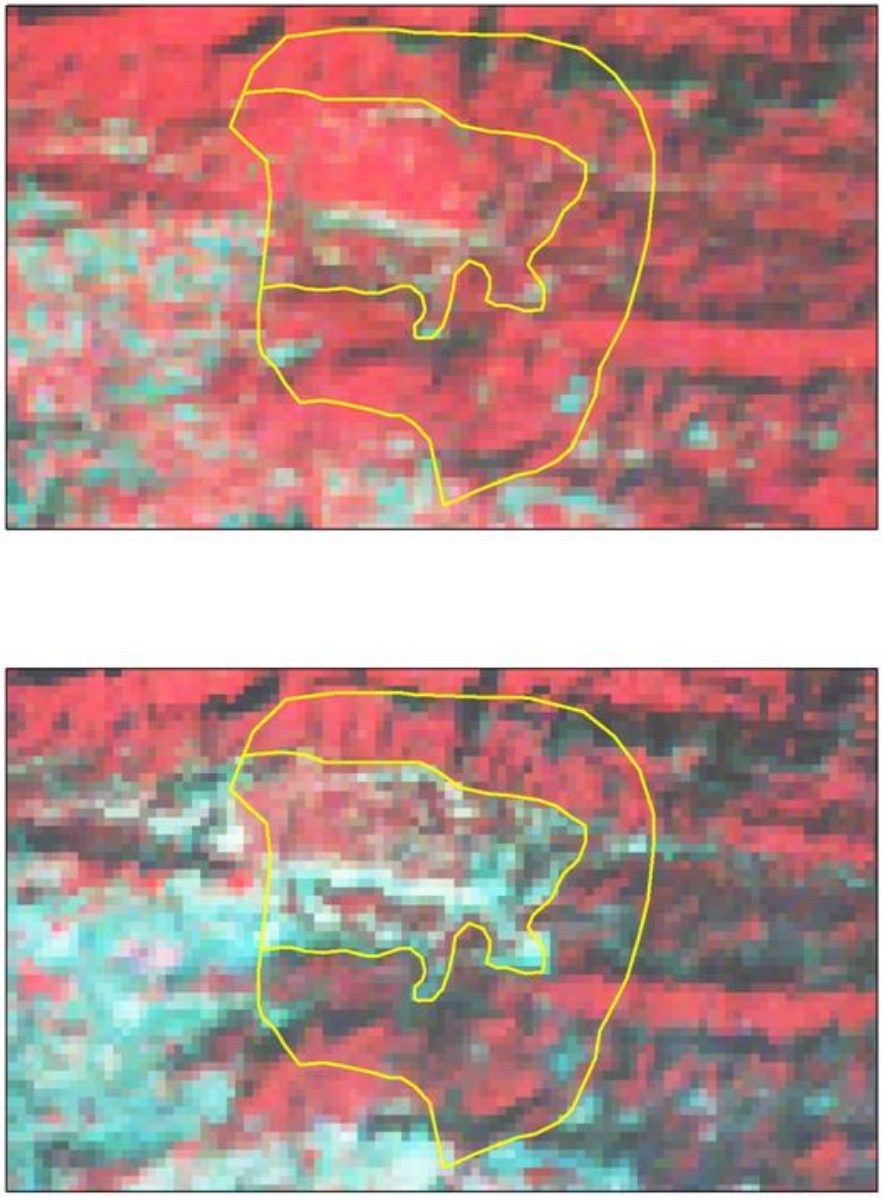


Figure 3.4 Satellite imageries of the project area in Renukoot for the year 1990 (above) and 2012 (below).

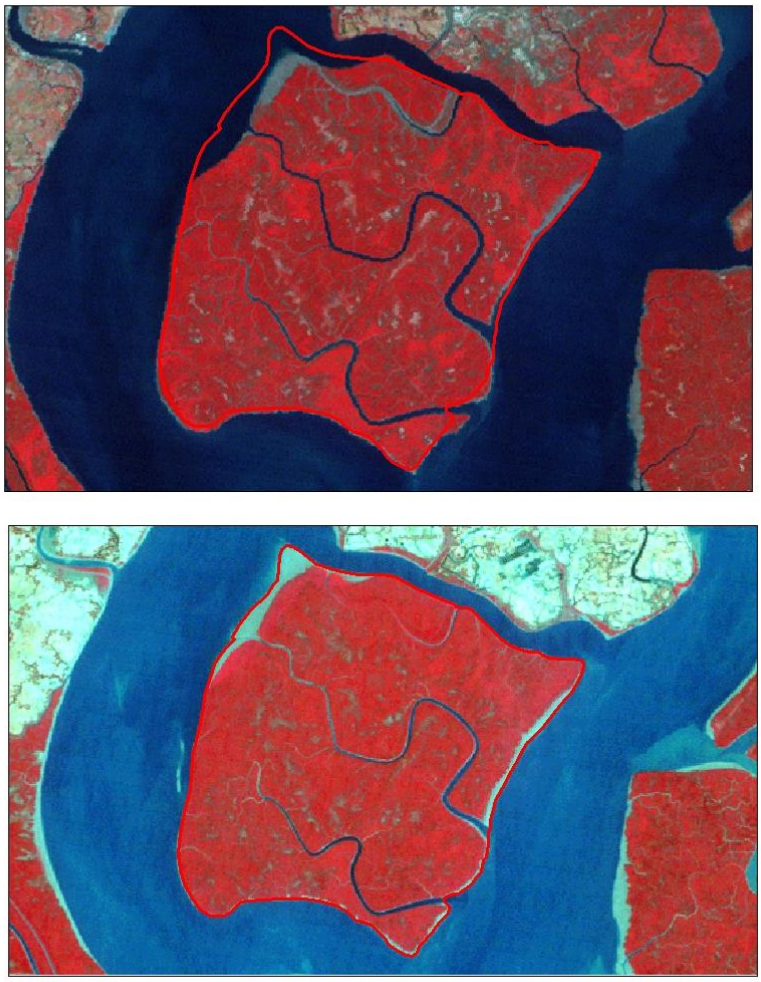


Figure 3.5 Satellite imageries of the project area in Sunderban for the year 1990 (above) and 2012 (below)

Methodology for assessing forest carbon stocks

Delineation of the project boundaries

There are many tools available for identifying and delineating the project boundaries, such as satellite imageries, aerial photographs and topographic maps. (Subedi et al, 2011). To prepare base map for each project site, forest compartment or beat maps along with the geo coordinates in the satellite imageries and toposheets were collected from the respective divisional forest office. With the help of these geo coordinates, base map for each site was prepared. . Each base map includes the details of the project areas such as different land use categories, forest types, water bodies, open land, agricultural land etc. On the basis of these base maps, project areas were calculated. Angul site comprises 200 hectare area, Chhindwara site comprises 162.33 ha and 314.84 ha respectively (total of 504 ha area), Mussourie site has 95 ha area, Renukoot site spreads over 77 ha area and Sunderban site spreads over 4420 hectares area. The project areas of each site have been verified in the field during the ground trothing. Further, project boundaries were clearly demarcated to facilitate accurate measuring, monitoring, accounting, and verification of the project activities.

To lay out the sample plots, stratified random samplings were done in all the selected five project sites covering all the project stratums in each project site. Numbers of sample plots to be laid out were calculated and locations were identified in the field. The geo coordinates of each sampled plot for all the sites were recorded with the help of Global Positioning System (GPS) and digitized in the satellite imageries of each respective site.

Estimating number of sample plots

To measure each and every tree within the each selected site is not only time consuming, but also practically not feasible. Pearson et al in 2005 has developed a statistical tool through which one can estimate the required number of sample plots to be laid in the project site that are statistically significant (Pearson et al, 2005). Thus, through this statistical tool, measuring only a fraction of trees from the total project area can provide true values of biomass of the entire project area. The number of estimated sample plots to be laid out in the selected site depends upon various factors such as size and number of stratums, basic carbon density and its standard deviation in the selected project area. In all the selected five pilot sites, estimated number of sampled plots to be laid out at each pilot site was calculated through this formula. The methodology for estimating the number of sample plots to be laid out at each pilot project site that were statistically significant is described below step by step in details.

Step I. Identify the desired precision level.

(± 10% of the mean at the 95% confidence interval is frequently used)

Step II. Identify the area or preliminary data.

(6-10 plots per stratum will suffice for variance analysis)

Step III. Estimate carbon stock per tree, per plot, per ha and mean carbon stock/ha.

Step IV. Calculate standard deviation of carbon (tC/ha) of all plots.

Step V. Calculate the required number of plots using following equations:

$$n = \frac{(N \times s)^2}{\frac{N^2 \times E^2}{t^2} + N \times s^2}$$

Whereas;

E = Allowable error or the desired half-width of the confidence interval. Calculated by multiplying the mean carbon stock by the desired precision (that is, mean carbon stock x 0.1, for 10 per cent precision),

t = Sample statistic from the t-distribution table for 90% confidence level at infinite degree of freedom is 1.645 (A default value, also referred in tools for calculating sample plots in afforestation and reforestation CDM projects).

N = Number of sampling units for stratum (total area divided by plot area)

n = Number of sampling units in the population

s = Standard deviation of stratum

In lieu of calculating the statistically significant number of sample plots in all the selected pilot project sites, a preliminary data collection and physical measurement of vegetation was carried out. Measurement of height and girth of trees were taken randomly from the distributed sample plots of size 20m * 25m dimension at each selected project sites. Then requisite calculations were done to estimate the biomass, carbon stock and CO_2e. The table 1 given below represents the number of sample plots to be laid at each project sites.

Table 3.1 Number of sample plots laid out at each project site

Project sites	Angul	Chhindwara	Mussourie	Renukoot	Sunderban
Total project area (ha)	200	504	95	77	4420
No. of pilot sample plots laid out	7	7	6	7	10
Sampling units (N)	4000	10080	6333	1540	88400
Std. Deviation (S)	1.78	2.59	1.75	1.35	3.89
Allowable Error (€)	0.77	1.13	0.59	0.64	1.2
No. of sample plots calculated	14	14	23	12	28
No. of actual sample plots laid out	20	20	30	22	40
Size of the sampled plot	20m*25m	20m*25m	10m*15m	20m*25m	20m*25m

Laying out of sample plots

The shape and size of the sample plots is a trade-off between accuracy, precision, time, and cost for measurement (CRISP, 2011). In general, sample plots should be either permanent or temporary. Permanent sample plots are statistically more efficient in estimating changes in forest carbon stocks. Similarly, sample plots can either be one fixed size or 'nested,' this means that they comprise smaller sub-units for various carbon pools. Nested plots are generally more practical and efficient in estimating forest biomass. Thus, in the present carbon inventory study, permanent nested sample plots were laid out in all the five selected pilot sites.

The required number of the permanent sample plots with appropriate sizes and shapes was carried out at the start of the project in each project sites. The size of the permanent sample plot was 20m x 25m at all the sites except at Mussourie Forest Division where it was 10m x 15m due to undulating terrain and steep slopes. Approximately, 20 to 40 nested permanent sample plots were laid out at each project site of Angul, Chhindwara, Renukoot and Sunderban forests, while 30 permanent nested sample plots were laid out at Mussourie forest division due to uneven, hilly and undulating terrains. The size of all the permanent nested sample plot in all the sites were 20m x 25m for tree species, 2m x 2m for deadwoods and 1m x 1m for leaf litter, except for except Mussourie forest division. Wherein the size of the sample plot was 10m x 15m for tree species, 2m x 2m for deadwoods and 1m x 1m for Leaf Litter. In each permanent nested sample plot of tree species, total three sub plots for deadwoods and three sub plots for Leaf Litter were laid out randomly.

Photo 3.1 Laying out of sample plots in project area

The figure below provides the picture of the permanent nested sample plots being laid out in requisite number at project sites. A bigger plot of size 20m x 25m was first laid to measure the girth and height of the trees, then inside this bigger plot three sub plots of 2m x 2m for estimating deadwood biomass and another three sub plots of 1m x 1m for estimating leaf litter biomass were laid out (Gera and Chauhan, 2010). Soil samples were also collected from the two different corners of the permanent sample plot at three different depths i.e. 15 cm, 30 cm and 45 cm.

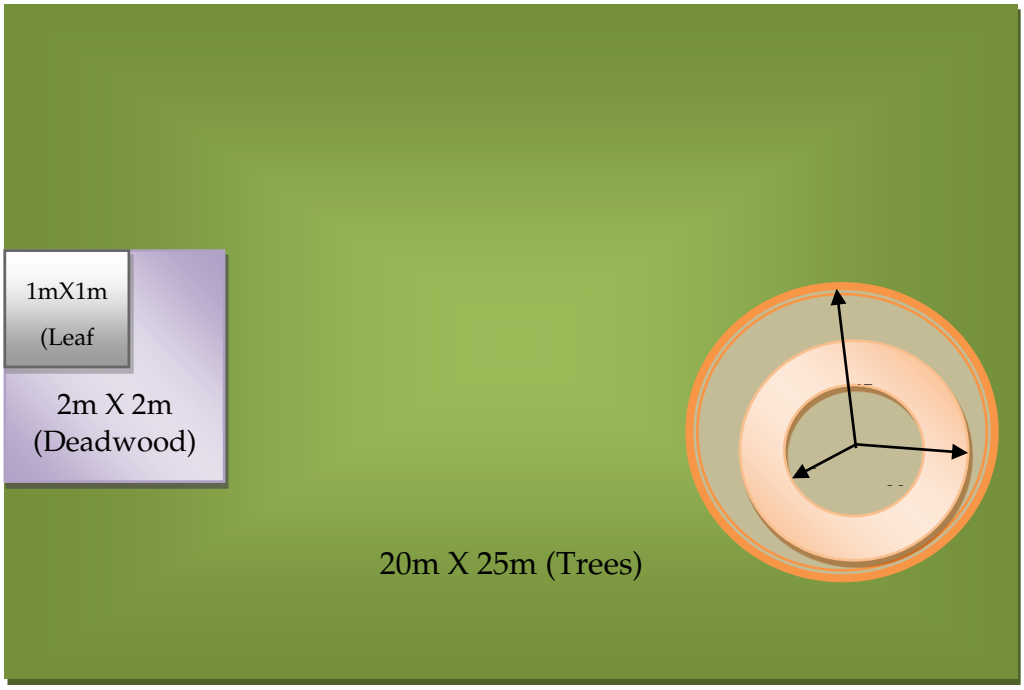


Figure 3.6 Permanent nested sample plot laid at all the project sites

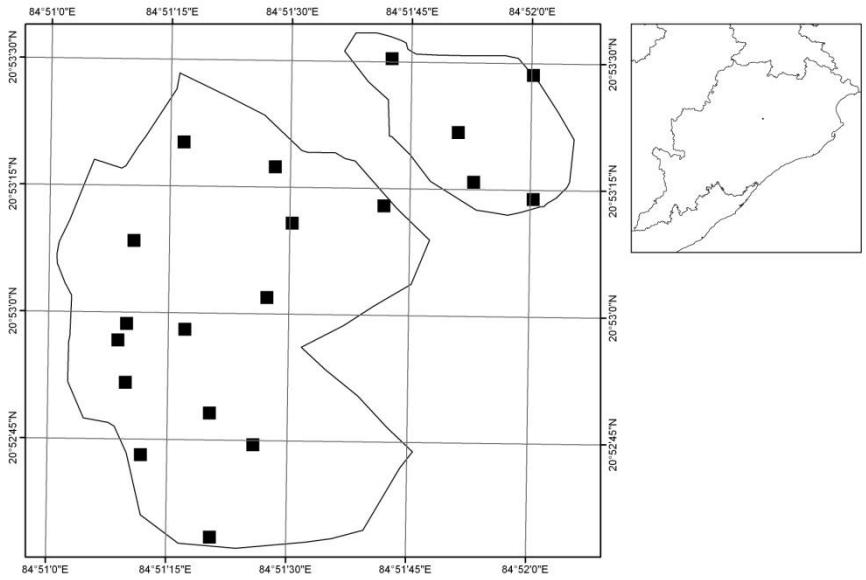


Figure 3.7 Location of the sample plots laid out at Angul site

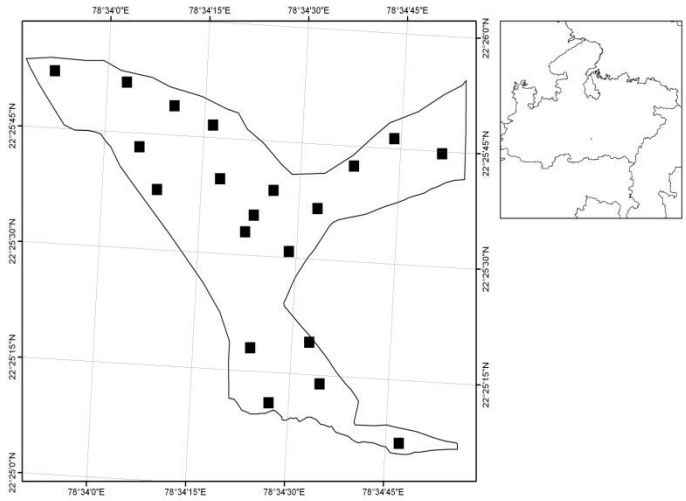


Figure 3.8 Location of sample plots laid out at Chhindwara site

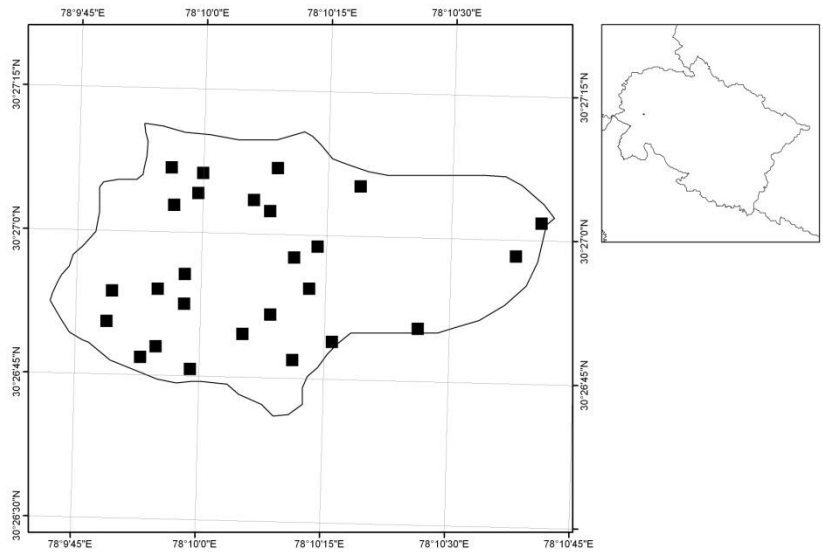


Figure 3.9 Location of sample plots laid out at Mussourie

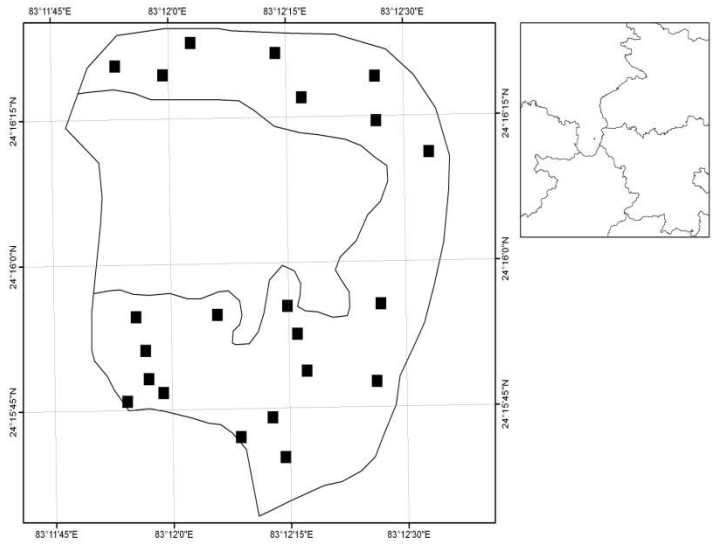


Figure 3.10 Location of sample plots laid out at Renukoot site

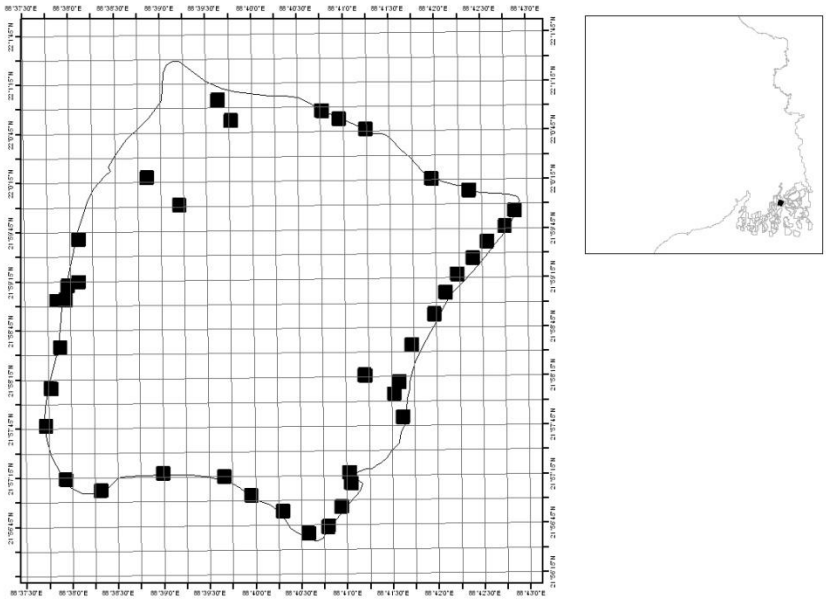


Figure 3.11 Location of sample plots laid out at Sunderban site

Eligible carbon pools

Major eligible carbon pools from the forest areas are Above Ground Tree Biomass (AGTB), Below Ground Tree Biomass (BGTB), Deadwoods (DW), Leaf Litter (LL) and Soil Organic Carbon (SOC). Generally, the carbon pools which require less efforts, time and resources in estimating the carbon were selected. A pool should be measured if it is large or if it is likely to be affected by land use, or size of the pool are uncertain. Small pools or those unlikely to be affected by land use may be excluded. Though all these five carbon pools are not necessarily required in every project, but in the present carbon inventory study we have selected all these five major carbon pools from all the selected project sites for estimating the overall carbon in each project site. The AGTB mainly includes biomass of tree bole and branches, BGTB includes biomass from the roots of the tree, DW includes biomass from fallen twigs and branches, Leaf Litter includes biomass from the semi decomposed leaf material and SOC includes the carbon present in the soil of each pilot project site. Estimation of carbon through measurement of trees, dead wood, leaf litter, and soil organic carbon was carried out in scientific and systematic ways (Chauhan and Gera, 2010). Field measurement data was collected based on an appropriate sampling strategy and statistical sampling design. A combination of systematic and stratified random sampling was adopted for data collection in each project site (FSI, 2011).

Measurement of tree

Measurement with precision and accuracy were maintained by the field expert to minimize any systematic or random errors during measuring the tree lying within the sample plots. Measurements were recorded for all the trees lying within the permanent nested sample plot, starting from the north direction. Botanical as well as local names were recorded for all the trees present within the sample plot. Diameter at breast height (DBH) is the basic measurement standard for trees, which was measured at 1.37 m height of the tree. Care was taken while measuring the DBH of a tree, if a tree was on the slope, it was measured from the uphill side. Trees on the border of the sample plot must be included if > 50% of their basal area fall within the plot and excluded if < 50% of their basal area fall outside the plot. Trees overhanging into the plot are excluded, but trees with their trunks inside the sampling plot and branches outside are included. If a tree was forked at below the dbh, it was measured just below the fork point. If it is not possible to measure below the fork than it was assumed to be two separate trees (Chaturvedi and Khanna, 1982). Similarly, height of the tree was measured directly by various instruments such as Ravi multi meter and Haga altimeter. Before taking the height, slope correction was taken into account especially in case of the Mussourie site, where the project site was mountainous, uneven and undulating. Before laying out a sample plot, 90 degree pythagoras check was prepared to get the correct rectangular plot. Botanical names and local names were recorded for each tree species lying with in the rectangular plot this helped us in improving the estimates of wood densities and application of local volume equations. The tree species which were <=10 cm in girth were considered as saplings and measured separately. Further, the stem girth (in cm) was converted to a diameter (d, in cm) using the following formula: d = Girth/ , (= 3.14).

Photo 3.2 Measurements of tree height and girth

Measurement of Deadwood (DW)

Within each permanent sample plot, randomly three sub plots of size 2m x 2m were laid separately for estimating the biomass and carbon content from deadwoods in each project site. To maintain the uniformity of these sub plots, locations inside the nested tree sample plot were identified mainly at the corners of the tree sample plot. The fallen twigs, branches and deadwoods were collected from these sub plots, sun dried and then directly weighed in the field itself to get the dry weight of the deadwoods. The dry weight of deadwoods from all the three sub plots in each quadrant was averaged and extrapolated on per hectare basis. This data was recorded in the separate work sheets.

Photo 3.3 Measurements of dead wood within the sample plot

Measurement of Leaf Litter (LL)

Within each permanent nested tree sample plot, three sub plots for Leaf Litter (LL) were laid randomly for estimating the biomass and carbon content from it. The size of each sub plot was 1m x 1m and for uniformity these sub plots were laid generally at the corners within the shrub plots of 2m x 2m. All the semi decomposed materials in the form of Leaf Litter were collected from the organic layer upto 5 cm depth, sun dried it, sieved it and then weights it to get the dry weight of the Leaf Litter in each sub plot. The dry weight of the Leaf Litter from all the three sub plots in each tree quadrant was averaged and calculated on per

hectare basis. Data for Leaf Litter were recorded in separate worksheets. Data feeding and compilation work was then performed to assimilate and maintain systematic and clear database of all measurements in each plot and sub plot.

Photo 3.4 Measurements of leaf litter within the sample plot.

Collection of soil samples

The main aim of soil sample collection was to analyse the carbon percentage within each project site. For collecting the soil samples, litter and small plants were first cleaned from the surface of the soil surface to remove contaminations from small plants and litters and then soil augur was used for digging the soil. Soil auger was made to rotate clockwise gently up to a depth of 15 cm and soil sample was collected in a polythene marked with 0-15 cm. Using auger and repeating the process, soil samples from 16-30 cm layer and 31-45 cm layer were collected in different polythene marked with 16-30 cm and 31-45 cm respectively (Hairiah K, 2010). Soil samples were taken from three different depths i.e., 15 cm, 30 cm and 45 cm at two diagonally opposite corners of each alternate permanent tree sample plot from all the selected project sites. Soil sample from different places were mixed together to form a uniform mixture on the basis of the depth from which it was collected. Thus around ten soil samples for each depth were collected from each project pilot sites for analysing the carbon percentage in the soil laboratory.

Photo 3.5 Collection of soil samples

Data Analysis

Above Ground Tree Biomass (AGTB)

The selection of the appropriate allometric equation is a crucial step in estimating the aboveground tree biomass (AGTB). Allometric equations for biomass usually include information on trunk diameter at breast height, total tree height and basic wood density. Thus, to assess the AGTB, species specific allometric equation or biomass values from the biomass tables based on the allometric equations were applied for all the tree species. Volume equations were mainly referred from the Forest Survey of India's publication published in 1996, which comprised volume equations of major tree species of India, Nepal and Bhutan (FSI, 1996). Besides, research articles, forest working plans and forestry journals were also reviewed thoroughly to get the volume equations of the tree species that were not available in the FSI publication. General volume equations or volume of cylinder was considered for those tree species whose allometric volume equations were not available, assuming cylindrical bole of the tree (Chatuvedi and Khanna, 1982). Once height and girth of the tree species were measured, then data analysis was done through analytical techniques such as MS excel formulas, and volume tables Data extraction was done species wise in every quadrat for all the project sites. Wood density of all the tree species observed in all the project sites was taken from the Good Practices Guidelines of IPCC (IPCC, 2006). All the volume equations and wood densities of the tree species along with the references observed in all the project sites were outlined at the end of this report in annexure - 1 and 2.

After applying the volume equations to each tree species, volume of the tree bole was calculated. Once volume of the tree bole was calculated, it was multiplied with the basic wood density for each tree species to convert the volume into dry mass in tons. Further, this dry mass was multiplied with Biomass Expansion Factor (BEFs) of each species which provide the AGTB. BEFs for all the tree species were taken as 3.4 from the IPCC, Good Practices Guidelines (IPCC, 2006). The BEF values were taken for tropical broad leaf forests. In this way dry biomass content of all the tree species in each quadrat was calculated and their summation was used. With this approach total above ground tree biomass for each project site was estimated, which was then used for assessing carbon stock at each site. The formula used for calculating the carbon stock in above ground tree biomass at each of the project site was:

$$CAB, j, p, i = Vj * D * BEF j * CF$$

Where,

CAB, j, p, i = Carbon stock in above ground biomass of tree species j, in sample plot p of stratum i.

Units: tC

Vj = Merchantable volume of tree species type j (calculated from volumetric equation of each species type.) Units: m^3

D = Basic wood density of species type j. Units: t d.m. m^{-3}

BEF = Biomass Expansion Factor for conversion of merchantable biomass to above ground tree biomass. (A default value of 3.4 is taken for all the tree species type) Units: Dimensionless

CF = Carbon fraction of dry matter for species type j. Units: t C (t d.m.)$^{-1}$

After having the total value of Above Ground Tree Biomass, calculation of carbon stock of each project site was estimated by multiplying the total above ground biomass content with a default value of 0.45, which is also known as carbon fraction of dry matter for any species.

Below Ground Tree Biomass (BGTB):

Measurement of below ground biomass is highly uncertain and difficult. Although, there are various regression models developed for different forest types to calculate the BGTB, but generally it was calculated through the root to shoot ratio, which has become the standard method for estimating root biomass from the more easily measured shoot biomass. In simple, the BGTB was calculated by multiplying the AGTB with a default value of 0.27, provided by Intergovernmental Panel on Climate Change (IPCC, 2006). It has been assumed that 27% of the total above ground tree biomass is equivalent to below ground tree biomass. The formula used for calculating the carbon content in below ground tree biomass at each of the project sites was:

$$CBB, j, p, i = CAB, j, p, i * Rj$$

Where;

CBB, j, p, i = Carbon stock in below ground biomass of tree species *j*, in sample plot *p* of stratum *i*. Units: tC

CAB, j, p, i = Carbon stock in above ground biomass of tree species *j*, in sample plot *p* of stratum *i*. Units: tC

Rj = Root shoot ratio appropriate for biomass stock for species *j*. (A default value of 0.27 is taken). Units: Dimensionless

Thus, carbon stock from the BGTB was calculated by multiplying the total below ground tree biomass with a default value of 0.45. Since, it is assumed 45% of dry biomass is a carbon content.

Deadwood (DW)

Deadwoods biomass was calculated through converting the fresh biomass weight into dry mass and then physically weighing the dry mass in the field. Dry biomass weight was calculated from all the three sub plots separately, averaging and then calculating on per ha basis. Multiplying the dry mass by 0.45 provided carbon content present in deadwoods.

Leaf Litter (LL)

Similarly, biomass from the Leaf Litter, herbs and grasses was calculated in the same manner in which it was calculated from the Deadwood. The fresh weight of the LL was calculated from each sub plot, averaging and then calculating on per ha basis. Multiply the dry mass weight by 0.45, this will provide the weight of carbon content in Leaf Litter, assuming 45% of dry biomass is carbon content in the Leaf Litter.

Soil Organic Carbon (SOC)

Soil depth, bulk density and organic carbon concentration are essentially required to estimate the soil organic carbon. In the present research study, bulk density of the soil was assumed as 1.2 for all the project sites. In all the project sites, soil samples from three soil

depths i.e. 15 cm, 30 cm and 45 cm were collected separately and transported to the soil laboratory. Carbon percentage in all the soil samples was calculated through the titration method in soil laboratory. Weight of the soil in tons per hectare was calculated by multiplying a default value of bulk density (1.2) by volume of soil at three different depths. The soil organic carbon was estimated by the formulae provided by Pearson et. al in 2007.

$$SOC = \rho * d * \%C$$

Whereas;

SOC = soil organic carbon stock per unit area [t ha^{-1}],

ρ = soil bulk density [g cm^{-3}],

d = the total depth at which the sample was taken [cm], and

C = carbon concentration [%].

Biomass estimation using remote sensing techniques

In the present research study, remote sensing technology was applied by using LANDSAT imageries that were available freely on Internet. Two LANDSAT data sets - 1990 as a baseline year and 2012- as current year were employed for developing vegetation and biomass change detection through Normalized Difference Vegetation Index (NDVI). Remote Sensing, in the simplest sense, means a technique to acquire information about an object or a phenomenon by recording device (sensor) that is not in physical contact with the object, by measuring a portion of reflected or emitted Electromagnetic Radiation (EMR) from the Earth's surface. The principle involved in remote sensing is that the different objects based on their structural, chemical and physical properties return different amount of energy in different wavelength regions of EMR incident upon it. The developments in space technology particularly, the repetitive satellite remote sensing across various spatial and temporal scales offers the most economic means of assessing the forest resources and impact of the developmental processes. It provides excellent capability to monitor composition of the forest landscape, its management and degradation processes. Thus in the present carbon inventory pilot study, carbon from the forest have been calculated by using this tool. Landsat TM datasets of 1990 as the base line year and 2012 as a current year were used to estimate the past and current status of forest biomass and land use distribution in the selected project sites. For estimating the carbon stock through RS/ GIS technique, the entire project area was divided into the grids of 1 ha each in a Landsat TM datasets with a resolution of 30 mx 30 m. Each grid cell comprised around 11 pixels and then Normalized Difference Vegetation Index (NDVI) value of each pixel was calculated with the help of GIS/ RS software. Average NDVI value was calculated from each grid. The NDVI is often used to stratify vegetation and non-vegetation areas and was calculated through the below given formulae.

Normalized Difference Vegetation Index (NDVI) = (IR-R) / (IR+R)

Further, linear fit equations were developed through correlating the biomass values obtained from the field survey with the NDVI values of same coordinates (pixel) in 2012 satellite imageries for each pilot site. Using the linear fit regression equation, biomass for entire project site was calculated for 2012. Similarly, with the help of this regression equation, biomass values of the same site for 1990 were estimated. Thus, the difference in the biomass values from 1990 and 2012 was calculated. The grids where an increase in canopy

density is observed with respect to the benchmark year indicated additionality due to Sustainable Forest Management initiatives or other effective forest management practices. Similarly, a decrease in biomass over the years indicated loss of carbon from the area due to unsustainable forest management practices and/or anthropogenic pressures. The present interpretation scale of 1:50,000 along with improved spatial resolution have made it possible to capture forest cover patches up to 1 ha area. Carbon estimation from soil, deadwoods, leaf litter and decomposed material were estimated based on the field data, and it can be further compared with future projects of the same area. The details of the regression for all the sites are provided below.

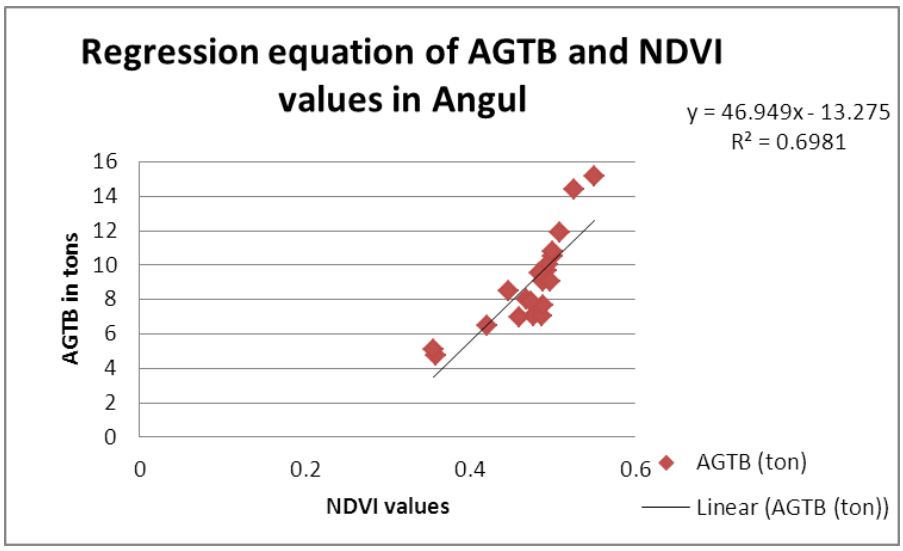


Figure 3.12 Regression equation of AGTB and NDVI in Angul

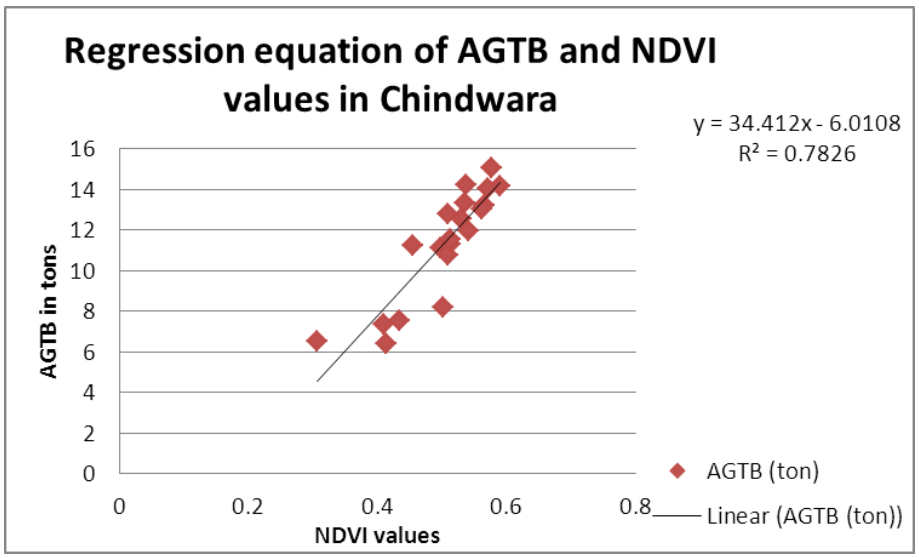


Figure 3.13 Regression equation of AGTB and NDVI in Chhindwara

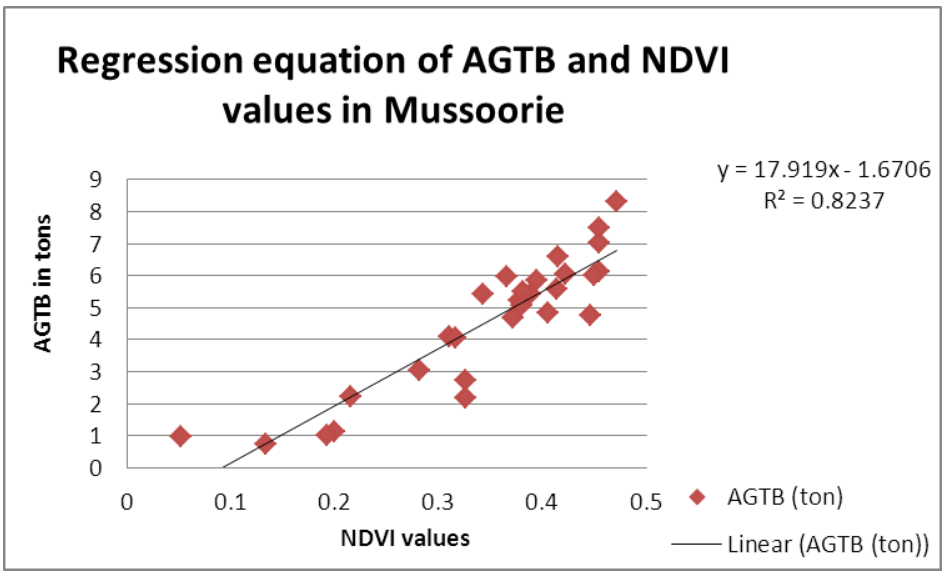


Figure 3.14 Regression equation of AGTB and NDVI in Mussourie

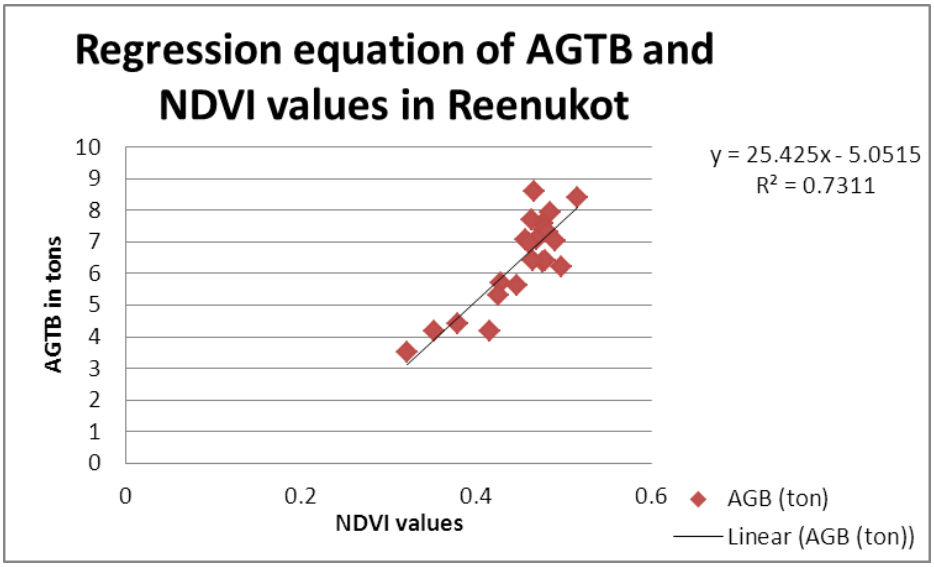


Figure 3.15 Regression equation of AGTB and NDVI in Renukoot

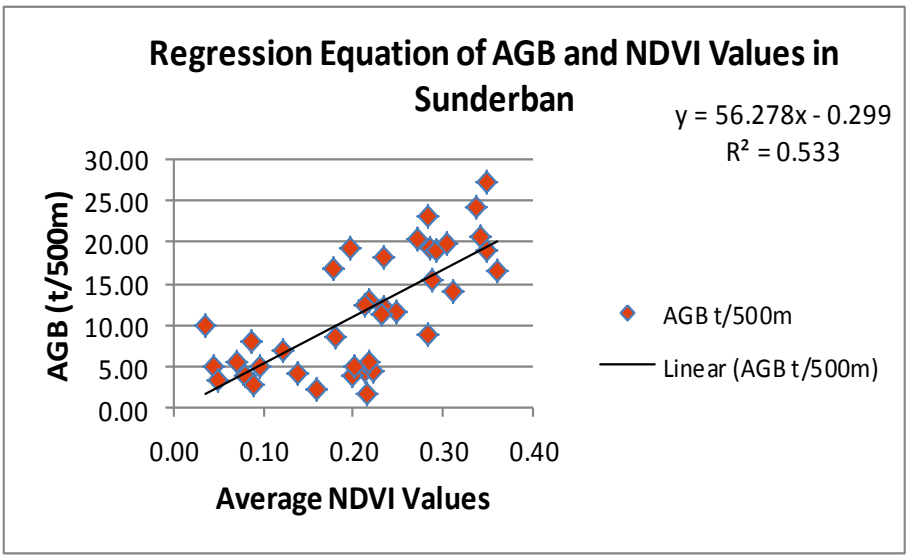


Figure 3.16 Regression equation of AGTB and NDVI in Sunderban

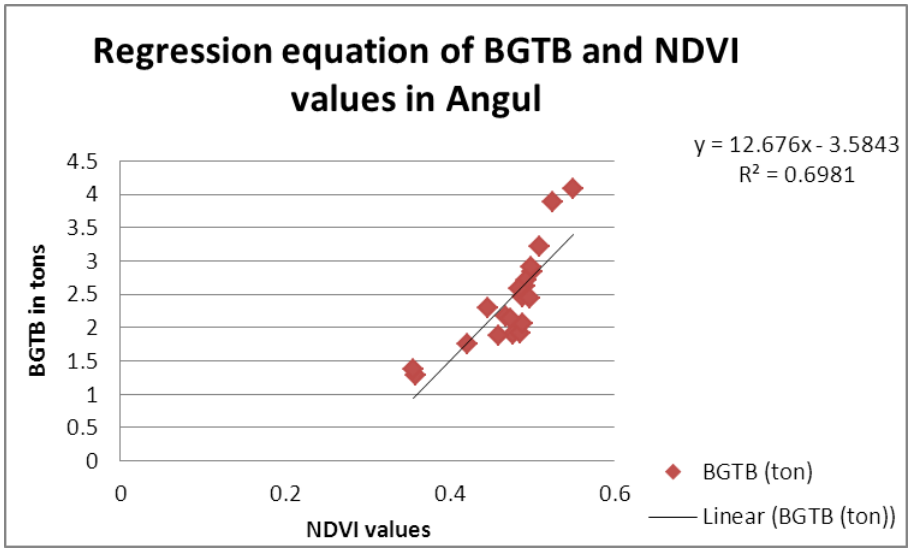


Figure 3.17 Regression equation of BGTB and NDVI in Angul

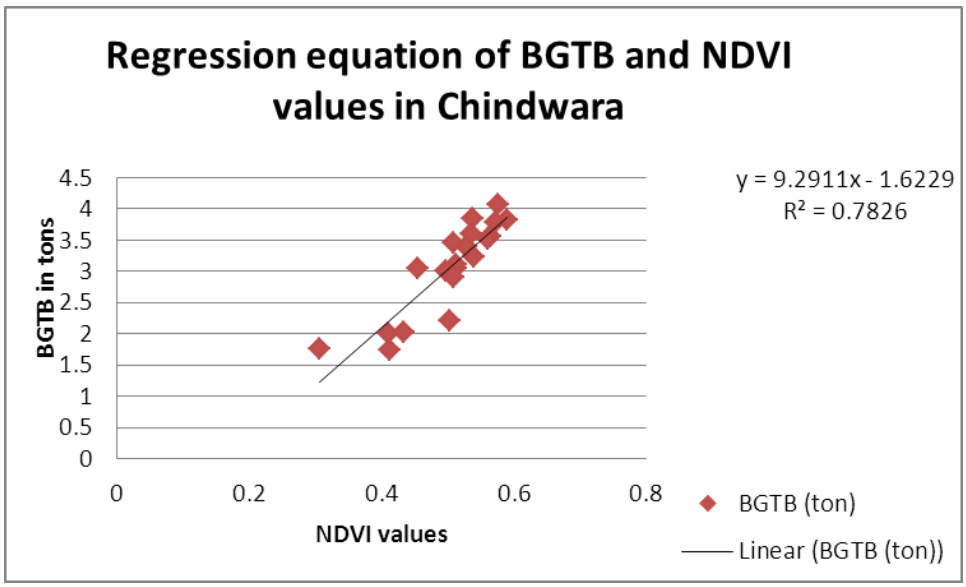


Figure 3.18 Regression equation of BGTB and NDVI in Chhindwara

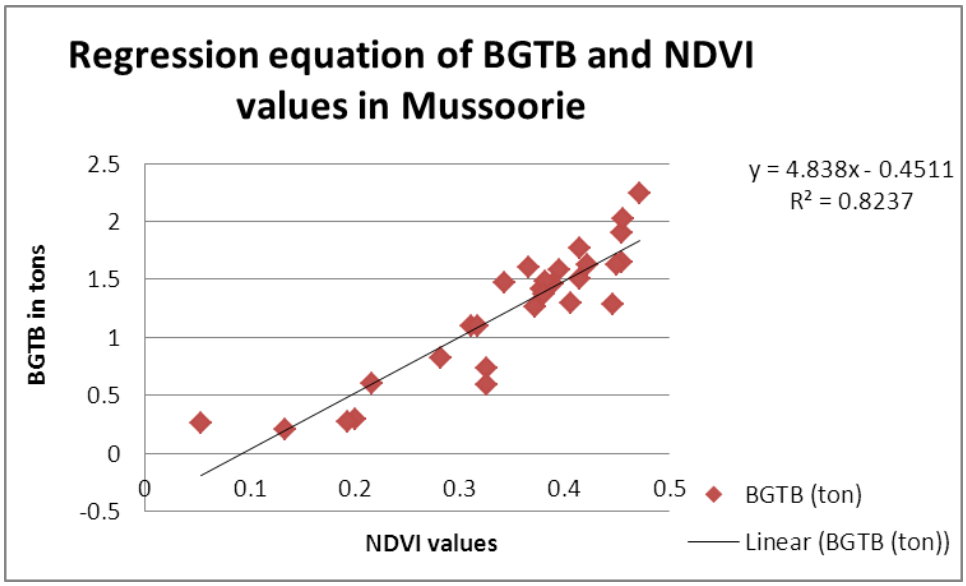


Figure 3.19 Regression equation of BGTB and NDVI in Mussourie

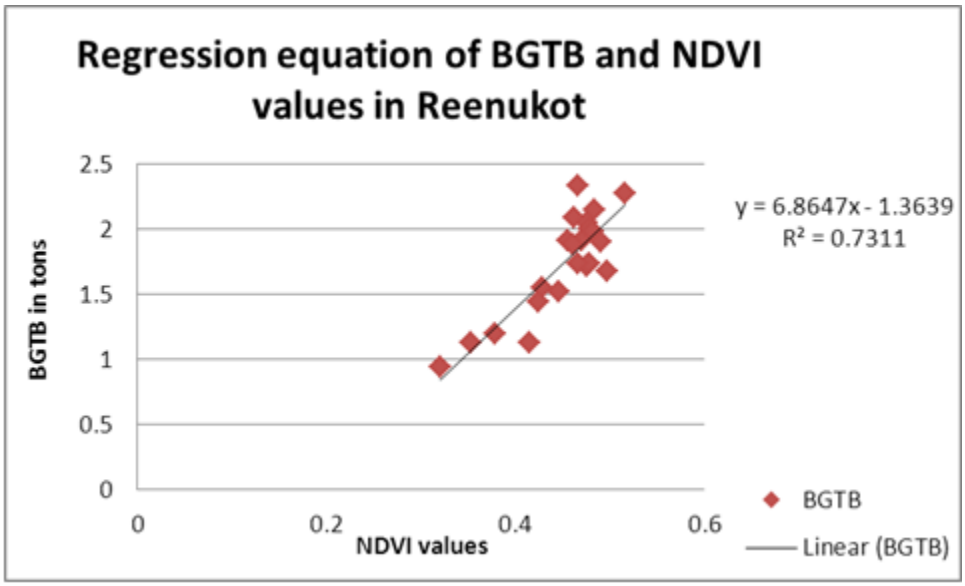


Figure 3.20 Regression equation of BGTB and NDVI in Renukoot

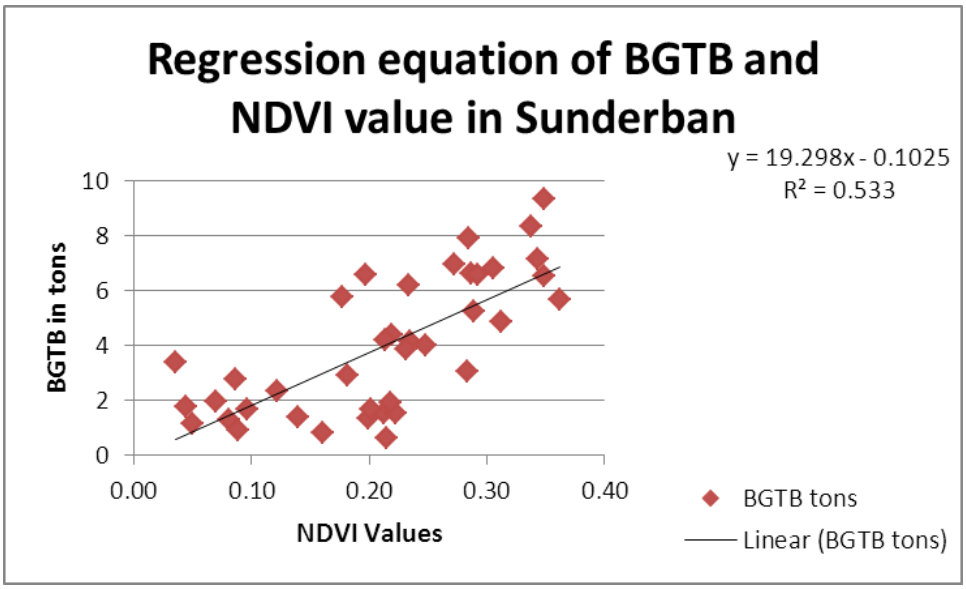


Figure 3.21 Regression equation of BGTB and NDVI in Sunderban

Thus, RS/ GIS based methodology helped in estimating carbon stock of the benchmark year as well as in estimating future stock at periodic intervals. The output generated through this tool helped us in understanding the impact of ongoing management practices. Annual increment data of dominant species from secondary sources such as working plan documents were used to refine the estimate, particularly in the grids where there was no change in the density class over the past few years.

Results

Change in Above Ground Tree Biomass

The results shows that change in Above Ground Tree Biomass values varies from Mussourie site (-2.69 ton per ha) to Chhindwara site (89.45 tons per ha) as compared to the baseline year of 1990 to the present year 2012. Similarly, change in the total AGTB varies from Mussourie site (-256 tons) to Sunderban site (386617 tons). Angul (9.78%), Chhindwara (85%), Renukoot (75.68%) and Sunderban (34%) show increase in AGTB from the baseline year of 1990 with respect to the present year. This might be due to the sustainable forest management initiatives undertaken by the respective state forest departments with the help of the JFMCs or some other effective forest management practices in these sites. Although Mussourie site shows highest standing biomass per hectare values as compared to the other sites, which is due to Chirpine and Oak forests, there is decrease in biomass of around 1% from the baseline year, this would be due to over exploitation of the forest resources such as fuel wood, fodder, timber and NTFPs. The details of the results of AGTB are provided in table below.

Table 3.2 Change in AGTB from baseline to present year

	Project Area (in ha)	AGTB (ton ha^{-1})			Total AGTB (ton)		
Project sites		**1990**	**2012**	**Change**	**1990**	**2012**	**Change***
Angul	200	144.65	158.81	14.16	28930	31763.20	2833.20 (9.78)
Chhindwara	504	104.87	194.32	89.45	52856.50	97939.80	45083.30 (85.29)
Mussourie	95	306.22	303.53	-2.69	29091.38	28835.35	-256.02 (0.89)
Renukoot	77	70.41	123.70	53.29	5421.72	9524.97	4103.25 (75.68)
Sunderban	4420	256.74	344.21	87.47	1134790.80	1521408.20	386617.40 (34.06)

**Values in parenthesis refers to the change in percent from the baseline year to the present year*

Change in Carbon from Above Ground Tree Biomass

The change in carbon values from AGTB varies from Mussourie site (-1.21 ton per ha) to Chhindwara site (40.25 tons per ha) as compared to the baseline year. Change in the total carbon values from the AGTB varies from Mussourie (-115.21 tons) to Sunderban site (173977 tons). Chhindwara (20287 tons), Renukoot (1846.46 tons), and Angul (1274.94 tons) show an increase in the carbon values from AGTB as compared to the baseline year of 1990. Details of the results in change of carbon values are provided in table below.

Table 3.3 Change in AGTB Carbon from baseline to project year

	Carbon (ton ha^{-1})			Total Carbon (ton)		
Project sites	**1990**	**2012**	**Change**	**1990**	**2012**	**Change**
Angul	65.09	71.47	6.37	13018.50	14293.44	1274.94
Chhindwara	47.19	87.45	40.25	23785.43	44072.91	20287.49
Mussourie	137.80	136.59	-1.21	13091.12	12975.91	-115.21
Renukoot	31.69	55.67	23.98	2439.78	4286.24	1846.46
Sunderban	115.53	154.89	39.36	510655.86	684633.69	173977.83

Change in Below Ground Tree Biomass

The results show that change in Below Ground Tree Biomass values varies from Mussourie site (-0.72 ton per ha) to Chhindwara site (24.15 tons per ha) compared to the baseline year of 1990. Similarly, change in the total BGTB varies from Mussourie site (-69.12 tons) to Sunderban site (104386 tons). Angul (764.96 ton), Renukoot (1107.87 ton) and Chhindwara (12172 ton) show increase in the BGTB from the baseline year of 1990. This could be due to the sustainable forest management initiatives undertaken by the forest department with the help of the JFMCs or some other effective forest management practices in these sites. While there is decrease of around -69.12 tons from the baseline year in BGTB at Mussourie site, which would be due to over exploitation of the forest resources such as fuel wood, fodder, timber and NTFPs. The details of the results of BGTB are provided in table below.

Table 3.4 Comparative analysis of BGTB from baseline to present year

	BGTB (ton ha^{-1})			Total BGTB (ton)		
Project sites	**1990**	**2012**	**Change**	**1990**	**2012**	**Change**
Angul	39.05	42.88	3.82	7811.10	8576.06	764.96
Chhindwara	28.31	52.46	24.15	14271.26	26443.75	12172.49
Mussourie	82.68	81.95	-0.72	7854.67	7785.54	-69.12
Renukoot	19.01	33.39	14.38	1463.86	2571.74	1107.87
Sunderban	69.31	92.93	23.61	306393.51	410780.21	104386.69

Change in carbon from BGTB

The change in carbon values from BGTB varies from Mussourie site (-0.32 ton per ha) to Chhindwara site (10.86 tons per ha) with respect to the baseline year. Change in the total carbon values from the BGTB varies from Mussourie (-31.10 tons) to Sunderban site (46974 tons). Angul (344.23 tons), Renukoot (498.54 tons) and Chhindwara (5477 ton) show

increase in the carbon values from BGTB as compared to the baseline year of 1990. Details of the results in change of carbon values are provided in table below.

Table 3.5 Comparative analysis of carbon from BGTB.

	Carbon (ton ha^{-1})			Total Carbon (ton)		
Project sites	**1990**	**2012**	**Change**	**1990**	**2012**	**Change**
Angul	17.57	19.29	1.719	3514.99	3859.22	344.23
Chhindwara	12.73	23.60	10.86	6422.06	11899.69	5477.62
Mussourie	37.20	36.87	-0.32	3534.60	3503.49	-31.10
Renukoot	8.55	15.025	6.47	658.73	1157.28	498.54
Sunderban	31.19	41.82	23.62	137877.08	184851.09	46974.01

Deadwood carbon stocks

The dry weight of deadwood in Angul, Chhindwara, Renukoot, Mussourie and Sunderban sites are 2.93, 3.17, 2.65, 1.75 and 0 tons per ha respectively. The total dry weight varies from Mussourie (166.25 tons) to Chhindwara site (1597.68 tons). In Angul and Renukoot sites it was estimated 586 and 204 tons respectively. Biomass could not be recorded in Sunderban site due to waterlogged conditions.

Carbon from the deadwood in Angul, Chhindwara, Renukoot, Mussourie and Sunderban sites is 1.32, 1.43, 1.19, 0.79 and 0 tons per ha respectively. The total carbon varies from Sunderban (0 tons) to Chhindwara site (718.95 tons). While in Angul, Renukoot and Mussourie sites it was estimated 263.70, 91.82 and 74.81tons respectively. Details are provided below.

Table 3.6 Deadwood biomass and carbon estimation in all the pilot study sites

Project sites	**DW (tdm)**		**Carbon (ton)**	
	Ha^{-1}	**Total**	**Ha^{-1}**	**Total**
Angul	2.93	586.00	1.32	263.70
Chhindwara	3.17	1597.68	1.43	718.95
Mussourie	1.75	166.25	0.79	74.81
Renukoot	2.65	204.05	1.19	91.82
Sunderban	NM	NM	NM	NM

*Not measured (due to waterlogged conditions)

tdm: Tons of dry mass

Leaf litter carbon stocks

The dry weight of leaf litter in Angul, Chhindwara, Renukoot and Mussourie sites is 3.70, 3.12, 2.57 and 2.23 tons per ha respectively.

Carbon from the leaf litter in Angul, Chhindwara, Renukoot and Mussourie 1.67, 1.40, 1.16 and 1.01 tons per ha respectively.

Table 3.7 Leaf litter and carbon emission in all the pilot study sites

Project sites	LL (tdm)		Carbon (ton)	
	Ha^{-1}	Total	Ha^{-1}	Total
Angul	3.70	740.00	1.67	333.00
Chhindwara	3.12	1572.48	1.40	707.62
Mussourie	2.23	211.85	1.01	95.33
Renukoot	2.57	197.89	1.16	89.05
Sunderban	NM	NM	NM	NM

*Not Measured

Estimation of soil organic carbon

The soil organic carbon in three different depths was estimated for all the project sites. In 0-15 cm depth, the carbon values vary from Angul site (22.35 tC ha^{-1}) to Mussourie (46.20 tC ha^{-1}), while in Chhindwara, Renukoot and Sunderban sites the organic soil carbon were estimated as 22.41, 31.19 and 12.36 tons per hectare. The total organic soil carbon at 0–15 cm depth in Angul, Chhindwara, Renukoot, Mussourie and Sunderban sites are 4470, 11294, 2401, 4389 and 54631tons respectively.

At 16 - 30 cm depth the organic soil carbon varies from Sunderban site (111.68 tC ha^{-1}) to Renukoot site (27.62 tC ha^{-1}), while in Mussourie, Angul, Chhindwara it was estimated at 12.18, 13.61 and 14.75 tC ha^{-1} respectively. The total organic soil carbon at 16-30 cm depth in Angul, Chhindwara, Renukoot, Mussourie and Sunderban sites are 2722, 7434, 2126, 1157 and 51625 tons respectively.

Similarly at 31-45 cm depth, the organic soil carbon values varies from Renukoot site (9.48 tC ha^{-1}) to Mussourie (25.14 tC ha^{-1}), while in Angul, Chhindwara and Sunderban it was estimated as 17.17, 18.14 and 19.28 tC ha^{-1} respectively. The total organic soil carbon at 31-45 cm depth in Angul, Chhindwara, Renukoot, Mussourie and Sunderban sites are 3434, 9142, 729, 2388 and85217 tons respectively.

There is a mixed result for the carbon content at different depths among all the pilot project sites. Organic soil carbon per hectare was slightly higher at Mussourie and Renukoot sites, which might be due to the present of the tree species, whose leaf litter decomposition rate is higher and enriched with more carbon contents. In rest of the pilot sites human activities and other disturbances such as changes in forest type, productivity, decay rates and disturbances may alter the carbon dynamics of forest soils. Different forest management

activities, such as rotation cycle, choice of tree species, drainage, soil erosion, harvest practices and fertilization may also affect the soil organic carbon stocks in these sites. The change in soil carbon contents takes huge time, but estimation was made for one time for this study. These carbon values can be considered as a baseline for the future projects for these pilot sites. Project site details for organic soil carbon for all the project sites are provided below in the table below.

Table 3.8 Estimation of Soil Organic Carbon in all the project sites

Site	Soil Weight (t ha^{-1})	Average Soil Carbon Percentage (%)	Soil Organic Carbon (tC ha^{-1})	Total Soil Organic Carbon (tC)
Depth 0-15 cm				
Angul	1800	1.24	22.35	4470
Chhindwara	1800	1.24	22.41	11294.64
Mussourie	1800	2.56	46.2	4389
Renukoot	1800	1.73	31.19	2401.63
Sunderban	1800	0.69	12.36	54631.2
Depth 16-30 cm				
Angul	3600	0.99	13.61	2722
Chhindwara	3600	1.03	14.75	7434
Mussourie	3600	1.62	12.18	1157.1
Renukoot	3600	1.63	27.62	2126.74
Sunderban	3600	0.67	11.68	51625.6
Depth 31- 45 cm				
Angul	5400	0.98	17.17	3434
Chhindwara	5400	1.02	18.14	9142.56
Mussourie	5400	1.54	25.14	2388.3
Renukoot	5400	1.26	9.48	729.96
Sunderban	5400	0.8	19.28	85217.6

Conclusion

Overall net increase in the Carbon from AGTB and BGTB from all the five pilot project sites is 250534.81 tons of Carbon which is equivalent to 919462.80 tCERs. The net increment from the baseline year to the present project year is around 34%. In Angul, there is a total of 1619 ton of carbon increase, which is around 9.8% from the baseline year. In Chhindwara total net increment is 25765 tons of Carbon, which is around 85.3% from the baseline year. In Renukoot total net increment is around 2345 tons of Carbon, which is around 75.68% from the baseline year. Similarly, in Sunderban total net increment is around 220951 tons of Carbon, which is around 34.06% from the baseline year. In case of Mussourie the change is in negative and there is total net decrease of 146 tons of Carbon from the baseline year, which is around 1% from the baseline year. The details of the net change of Carbon in all the five pilot sites are provided in table below.

Table 3.9 Net Carbon change from AGTB and BGTB in all five pilot sites

Project Site	Area (ha)	Carbon Stock						
		1990 (t)	1990 (t/ha)	2012 (t)	2012 (t/ha)	Change (t)	Change (t/ha)	Change (%)
Angul	200	16533	83	18153	91	1619	8	10
Chhindwara	504	30207	60	55973	111	25765	51	85
Mussourie	95	16626	175	16479	173	-146	-2	-1
Renukoot	77	3099	40	5444	71	2345	30	76
Sunderban	4420	648533	147	869485	197	220952	50	34

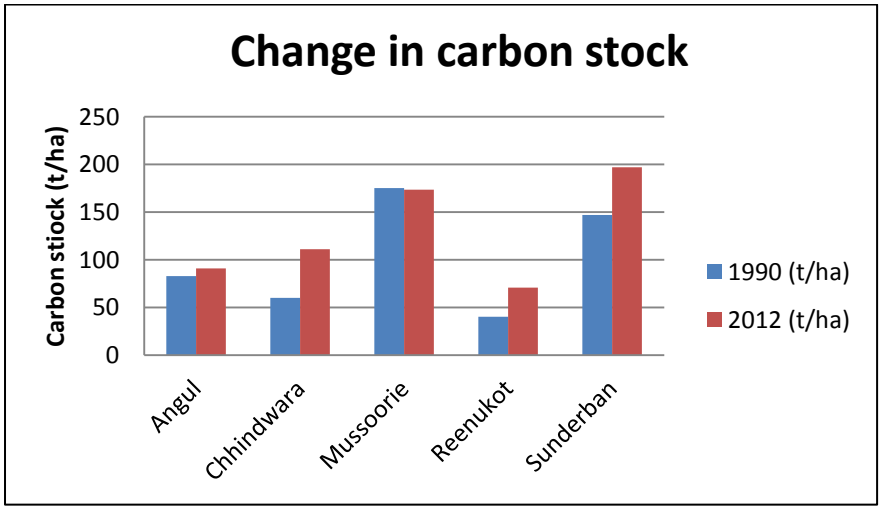


Figure 3.22 Change in carbon stock (1990 – 2012)

Four of the five pilot sites show notable enhancement of carbon stock. In case of the Mussourie site, there is a marginal decrease in carbon stock but it may be noted that the site had a relatively high baseline value.

The pilot sites show patterns of unsustainable extraction of forest resources, specially fuelwood, fodder and minor forest produce in most cases. The increments in carbon stock could be potentially higher if such practices are checked by providing alternative livelihoods. Detailed assessment of socio-economic conditions, levels of forest dependence and extent of sustainable use is provided in Chapters 4-7 of this report. For the Sundarban site, an assessment of the protective functions of the forest is also provided. From the REDD+ angle, it is important to track changes in carbon stock against the patterns of resource extraction and the available livelihood options. A simple and practicable methodology for doing this has been suggested in this Chapter.

References

1. Bhishma P. Subedi, Shiva Shankar Pandey, Ajay Pandey, Eak Bahadur Rana, Sanjeeb Bhattarai, Tibendra Raj Banskota, Shambhu Charmakar, Rijan Tamrakar. (2011). Forest carbon stock measurements. Guidelines for measuring carbon stocks in community managed forest. ANASAB, FCF and ICIMOD, Kathmandu, Nepal.
2. Brown, S. (1997). Estimating biomass and biomass change of tropical forests. A primer. FAO Forestry Paper 134. Food and Agriculture Organisation of the United Nation, Rome, Italy.
3. Chauhan S., Gera M. (2010). Carbon benefits from growing trees of medicinal importance in Punjab. The Indian Forester, vol.136 (7):861-876.
4. Chauhan S., Saxena A. (2012). Policy paper on 'Methodology for Assessing Carbon Stock for REDD+ Projects in India'. New Delhi, India: TERI.
5. Chaturvedi A.N. and Khanna L.S. (1982). Forest Mensuration and Biometry, Measurement of volume of trees. 364 pp.
6. Forest Survey of India. (2011). India State of Forest Survey Report, 2011.New Delhi: FSI, Ministry of Environment of Forests (MoEF) Government of India.
7. Forest Survey of India. (1996). Volume Equations for Forests of India, Nepal and Bhutan. New Delhi: MoEF, Government of India. p. 249.
8. Forest Working Plan, Angul Forest Division. (2010). Divisional Forest Office, Angul, Odisha.
9. Forest Working Plan, West Chhindwara Forest Division. (2010). Divisional Forest Office West Chhindwara, Madhya Pradesh.
10. Forest Working Plan, Mussourie Forest Division - (2011-12 to 2020-21).(2010). Divisional Forest Office, Mussourie, Uttarakhand.
11. Forest Working Plan. Renukoot Forest Division. (2010). Divisional Forest Office, Renukoot, Uttar Pradesh.
12. Gera M., Chauhan S. 2010. Opportunities for carbon sequestration benefits from growing trees of medicinal importance on farmlands of Haryana. The Indian Forester, vol. 136 (1):287-300.
13. IPCC. (2006). Good Practices Guidelines for National Greenhouse Gas Inventories. Switzerland: Intergovernmental Panel on Climate Change.
14. Kurniatun Hairiah, Sonya Dewi, Fahmuddin Agus, Sandra Velarde, Andree Ekadinata, Subekti Rahayu and Meine van Noordwijk. (2010). Measuring carbon stocks across land use systems - A Manual. World Agroforestry Centre (ICRAF), SEA Regional Office, Indonesia: 155pp.
15. Pearson, T R, Brown, S L, Birdsey, R A. (2007). Measurement guidelines for the sequestration of forest carbon. U.S.: Northern research Station, Department of Agriculture.

16. Reyes G, Brown S, Chapman J, and Lugo A E. (1992). Wood Densities of Tropical Tree Species. US Department of Agriculture Forest Service, New Orleans.

17. Timothy Pearson, Sarah Walker and Sandra Brown (2005). Sourcebook for land use, land use change and forestry projects. Winrock International.

Chapter 4 REDD Plus Assessment in Angul

Introduction

The forest managed by Jerang Budhi Pahad VSS[1] in Jarapada beat of Durgapur range in Angul Forest Division in Odisha is one of the pilot sites under this project. The membership of the VSS constitutes all the households in the village Jerang which comes under Jerang Dehuri Sahi Gram Panchayat under Chendipada Community Development Block of Angul district. The village is located 31 km west along National Highway 42 from district headquarter Angul town and is around 3 km from Durgapur forest range office in Jarapada. The VSS manages 200 ha of Reserve Forest and Proposed Reserve Forest (Katada RF and Para PRF) and has been registered on 9th March 2008 as VSS vide registration number C1D1R2S3V04. This 200 ha forest is spread over three patches of different size i.e. two contiguous patches of 100 ha, 65 ha and a separate patch of 35 ha with all located within 3 kms from the village (see Fig. 1). The closest among them to the main village is the one with 35 ha. This is a sacred grove which is known as Budhi Pahad locally, named after the village goddess Budhi Thakurani. The history of forest protection in this village dates back to 1990 with youth of the village initiating measures to protect the forest adjacent to the village in response to the popular campaigns in the district as well as state highlighting the role of local communities in forest protection. The mirco-plan suggests that the forest this VSS manages is classified as degraded state of Northern deciduous forest (5D/S1) and is managed under Rehabilitation Working Circle of the Forest Department. This VSS is also included in JICA funded OFSDP and different interventions like ANR, AR, EPA, IGA, etc. has been undertaken in last few years.

As part of the socio-economic and institutional assessment, data on various relevant aspects has been collected through village level meetings, key informant discussions and a detailed household survey during July to November 2012. This exercise aimed assessing a) Socio-economic profile of the pilot site and sources of livelihoods for local people, b) Dependence on and use of forest resources (and determine whether the extraction of the resources is sustainable), c) Local institutional arrangements for management of forest, and d) Gendered role distribution in extraction of forest resources, other sources of livelihood and decision making over forest resources. The purpose of the survey was to gather data in a one-time scenario (at present) and use this to serve as a baseline for a future scenario of measuring impact or change over this. Though some historical information on forest use and protection has been gathered during the field survey, this does not take recourse to capture a previous baseline data (of 1990 that has been taken as the base year in the case of measuring changes in carbon stock). The study has adopted census method for household survey covering different aspects like household composition, household assets, livelihood patterns, dependence on forest, and participation in collective activities related to forest protection/management. So all the 116 households were enumerated for the household survey and the details of the finding of the survey have been presented in subsequent sections.

Carbon stock assessment of this 200 ha forest managed by the VSS has been done by adopting five pool (Above Ground Tree Biomass (AGTB), Below Ground Tree Biomass (BGTB), Deadwoods (DW), Leaf Litter (LL) and Soil Organic Carbon (SOC)) measurement methods (see Chapter 3). However, two pool method (considering only AGBT and BGBT)

[1]Vana Samrakshyana Samiti (VSS) is the joint forest management institution in Odisha

has been used to estimate the temporal change (with 1990 as baseline) in carbon stock. 20 permanent sample plots are laid covering all 3 forest patches managed by the villagers (see Figure 4.1). The size of all the permanent nested sample plot are 20m x 25m for tree species, 2m x 2m for deadwoods and 1m x 1m for leaf litter. In each permanent nested sample plot of tree species, total three sub plots for deadwoods and three sub plots for Leaf Litter were laid out randomly. Temporal changes were estimated with 1990 as base year and 2012 as current year. Normalised Difference Vegetation Index (NDVI) developed through remote sensing application by using LANDSAT images for these two periods.

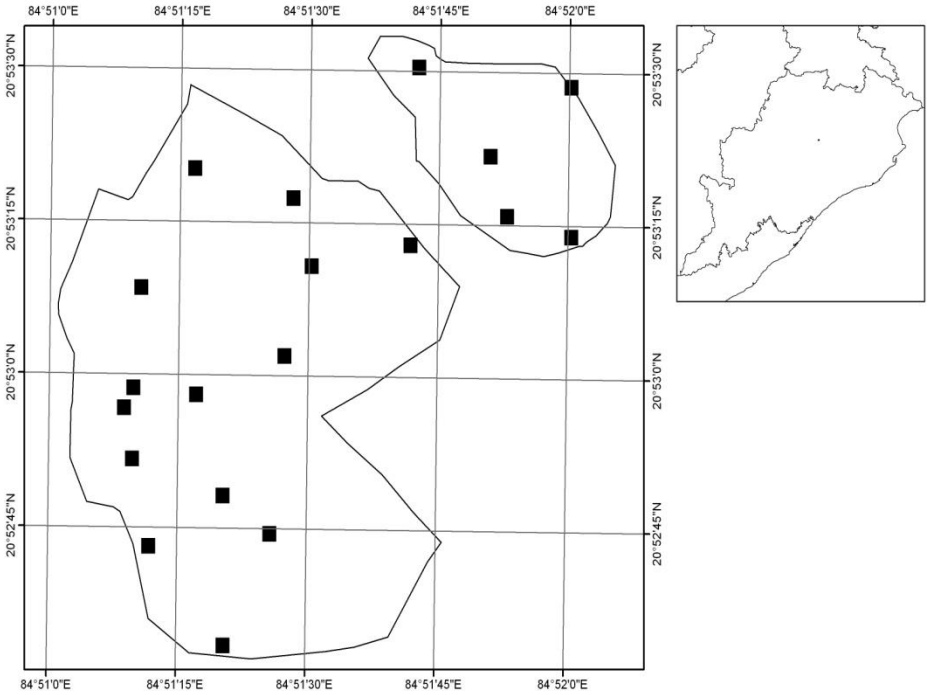


Figure 4.1 Map showing the VSS forest and the sample plots

Demographic and Socio-economic Profile of the Village

There are 116 households in the village spread over four hamlets (locally called para or sahi) with Dehuri Sahi constituting the main village with largest number of households (table 4.1). The total area of the village is 240 ha as per the revenue land records of which 120 ha are agricultural land owned privately by the households, 40 ha pasture land, 20 ha village commons, 56 ha government land and 4 ha of waste land.

Table 4.1 Number of Households in Village

Sl No	Name of the Hamlets	Number of Households
1	Dehuri Sahi (main village)	64
2	Harijan Sahi	29
3	Sauria Sahi	10
4	Gopinathpur	13
	Total	**116**

Source: Village Level Meeting 2012

Being located besides a national highway the main village (Dehuri Sahi) is well connected for road transport. The other three settlements, located in other side of a nala (natural water course or drainage channel locally named Bauria) though connected with pucca roads do not have all weather connectivity. The nala that runs full in the rainy season or after a heavy rainfall poses a formidable challenge for all the hamlets to be connected with main village and national highway. The main village also faces difficulties as forest, pastures, temple and most of the agricultural lands are located in other side of this nala. There are primary and middle English (up to class 7) schools within the village whereas the high school and an inter-college is located around 3 kms (Jarapada) away from the village. The village houses the Gram Panchayat office and also has a post office and anganwadi centre within its premises. The nearest primary health centre, veterinary hospital, bank, railway station, forest range office etc. are located in and around Jarapada.

The total population of the villages is 635 (table 4.2) and share of male and female to the total population is 52 and 48 per cent respectively. The gender wise distribution of the total population is depicted in figure 4.2. Interestingly, the share of female among minor population is higher than the adult population in the village.

Table 4.2 Demographic Composition

	Minors	Adults	Total
Male	127	206	333
Female	129	178	307
Total	**256**	**384**	**640**

Source: Household Survey 2012

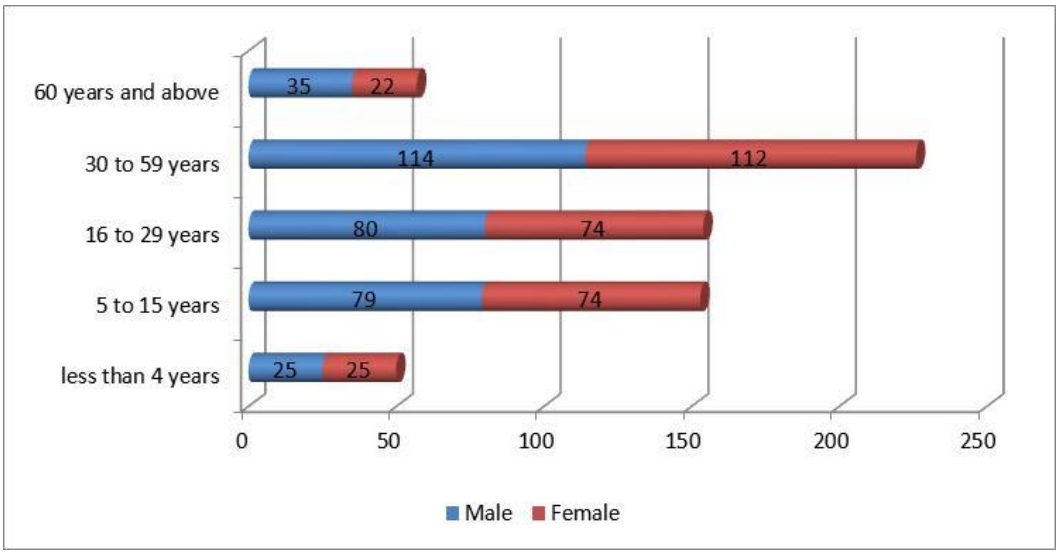


Figure 4.2 Gender-wise distribution of population in the village

The age wise demographic composition of the village indicates that around 59percent of the population in the village are in working age group. Infants and old age population together constitutes around 17 per cent of the total population with remaining 24 per cent with the age group of 5 to 15 years (see table 4.3). A significant percentage of the later population group are school/college going with some of them who dropped out school is part of regular/occasional working population. Figure 4.3 depicts the age wise distribution of population in the study village.

Table 4.3 Age Group Categories

Age Group Categories	Male	Female	Total
less than 4 years	25	25	50 (7.81)
5 to 15 years	79	74	153 (23.91)
16 to 29 years	80	74	154 (24.06)
30 to 59 years	114	112	226 (35.31)
60 years and above	35	22	57 (8.91)
Total	**333**	**307**	**640**

Note: Figures in parenthesis are percentage

Source: Household Survey 2012

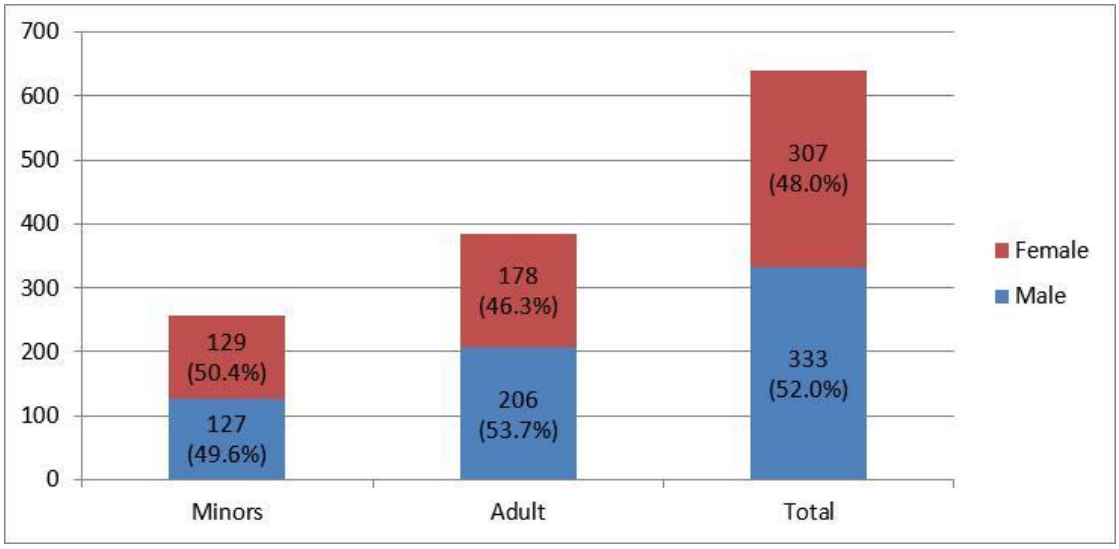


Figure 4.3 Age-wise distribution of population

As far as the social group characteristics of the village are concerned all the households are Hindus by religion and OBCs and SCs are the dominant caste groups with the village with 59 and 51 households respectively. There are only 2 ST households and 4 general caste households in the village. Table 4.4 presents the distribution of households and respective population across different caste groups in the village. The distribution of population across social groups is more or less proportional to the distribution of households. There are around 20 sub-caste groups in the village.

Table 4.4 Social Groups in the village

Caste Groups	Number of Households	Population
General	4	34
	(3.45)	(5.31)
Other Backward Caste (OBC)	59	351
	(50.86)	(54.84)
Scheduled Caste (SC)	51	247
	(44.97)	(38.59)
Scheduled Tribe (ST)	2	8
	(1.72)	(1.25)
Total	**116**	**640**

Note: Figures in parenthesis are percentage

Source: Household Survey 2012

The village has a high literacy level with 96 per cent of the population being literate. A significant share of illiterate population is reported to be elderly people. However, only six per cent of the population has studied beyond higher secondary indicating low levels of educational attainment (see table 4.5). The literacy as well as educational attainment among females is lower in compared to male population in the village. The village has educational infrastructure up to primary education which has resulted in higher enrolment up to 7th class with more than 42 per cent of the people having attained this level of education.

Table 4.5 Literacy and Educational Attainment

Education Level	Male	Female	Total
Illiterate	8(2.6)	13 (4.61)	21 (3.56)
Just Literate(Non Formal education)	33 (10.71)	73 (25.89)	106 (17.97)
Primary Education	139 (45.13)	109 (38.65)	248 (42.03)
Secondary	107 (34.74)	75 (26.6)	182 (30.85)
Higher Secondary	12(3.9)	9(3.19)	21(3.56)
Graduation or above	9(2.92)	3(1.06)	12 (2.03)
Total	**308**	**282**	**590***

Note: * infants are excluded; Figures in parenthesis are percentage

Source: Household Survey 2012

The land ownership pattern of the households in the village indicates that most of them are small and marginal farmers (see table 4.6). There are 13 landless households and more than 70 per cent of the households own less than 1 acre of land. Less than 3 per cent of the households own land more than five acres whereas the remaining 15 per cent of the households own land more than 1 acre but less than 5 acres.

Table 4.6 Landownership across social categories

Landownership	Number of Households	Households across Social Categories			
		Gen	OBC	SC	ST
Landless	13 (11.21)	2	5	6	0
Less than 1 acre (Marginal Famers)	83 (71.55)	2	38	41	2
1 acre to 2.5 acres (Small Farmers)	9 (7.76)	0	7	2	0
2.5 acres to 5 acres (Semi-Medium Farmers)	8 (6.9)	0	7	1	0

Landownership	Number of Households	Households across Social Categories			
		Gen	OBC	SC	ST
5 acres to 7.5 acres (Medium Farmers)	3 (2.59)	0	2	1	0
Total	116	4	59	51	2

Note: Figures in parenthesis are percentage

Source: Household Survey 2012

The landownership pattern in the village is not aligned with hierarchies of the caste groups though some of the households belonging to some sub-caste groups have similar holdings. The land ownership across caste groups in the village does not show any significant differences with instances of landlessness among all caste groups except ST, OBCs and SCs, the two largest social groups in the village has more or less similar trends landownership pattern.

Around 79 per cent of the households in the village are listed as below poverty line (BPL) households and avail benefits of the various government schemes targeted at BPL families. The OBC households have higher percentage of BPL cards than the SC households in the village. The BPL status of the households across social categories is presented in Table 4.7. Around 70 per cent of the houses in the village are thatched houses and only 19 per cent of houses have concrete structure with remaining 11 per cent having both thatched and concrete houses. Only 11 households have reported to have private well or tube well whereas all other households depend on community well or tube well for drinking water and water for other domestic use. Agriculture is mostly rain fed and subsistence in nature. There are no irrigation facilities in the village and. However, farmers having lands close to the nala or well grow vegetables and other cash crops like onion and groundnut.

Table 4.7 BPL Status of the Households across different social groups

Social Groups	BPL Families
Gen	3 (75.0)
OBC	53 (89.8)
SC	34 (66.7)
ST	2 (100.0)
All Households	92 (79.3)

Note: Figures in parenthesis are percentage

Source: Household Survey 2012

Livelihood Sources

Agriculture, though mostly subsistence, along with wage labour is the mainstay of livelihood for majority of the households. This is quite evident form the occupational structure of the household members in the working age group. The active workforce in the village constitutes 60percent (385 individuals) of the total population of which 346 works in the villages and 39 works outside the village. Most of those who work outside the village are male and their migration period varies with some of them commuting daily to the nearest industrial towns while others staying back in their places of work in faraway cities and towns. Agriculture is the primary occupation of 27percent of the workforce in the village whereas wage labour is the primary occupation of 15percent (see table 4.8). A significant percentage of the population engaged in agriculture also work as unskilled labour in off-season as the return from agriculture is enough to sustain the families. Around 42percent of the workforce are reported to be engaged in domestic cores and mostly constitutes women in the household. Many of them also work as wage labour and also work in agricultural fields as well as other activities related to agriculture. The proximity of the village to National Highway created opportunities for some households to have regular businesses like roadside eateries, chicken shop, and petty shops selling pan, cigarette and other stationaries. Some people also do seasonal businesses like buying agricultural commodities and NTFPs from the villages and selling them in nearby towns. There are blacksmiths and carpenters caste groups in the village and some of them are engaged in their traditional family occupation. We have grouped them as skilled labour working within the village. The other occupations in skilled labour category are masons, tailors, drivers and mechanics engaged in repair of electronic appliances. Around 23 per cent of those worked outside also engaged in such skilled labour. Largest number of the migrants (who work outside village) work as temporary employees in various sectors. Those in permanent service are employed in various government services and work in stations at which their posted.

Table 4.8 Occupational Structure

Primary Occupation	Individuals working in village	Individuals working outside village	All Working Individuals
Agriculture	93(26.88)	-	93(24.16)
Regular Business	5(1.45)	2(5.13)	7(1.82)
Seasonal Business	8(2.31	1(2.56)	9(2.34)
Skilled Labour	28(8.09)	9(23.08)	37(9.61)
Unskilled Labour	51(14.74)	6(15.38)	57(14.81)
Temporary Service	11(3.18)	13(33.33)	24(6.23)
Permanent Service	5(1.45)	7(17.95)	12(3.12)
Domestic Work	144(41.62)	1(2.56)	145(37.66)

Primary Occupation	Individuals working in village	Individuals working outside village	All Working Individuals
Any Other	1(0.29)	-	1(0.26)
Total	346	39	385

Note: Figures in parenthesis are percentage

Source: Household Survey 2012

Agriculture in the village is mostly rain fed as there are no irrigation facilities. Farmers mostly grow two crops in a year. Farmers having lands close to the nalas and the well (water for irrigation) grow different cash crops like onion, garlic and other vegetables. Paddy is the dominant crop in Kharif season and other crops grown in this season are green gram, horse gram, black gram, maize, til and groundnut. Paddy is mostly grown in lowlands where as pulses, cereals and oilseeds grown in uplands during Kharif. The total area under Kharif crops in this village is around 82.54 acres (see table 4.9). The crops grown in Rabi season are green gram, Bengal gram, arhar, til, mustard, onions, garlic and other seasonal vegetables.

Table 4.9 Area under different crops

Cropping Season	Major Crops Grown	Total area under these crops (in acres)
Kharif	Paddy, Green Gram, Horse Gram Black Gram, Maize,Til, Groundnut.	82.54
Rabi	Green Gram, Bengal Gram, Til,Arhar, Mustard, Onions, Garlic and Vegetables	62.83

Source: Household Survey 2012

Paddy is the major crop and around 78 per cent of the households in the village reported to grow paddy. The total area under paddy is estimated to be 48.25 acres with a total production of 308 quintals (see table 4.10). Green gram is the crop with largest area (34.06) after paddy and is grown both in Kharif and Rabi with the total production is reported to be 74 quintals. Around 62 families grow green gram. The details of the area, production of different major crops and number of families reported to grow these crops are presented in table 10. Til and Bengal gram is also two other crops cultivated extensively by several farmers in the village (19.45 and 16.08 acres respectively). The other major crops are groundnut, black gram, horse gram and maize. Though very few households reported to sell paddy or rice, several households earns some income by selling other crops like groundnut, green gram, Bengal gram, black gram, til and vegetables. The survey targeted to generate data on income from agriculture but couldn't as a small fraction of household reported it as they don't sell agricultural products at one go. Agriculture in the village is marred with low productivity as the farmers adopt traditional cultivation practices for lack of irrigation and very small operational holdings (mean size 0.71 acres).

Table 4.10 Production of Major Crops

Major Crops Grown	Area under Crops in different seasons (in Acres)		Total Production (in Quintals)	Number of Families
	Kharif	Rabi		
Paddy	48.25	-	308	90
Green Gram	11.56	22.5	74	62
Black Gram	6.05	-	14	26
Groundnut	8.23	-	42	38
Maize	1.5	-	13	17
Horse Gram	5.5	-	11	24
Til	1.45	18	49	16
Bengal Gram	-	16.08	30	48
Onion. Garlic and Vegetables	-	6.25	-	42

Source: Household Survey 2012

The fact that the farmers practise subsistence agriculture is reflected in the productivity of crops when compared to the state and national average (see table 4.11). The productivity of paddy is more or less similar to the state average and significantly less than the national average. Similarly, the productivity of maize and oilseeds (til and groundnut here) is also similar to the state average but less than the national average. The productivity of pulses (green gram, black gram, horse gram and Bengal gram) is higher than the state average but lower than the national average.

Table 4.11 Productivity of Major Crops

Food grains	Area in different seasons (in Acres)		Total Production (in Quintals)	Total Area (in acres)	Total Area (in ha)	Productivity (Qt/ha)		
	Kharif	Rabi				Survey Households	All Odisha*	All India*
Paddy	48.25	-	308	48.25	19.53	15.77	15.53	23.55
Pulses	23.11	38.58	129	61.69	24.97	5.17	4.97	6.55
Oilseeds	9.68	18	91	27.68	11.20	8.12	8.48	10.26

Food grains	Area in different seasons (in Acres)		Total Production (in Quintals)	Total Area (in acres)	Total Area (in ha)	Productivity (Qt/ha)		
	Kharif	Rabi				Survey Households	All Odisha*	All India*
Maize	1.5	-	13	1.5	0.61	21.42	22.45	23.35

*for the year 2008-09 sourced Department of Agriculture, Government of Odisha website http://www.agriorissa.org/pdf/Productivity%20of%20different%20crops%20in%20comparison%20to%20All%20India.pdf last accessed in Feb 2013

Source: Household Survey 2012

Livestock is an important capital asset in rural economies and supports the households with draught power for cultivation (bullocks), food (milk and meat) and income from the sale of milk, meat and often livestock. Cows constitute the largest bovine livestock in the village with 86 cows whereas goats are the largest ruminant population (124).The details of livestock and their ownership are presented in table 4.12 and also depicted in figure 4.4.

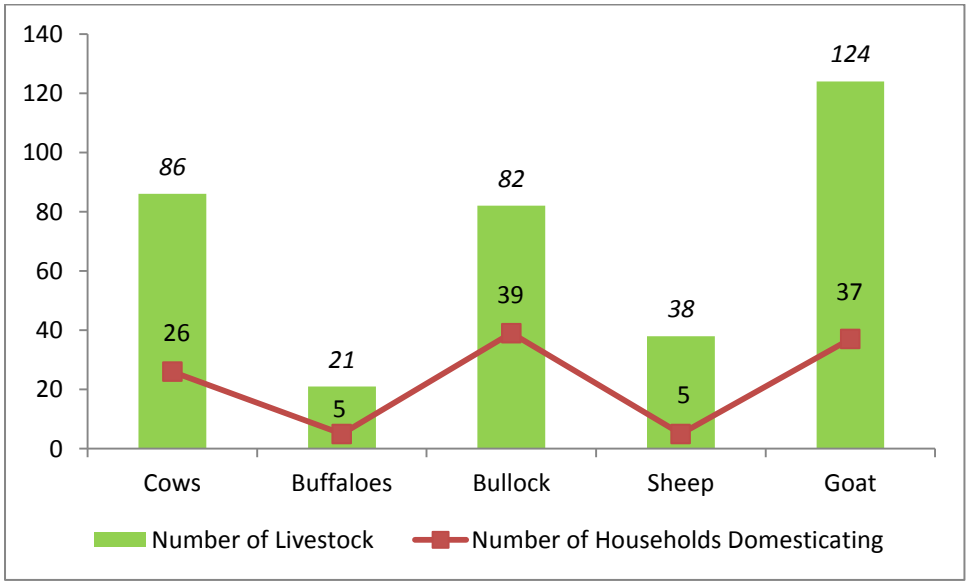


Figure 4.4 Number of Livestock and households rearing them

The number of households reported to domesticate cows and goats in the village are 26 (22 % of total households) and 37 (32 % of total households) respectively. Among the other livestock, there are 82 bullocks, 21 cows and 38 sheep in the village. The farming households usually own a pair of bullocks which they use for ploughing. Of the 39 households owning bullocks, 37 of them own a pair each and 2 of them own 2 pairs. Though around 90 families are into farming, several of them don't own any bullocks. They hire tractors and also bullock ploughs from others in the village to till the land. Buffaloes and sheep are domesticated by five households each in the village. The total livestock in the village when converted in cow units (see the note below table 11) is estimated to be 204 and are owned by 62 households (72

% of total households). As the income from livestock is concerned, selling of goats and sheep are the major sources as very few (only 4 of 16 households having milch cows) households have reported to sell milk during the survey. Most of the cows are of local breed and the average yield is less than 2 litres per day. Only two households own hybrid cows. The average milk yield of buffaloes is reported to be higher (4.5 litres/day) than cows and only the households owning milch buffaloes and hybrid cows sell milk to a local milk vendor. The households having milch hybrid cows and buffaloes earn in the range of Rs.12000 to Rs. 15000 per animal annually from the sale of milk. Those having local breed milch cows usually use milk for home consumption or sell 250 ml to 500 ml mostly to the neighbours in the village occasionally. The sheep and goats are usually sold for meat to the local traders. An adult male goat fetches Rs. 2500 to Rs. 3000 whereas a sheep fetches Rs. 1800 to Rs. 2000. The maximum number of goats sold by any individual households in a year is reported to 6.

Table 4.12 Livestock in the Village

Sl No	Livestock	Number of Livestock	Number of Households Domesticating
1.	Total Cows	86	26
1a.	Milch Cow	29	16
1b.	Non-Milch Cow	19	16
1c.	Calf/Heifer (Cow)	38	19
2	Total Buffaloes	21	5
2a	Milch Buffalo	6	2
2b	Non-Milch Buffalo	0	0
2c	Calf/Heifer (Buffalo)	15	5
3	Bullock	82	39
4	Sheep	38	5
5	Goat	124	37
	Total Livestock (in Cow units)*	204	62

*The cow unit has been estimated based on the average market value of different livestock categories by using following formula: Cow unit= Cow+ Bullock+ (1.2 x Buffalo) +(0.5 x Calf/Heifer) +(0.25 x Sheep) +(0.25 x Goat)

Source: Household Survey 2012

As the ownership patterns of the livestock are concerned, there is no significant difference among the social groups though the landownership pattern seems to have some linkage for ruminants. The bovine populations are spread over all land ownership groups whereas the ruminants (goats and sheep) are concentrated among the landless households or households with marginal land holding (see Figure 4.5). It has emerged from the discussion that the number of livestock has declined significantly over the years.

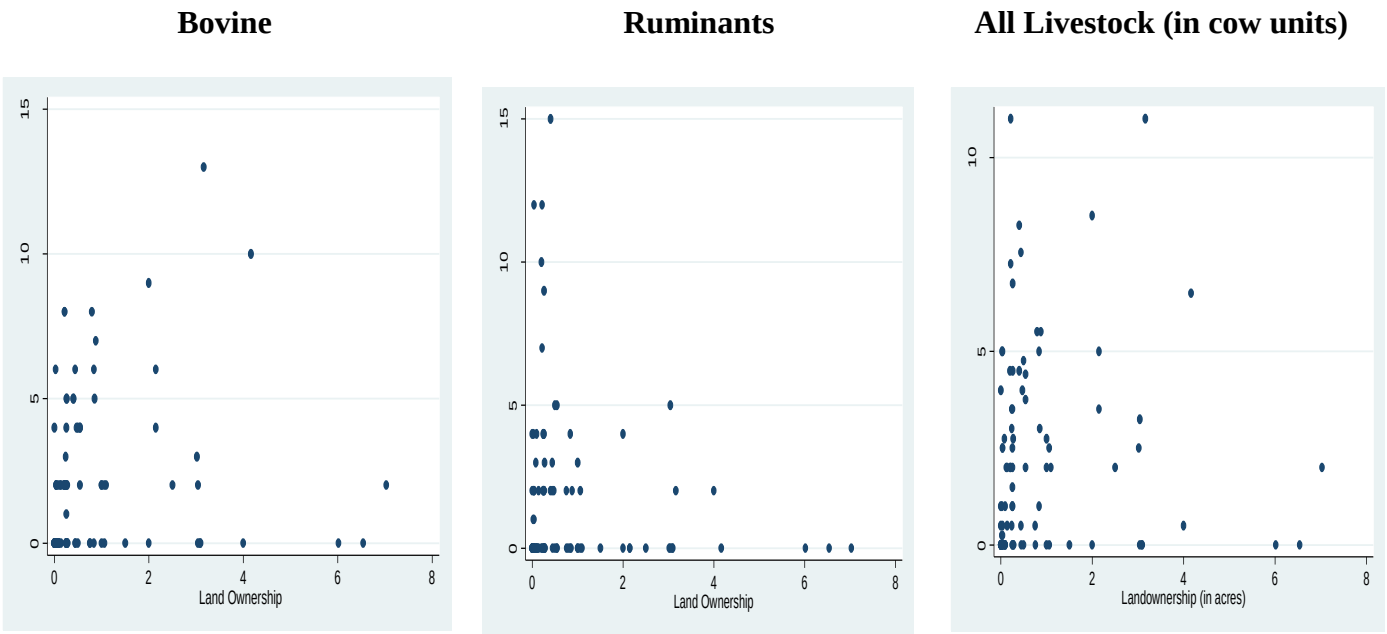


Figure 4.5 Livestock Units across Land Ownership

There is not much forest based income generating activities in the village except bee keeping by two households in the village. Both of them operate at a small scale and earn Rs. 1200 to Rs. 2000 per year. Around 24 per cent of the households reported to sell NTFPs and income from these sales varies from Rs. 200 to Rs. 3500 per year. Mahua flower and tendu leaves are the two major marketable NTFPs with a production of around 10 quintals and 8 quintals respectively. Sal seeds and wood apple also fetches some incomes. The village has 12 households belonging to blacksmith caste group and several of these households are into their traditional family occupation. They not only cater to the demand within the village but also of neighbouring villages. Some of them make sickle, shovel, plough chisel and several other agricultural implements as well as household tools to sell them in weekly markets and nearby towns. The village has also a Self Help Group (SHG) supported by the JICA funded OFSDP which is an important source of mirco-credit for member households. The group members borrow for a range of activities like buying livestock to meeting the medical expenses. The SHG also built a storage house for onions and garlic which the farmers use to store their crops to sell them in a later month at higher price. They pay a nominal fee towards storage rent to the SHG.

Dependence on Forest

The households living close to forests depend on forests for a host of products like firewood, fodder, timber, bamboos, fibres, leaf litter, food and a several other non-timber forest products (NTFPs). Some of these forest products also fetch income for the households collecting and selling them in market. The households in the pilot site too depend on forest for several products and the dependence level is depicted in Figure 4.6. All the households surveyed in the village reported to depend on forest for firewood and around 93 per cent of

the households collect NTFPs for their own use. These NTFPs include fruits and berries, leaves and vegetables, edible roots, fibres, honey, flowers and seeds for food and oil, varieties of wild mushrooms, medicinal plants and so on. The survey also found that around 50 per cent of the households depend on forest for fodder and leaf litter (use as manure in agricultural field). The percentage of households depending on forest for timber, poles, bamboos are 10.3, 22.4 and 83.6 respectively. These products are used by the households for construction and repairing of houses, making agricultural implements and other domestic use. As discussed earlier, only 24.1 per cent of the households reported to sell NTFPs. The marketable NTFPs collected by the villagers are mahua flower, tendu leaves, custard apple, wild mushroom, honey, sal seeds, barks, gums and resins. Among the different products, firewood, fodder and bamboo are the ones which most of the household collect in the study village.

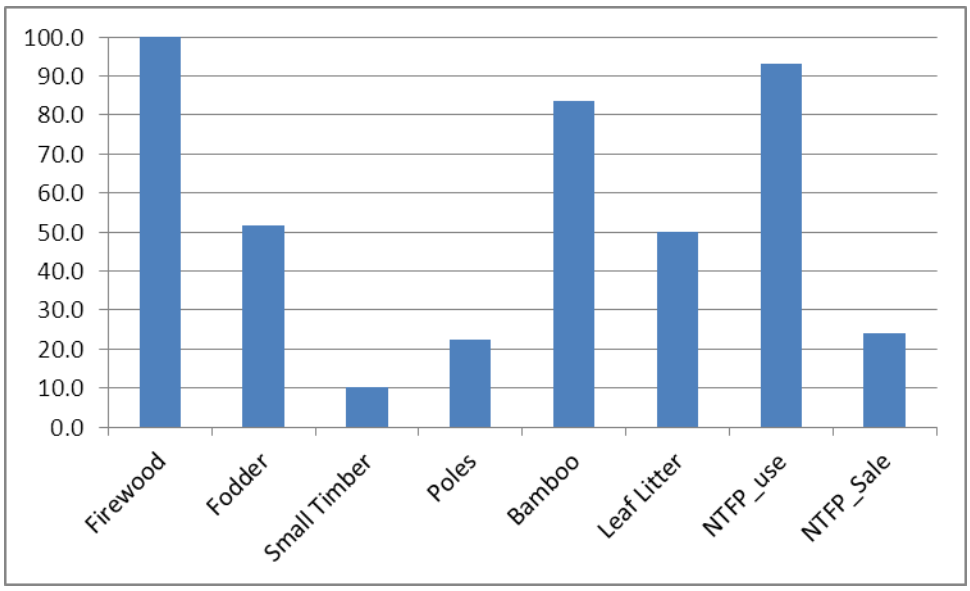


Figure 4.6 Percentage of Households Collecting Various Forest Products

Firewood: The households collect both green wood and dry wood form forest for firewood purposes. None of the households in the village collect firewood to sell in the market. The green wood is collected once in a year after the annual cleaning and thinning operation which is done usually during April-May every year. Each household is allowed to collect 2 cartload of greenwood at a price of Rs. 5 per cart for the member households. One cart load of firewood weighs around 500 kg. The villagers are allowed to collect maximum of two head loads of dry wood after October every year depending on their requirement with the average weight of the head load being 25 kg. The data on firewood are collected in terms of cartloads and head loads and later converted to kg by multiplying the average weights (i.e., 500 kg and 25 kg respectively). The mean volume of firewood collected by households is 1360 kg (±295.19) per year (see table 12). Greenwood, which households collect after the annual cleaning and thinning operation constitutes two third of the total firewood collected by the households from forests. The firewood collection pattern across the household size is depicted in Figure 4.7. It's evident from the graph that firewood consumption of the household increases with household size.

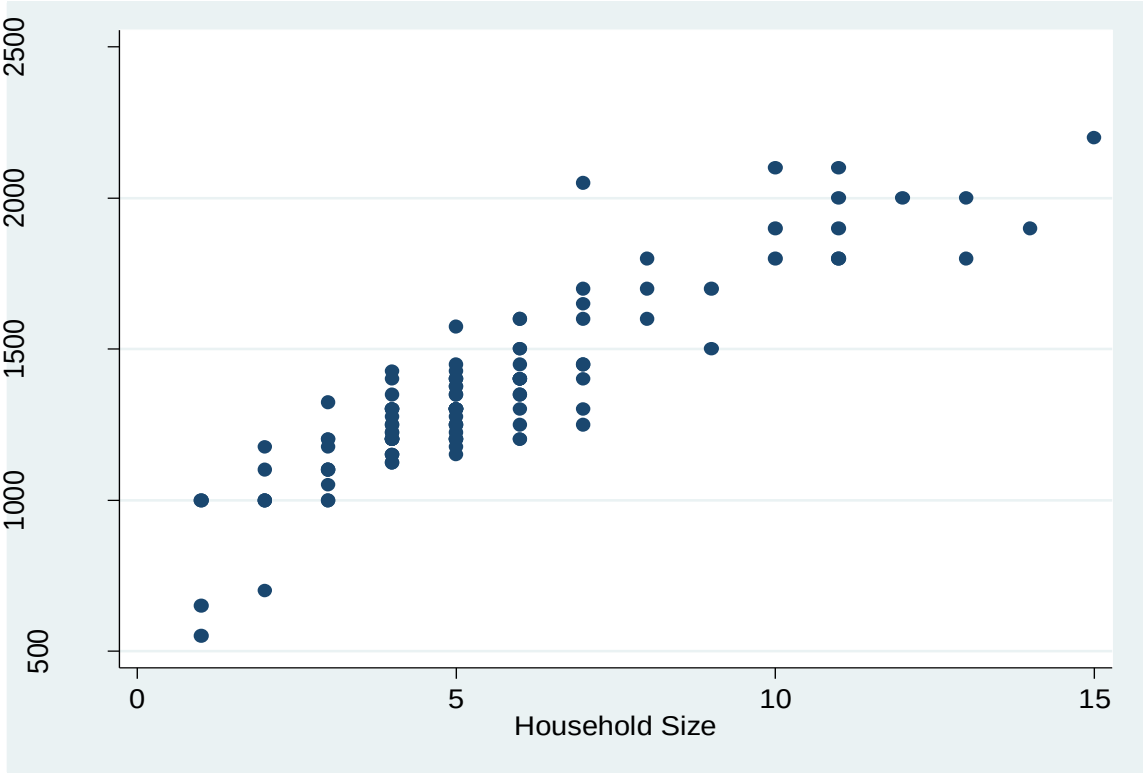


Figure 4.7 Household Size and Collection of Firewood (kg/year) from Forest

Fodder: Households domesticating livestock depend on forest for fodder as well as grazing. It has emerged from the discussion and the household survey that the villagers also source fodder from other village commons like agricultural land, community pasture, bunds of nala that flows through the village etc. The peripheries of the forests are usually used by the animals for grazing as the forest does not have much grass. Of all the households reported to have livestock, 42 households indicated that they depend both on forest as well as other commons for open grazing whereas 6 and 12 households depend mostly on forest and mostly on village commons respectively for open grazing (see Figure 4.8). Only two of the livestock owning households reportedly don't let their animal go for open grazing at all. Only 25 of the 62 livestock owning households collect tree fodder from forest. Tree fodder is found to be collected mostly by the households having goats and sheep. Forest is the major source for tree fodder with 18 households reported to have collected tree fodder mostly from forest and only two households reported not collect fodder from forest and mostly collecting it from other commons. The remaining five households depend on both the sources. Similarly, grass fodder is mostly collected from agricultural land and other commons with 47 households reported to be collecting from this source. The mean volume of grass fodder collected by 58 households is estimated to be 2287 kgs(±1874.73) (see table 4.13). Around 25 households reported to collect tree fodder and the mean volume of tree fodder collected by these household is found to be 722 kg .

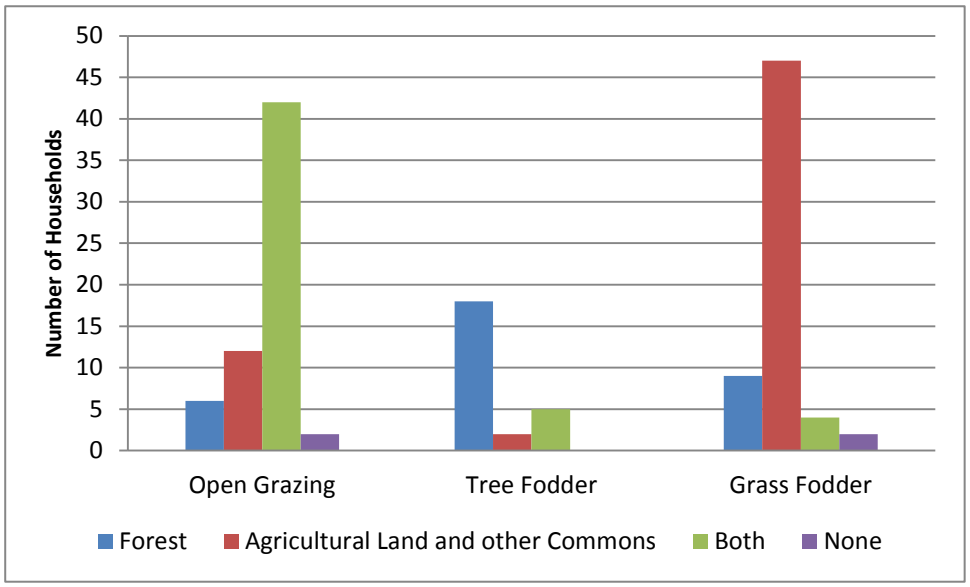


Figure 4.8 Sources of Fodder and Grazing

Bamboo: Bamboo is used by the households for a variety of purposes i.e. house building, making bullock carts and other agricultural implements, fencing the fields and so on. Each households in the village is entitled to extract upto 20 bamboos in a year by paying a nominal fee of Rs. 0.50 (fifty paise) during annual harvest. Those in need of more can pay Rs. 10 per bamboo and can extract with due permission only. It has been found from household survey that 97 households have got bamboo from forests in the survey year (see table 4.13). The average number of bamboos extracted from forest by these household is found to be 19 (±4.08).

Table 4.13 Summary Statistics of Firewood, Fodder and Bamboo Extracted Annually

Forest Products	Number of Households Extracting	Mean Volume (in Kg*.)	Standard Deviation	Minimum Volume (in Kg.)	Maximum Volume (in Kg.)
Greenwood	116	1012.93	139.27	500	1500
Dry wood	109	372.94	226.85	50	1000
Total Firewood	116	1359.91	295.19	550	2200
Grass Fodder	58	2287.07	1874.73	200	10000
Tree Fodder	25	722	985.18	100	5000
Total Fodder	60	2508.33	2064.19	100	10000
Bamboo	97	18.56	4.08	10	30

Note: * bamboo in numbers

Source: Household Survey 2012

Sustainability of Harvested Forest Resource

Sustainable use and extraction holds key to the sustainable management of forest by the local communities. Here we make an attempt to assess the sustainability of extraction of forest, fodder and bamboo by the villagers.

Firewood

The working plan of Angul forest division for the period 2007-08 till 2016-17 has estimated the annual firewood production in the division as follows:

143633 MT (for >30 cm gbh)

117916.79 MT (for < 30 cm gbh).

So the average firewood production in Angul for all forest = (143633+117917)/2=230775 MT

With the total forest area in the division being 73690.836 ha, the firewood yield per ha =230775/73691=3.13 MT annually

The village manage 200 ha of forest and the firewood extraction is limited to these 200 ha. So the annual firewood production in the village= 3.13 X 200 =626.33 MT.

Total Firewood Extracted based on the household survey data=157750 kg or 157 MT

(Greenwood=117500 and Drywood=40650)

So the annual extraction of firewood is much below the production and hence sustainable

Fodder

The results of the household survey suggest that household's dependence on forest is mostly for tree fodder and grazing. Grazing of cattle is limited to the peripheries of the forest as the core areas do not have much of grass. However, the ruminants do graze both in core and peripheries. The sustainability of grazing practices can be estimated with adequate field survey. However, as the extraction of fodder (grass and tree) is concerned, it is estimated to be 150500 Kg per year based on the household survey.

Total Fodder extracted=150500 kg (Grass Fodder=132650, Tree Fodder=18050)

The total fodder requirement of the livestock units of the village can be estimated based on the FSI formula and is presented below. The annual fodder requirement for all the livestock in the village is estimated to be 531075 kg. With FSI formula stating that 30 per cent of the total fodder is met from forest, the estimated extraction from forest would be 159053 kg annually.

Table 4.14 Estimated Fodder Requirement

Sl No	Livestock	Fodder Requirement per day* (in Kg)	Fodder requirement per year	Number of Livestock	Total Fodder Requirement per year(in Kg)
1	Cows	5	1825	86	156950

Sl No	Livestock	Fodder Requirement per day* (in Kg)	Fodder requirement per year	Number of Livestock	Total Fodder Requirement per year(in Kg)
2	Buffaloes	10	3650	21	76650
3	Bullock	5	1825	82	149650
4	Sheep	2.5	912.5	38	34675
5	Goat	2.5	912.5	124	113150
					531075

Note: * as specified in Working Plan of Angul Forest Division based on FSI formula.

Bamboo

We don't have data on the number of bamboo clumps or the total bamboo bearing areas in the 200 ha of forest managed by the villagers. This can be estimated as below:

Total bamboo bearing area in Angul (as specified in working plan) = 11263.724 ha which comes to 15.285 per cent of the total forest area of the division. Assuming the same share of bamboo bearing areas in the 200 ha forest managed by the villagers, the area under bamboo in the said forest= 30.57 ha. The working plan also estimated the average number of bamboo clumps per ha as 66 and average number of culms per clump is 18. So total number of bamboo clumps in 200 ha forest= 30.57 x 66= 2017.62 and total number culms in the forest=2017.62 x 18 = 36317.

The total number of bamboos extracted by the households as per the household survey is 1800 which is around 5 per cent of the total stock. The sustainable extraction limit being 15 per cent of the total stock, bamboo extraction by the villagers found to be sustainable.

The Institutional Mechanisms of Forest Management

The village has a functional and active VSS (JFM committee) that organise the member households for several protection activities and also regulate the collection and use of various forest products. As discussed earlier, the community based forest management initiatives in this village dates back to 1990 in response to the forest degradation and its adverse impact on the life and livelihood of the local communities. Angul, like other parts of Odisha is in the forefront community forest management initiatives that gained momentum in 1980s. The campaigns led by civil society organisations, school teachers and local activist spearheaded this movement and the support from various international organisations/agencies gave impetus to these initiatives. The policy measures by the central and state government in subsequent years have also formalised these efforts.

The conservation measures initiated by the people in Jerang village in 1990s formalised later as VSS in 2005 under the JFM guidelines of the state government. The general body of VSS constitutes 2 members (1 male and 1 female) from each household. The general selects an executive committee with a President, Secretary, Treasurer and eight executive committee members (5 male and 3 female). The local forest department official acts as the ex-officio Secretary of VSS. The forest department representative works as the official secretary

whereas the secretary selected by the villager is responsible for operation of VSS along with President and other EC members. The VSS also appoints one animator to who facilitate meetings, maintains records and look at the day to day activities of the VSS. The VSS carries out activities like daily forest patrolling, cleaning and thinning operations, maintaining of fire lines, planning and implementing forest conservation measures, design and enforcement of appropriation and provision rules[2], coordination with forest department and so on. The executive committee (EC) meets every month whereas the general body (GB) meets once in three months. However, the EC as well as GB too gets convened other times whenever required to discuss any pressing issue.

The VSS has a set of clearly defined provision and appropriation rules for the management of forest and the most of them seems to be enforced too. The VSS maintains several records like patrolling register, meeting proceeding register, extraction registers, accounts books, forest activities records books etc., to document the activities and also the processes. The daily patrolling team constitutes a group of 8 households with a team leader who takes a round of the forest daily and reports the status to the forest including the cases of illegitimate extraction by any of the member households or offenders from neighbouring village. The team leader of the group also report the presence or absence of any member in patrolling activities in the patrolling register that very day and pass the register to the next group responsible for patrolling next day. The President or Secretary checks the register every evening and take actions accordingly. These processes are meticulously documented. For instance, the President or Secretary signs the patrolling register every evening and specify the penalty for the members who absented from patrolling or illegitimate extraction by members as decided by the VSS. If the offences/violations are of a new kind for which the penalty has not been predefined, they mark it to discuss in the next EC or GB meeting. There are 14 patrolling groups in the village and each group consists of households located in different parts of the village with the group composition changing in every one or two years to avoid any possible collusion. The President, Secretary, Treasurer and Animator are exempted from the daily patrolling duty as well as other mandatory collective activities like annual cleaning and thinning operation, making fire lines etc. as they take other responsibilities. The other activities which are mostly undertaken with short notice like dousing forest fire, catching offenders, emergency meetings though need participation of all members are more voluntary in nature. However, the discussion with EC members and other key informants suggest that the usual participation even in such activities is quite high. The members violating the rules regarding participation in mandatory collective activities as well as the appropriation rules faces penalties in the form of fines, suspension from VSS membership and also ostracise socially. The records of VSS reveals graduated penalty structures where the volume of fine or severity of penalties is higher for repeat offenders.

As discussed earlier the village also has a clear set of rules concerning the extraction and use of forest resources. The major chuck of firewood is collected after the annual cleaning and thinning operation. The tree and branches cut during this operation are distributed equally among the each household and last year it was two cartloads of green wood. The households usually manage with this firewood from May-June to Sept-October. The VSS meets in Sept-Oct to discuss the firewood demand of the households and decides the

[2]Appropriation rules are the rules to regulate the collection and use of various forest products from forest. Provision rules are the rules concerning contribution (both physical labour and financial) of members for the forest protection.

quantum of dry wood (in head loads only) each household can collect from forest. The fee for cartload of firewood is Rs. 5 where as the head loads usually free. The VSS grants special permissions to collect more firewood for family festivals like marriage etc. on nominal payments, but the households seeking more firewood than the specified quantum for their regular use pay more. There are no specific rules for grazing and tree fodder collection as the VSS does not consider them having much of adverse impact of forest generation. However, the extraction of other forest products like bamboo, small timber, poles and several other NTFPs are well regulated. Each household is permitted to collect up to 20 bamboos on payment of 50 paise each and those who need more pay Rs. 10 each. Special consideration is given for the households building new houses or when any household loses their house due to fire or other calamities. The VSS also permits extraction of small timber and poles for agricultural implements, house building on payment. Usually the households approach the President or Secretary with their specific demands for any such products. The President or Secretary issues a paper slip specifying the numbers, tree species and even the extraction location. The patrolling team verify all these details and allow extraction accordingly. Any deviations are reported and fined as per the rules. The details of the extraction (date, numbers and fees) are entered in the extraction register and the fees are collected 2-3 times in year. The extraction register has one page for each household where all these details are entered. The extraction register for last two years also reveals fines up to Rs. 500 for illegitimate extraction and fines of Rs. 10 for extraction in violation of the specified permits.

The VSS auctions the Mahua trees and wood apple trees in the forest. Some of the member households usually take the annual lease of these trees and sell them in market. The VSS deposits all these money in their bank account and uses it for collective purposes. The VSS has also built community assets like a community hall and other capital assets like utensils and sound system which they earns some income when people hire for marriage and other household festivals. The villagers often contribute free labour for plantation activities planned under OFSDP and deposit the money for the in VSS account. The VSS, being the most active committee in the village also auction the fishing right over nala in one specific season and the money earned gets deposited in VSS account. Many such rules, both provision and appropriation, emerged over the years to meet different management challenges they face to manage forest and resolve the conflicts. One interesting example is the charcoal demand of the black smith families in the village. The VSS made them to do away with the age old practice of making charcoals by burning trees in the forest. They instead buy it from their neighbours who make them while burning firewood for cooking.

The field survey also found suspension of 3 households from VSS during last one year for not confirming to the norms and rules. The suspension often gets revoked after public apology or hefty fines depending upon the offences. The villages have also narrated many other interesting instances of conflict resolution concerning forest management within the village. Being part of the official JFM network also helped the long standing forest boundary disputes with neighbouring villages.

Gendered Roles in Forest Resource Extraction and Management

Women constitute 50 per cent of the GB and 30 per cent of EC of the VSS (as stipulated in JFM rules). The discussion with the EC members and key informants revealed participation of women EC members in EC meetings but very limited participation in GB meetings with fewer women attending the same. The proceeding register of different meetings also suggests attendance of fewer women in the meetings and decision making. There are 6

female headed households in the village and some of them do attend the meetings. The females from male headed households are less likely to attend the meeting unless they are EC members or specifically invited. Men EC members also undertake most of the travels be it visiting forest department offices or any exposure trips or training unless it's something specific to women members.

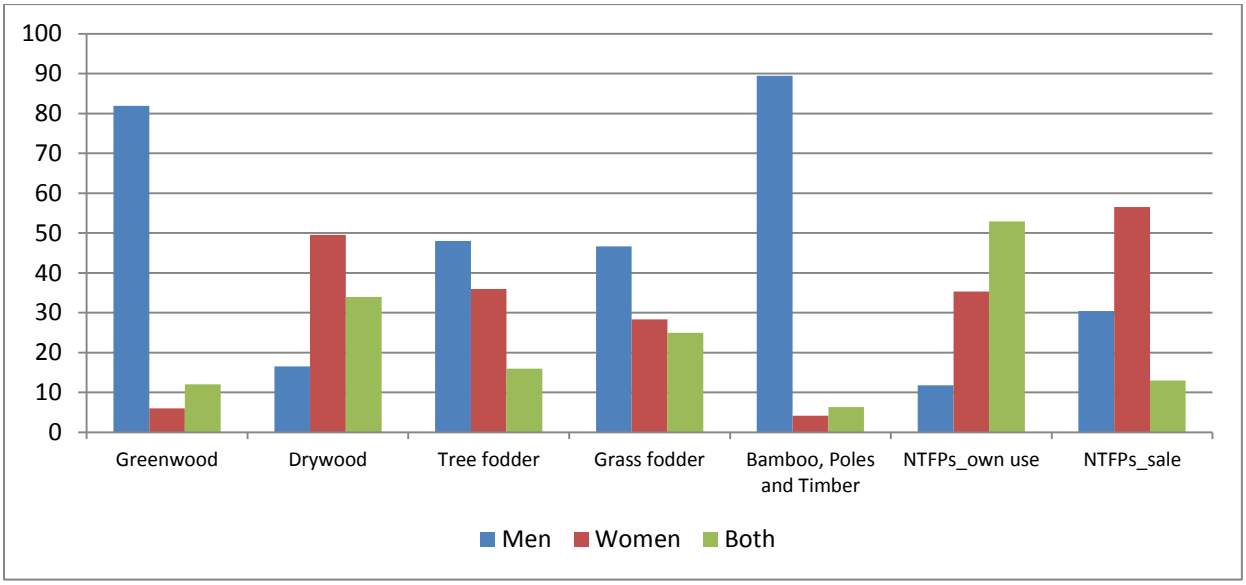


Figure 4.9 Gendered Role of Forest Product Extraction (in percentage)

However, women take lead in SHG activities as it's mostly a women group. Men also mostly participate in other collective activities like cleaning and thinning, plantation, making fire lines and so on. The gendered roles in extraction of various forests reveal interesting trends. This has been depicted in Figure 4.9.

It's the men mostly who collect greenwood which is used for firewood and bamboo, poles and timbers which people use for agricultural implements or house building. However, dry wood is mostly collected by women with 50 per cent of the households reporting this trend whereas for 34 per cent households both women and men do it together. However, the responsibility of drying and storage of firewood (both green and dry woods) rests on women in the household. Among all the households collecting fodders, it's the men who do it for majority of the households though pattern varies for tree fodder and grass fodder. However, women do the crushing and feeding of livestock at home. Women also play a major role in collection of NTFPs, both for own use and sale in the markets. Only 12 per cent of the households reported that men collect NTFPs for own use whereas for 35 per cent households it's mostly the women and for remaining 53 per cent it's both men and women together. Interestingly for marketable NTFPs, it's men for 30 per cent households, women for 57 per cent households and for the remaining 13 per cent it's both men and women.

Most of the domestic activities like cooking, child care and feeding of livestock at home are undertaken by the women. Milking of cows/buffaloes and milk processing are also mostly done by the women whereas the men have the responsibility to sell them in market. Women also work in agricultural fields and for wage labour like men. The storage of agricultural products, seeds and all other household food processing responsibilities like boiling paddy,

crushing of pulses, cleaning/winnowing etc. are shouldered by women members of the households. Women were also engaged in crushing paddy manually till rice mill were established in the localities in early 1990s.

Forest Cover Change and Carbon Stock Assessment

Forest Type and Vegetation

Given the tropical climatic conditions and concentration of precipitation mostly in monsoon months, the forests types in Angul forest division are North Indian Moist Deciduous and Northern Tropical Dry Deciduous (Revised Working Plan of Angul Forest Division 2007-08 to 2016-17, pp. 40). The moist deciduous are mostly moist peninsular Sal forest whereas northern tropical dry deciduous forest has two categories i.e., northern dry mixed deciduous forest and dry deciduous scrub. The details of the range wise distribution of forest types in the forest division are presented in table below.

Table 4.15 Range wise Distribution of Forest Types (Area in Ha.)

Name of the Range	Vegetation Types			
	North Indian Moist Deciduous Forest	Northern Dry Mixed Deciduous Forest	Dry Deciduous Forest Scrub	Grand Total
Chendipada	6392.06	2982.43	5537.67	14912.166
Durgapur	5549.19	5336.72	2249.21	13135.121
Kaniha	2930.93	4549.374	248.491	1728.784
Purunagarh	6548.75	5731.51	2569.33	14849.582
Raigoda	4305.59	1785.58	213.496	304.665
Talcher	3076.72	2901.65	2927.80	8906.166
Grand Total	**28803.25**	**23287.25**	**17745.98**	**69836.484**

Source: Revised Working Plan of Angul Forest Division 2007-08 to 2016-17

The pilot area is located in Durgapur Range and also has more or less similar forest type as the range. The detailed field investigation in 20 transects laid in the pilot area found 54 different species of flora (see Annexure. 4.3) with species density ranging from 39 to 121. The number of species found in each of the transects varies from 8 to 17.

Carbon Stock Assessment

As discussed earlier a five pool (Above Ground Tree Biomass (AGTB), Below Ground Tree Biomass (BGTB), Deadwoods (DW), Leaf Litter (LL) and Soil Organic Carbon (SOC)) measurement methods have been used for the assessment of carbon stock in pilot area based on the data collected from pilot site for 2012(Please refer to Carbon Stock Assessment Report for a detailed discussion on methodology). The results of the estimate of biomass as well as

carbon stock for all five pools in the pilot site in Angul are presented in table 4.16. As the results indicate, AGBT constitutes the largest carbon stock followed by BGBT.

Table 4.16 Carbon Stock of the Pilot Forest Area (200 ha.) in 2012

Measurement Method		Biomass (in ton)		Carbon Stock (in ton)	
		Ha^{-1}	Total	Ha^{-1}	Total
Above Ground Tree Biomass (AGTB)		158.81	31763.20	71.47	14293.44
Below Ground Tree Biomass (BGTB)		42.88	8576.06	19.29	3859.22
Deadwoods (DW)		2.93	586.00	1.32	263.70
Leaf Litter (LL)		3.70	740.00	1.67	333.00
Soil Organic Carbon (SOC)	0-15 cm			22.35	4470.00
	16-30 cm			13.61	2722.00
	31-45 cm			17.17	3434.00

Further, linear fit equations were developed through correlating the biomass values obtained from the field survey with the NDVI values of same coordinates (pixel) in 2012 satellite imageries for each pilot site. The present interpretation scale of 1:50,000 along with improved spatial resolution have made it possible to capture forest cover patches up to 1 ha area. Using the linear fit regression equation, biomass for entire project site was calculated for 2012. Similarly, with the help of this regression equation, biomass values (considering only AGBT and BGBT) of the same site for 1990 were estimated. So a two pool method has been used to discuss the temporal change (with 1990 as baseline) in carbon stock by comparing the difference in the biomass values from 1990 and 2012. So Remote Sensing (RS) or GIS based methodology can be used to estimate the carbon stock of the benchmark year as well as in estimating future stock at periodic intervals.

The output generated through this tool helps in understanding the impact of on-going management practices on forest ecosystem and carbon stock. Annual increment data of dominant species from secondary sources such as working plan document can also be used to refine the estimate, particularly in the grids where there was no change in the density class over the past few years. While RS data may not show any increase in grids where there was no change in canopy density, there was certainly an increase in carbon stock because of annual increments in the above ground woody biomass of the tree.

The regression for NDVI values and the AGBT in pilot site in Angul is presented in Figure 4.10.

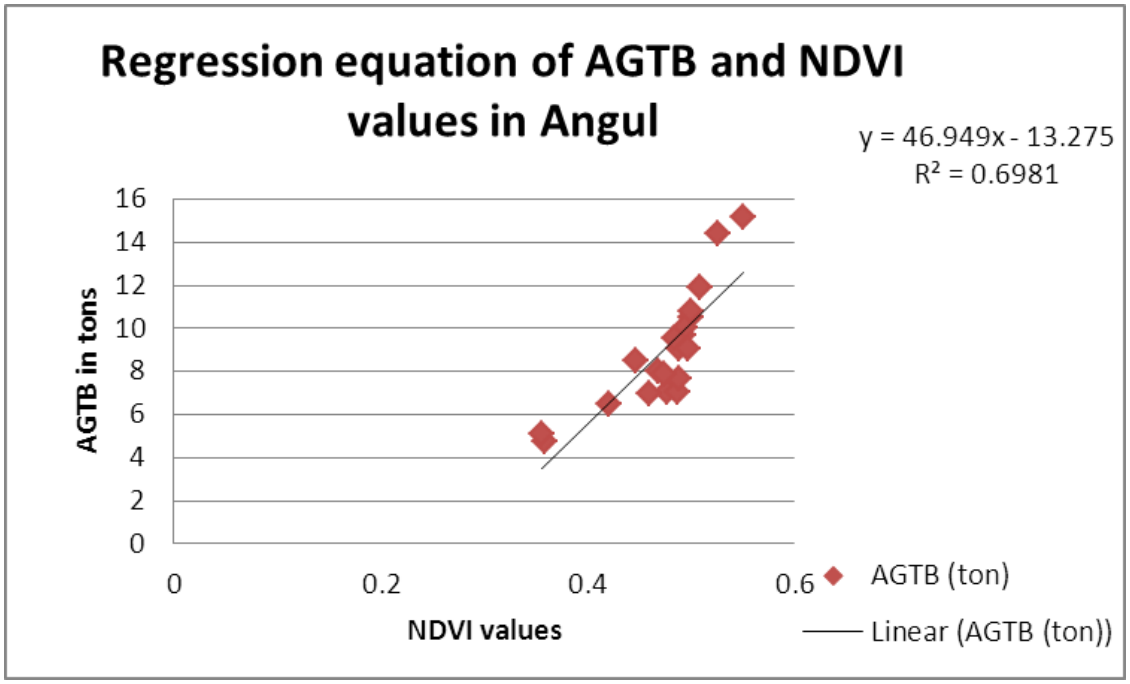


Figure 4.10 Regression equation of AGTB and NDVI in Angul

The grids where an increase in canopy density is observed with respect to the benchmark year indicated additionality due to Sustainable Forest Management initiatives by the VSS as well as other effective forest management practices. Similarly, a decrease in biomass over the years indicated loss of carbon from the area due to unsustainable forest management practices and/or anthropogenic pressures. So carbon estimation from above ground and below ground tree biomass can be compared with some baseline for which remote sensing data is available (1990 here) whereas the carbon stock in deadwoods, soil, leaf litter and decomposed material that are estimated based on the field data for 2012 can't be used to assess the temporal change with 1990 as base year. However, the current estimates for the later three pools would useful in comparing for future projects with 2012 as reference period. The results of two pool biomass and carbon stock estimates for 1990 and 2012 indicates that there has been an increase both in biomass as well as carbon stock in the pilot site by 10 per cent. This is presented in table 4.17. The protection initiative of the local community has resulted in increased forest biomass and carbon stock. The total carbon stock in this 200 ha of forest has increased from 16533 tons to 18153 tons with an additionality of 1619 tons of carbon. The per hectare carbon stock has also increased by 8 per cent. So the effective management and conservation efforts of the local community and forest department has not only brought a fine balance between the conservation and subsistence dependency of the local communities on forest but also resulted in increased carbon sequestration services.

Table 4.17 Change in Biomass and Carbon Stock 1990-2012 in Angul Pilot Site

Measurement Method	1990	2012	Change	1990	2012	Change*
	Biomass (ton ha^{-1})			Total Biomass (Ton)		
Above Ground Tree Biomass (AGTB)	144.65	158.81	14.16	28930	31763.2	2833.2
Below Ground Tree Biomass (BGTB)	39.05	42.88	3.83	7811.1	8576.06	764.96
Total (AGTB+BGTB)	183.7	201.69	17.99	36741.1	40339.26	3598.16 (9.79)
	Carbon (ton ha^{-1})			Total Carbon (Ton)		
Above Ground Tree Biomass (AGTB)	65.09	71.47	6.38	13018.5	14293.44	1274.94
Below Ground Tree Biomass (BGTB)	17.57	19.29	1.72	3514.99	3859.22	344.23
Total (AGTB+BGTB)	82.66	90.76	8.1	16533.49	18152.66	1619.17 (9.79)

**Values in parenthesis are the percentage change from the baseline year to the present year*

Limitations of the Study

Apart from the limitations of the carbon stock assessment methodologies which has been discussed in the respective section, the study for this pilot site has some other limitations concerning the estimation of extractions and the sustainable level. The extraction data is based on a onetime household survey conducted in the month of July-Sept 2012. Though the fuel wood and fodder use was verified for few of the respondent households during the survey, it is mostly based on the recall or the approximation based on the average daily use. The extraction of bamboo, poles etc. are based on the recall method only. None of the extraction data reflect the pattern of change in collection of these products due to natural calamities and other socio-economic shocks. The productivity of fuel wood and bamboo were estimated based on the available productivity data for the entire division in working plan.

Summary and Conclusions

The report makes a comprehensive assessment of forest management practices, dependency of the local communities and carbon stock of the forest managed by the JFM committee in the pilot site in Angul forest division in the state of Odisha. Angul has a history of community based forest management initiatives and the state forest department also played a catalysing role in furthering the same. As part of the pilot for REDD+, the forest managed by Jeranga Budhi Pahad VSS in Angul forest division has been selected for the detailed assessment. The villagers of Jerang have been protecting the forests around their village since 1990s which got formalised through constitution of VSS (JFM committee) later in 2008. As per the official records the villagers manage 200 ha of forest which is located in Jarapada beat of Durgapur range.

There are 116 households in the village with majority of them either being small farmers (72 % owning less than 1 acre of land) or landless (11%) and hence depending on forest for their subsistence needs like firewood, fodder and a range of other minor forest produces. Further 79 per cent of the households listed as below poverty line (BPL) households in the village indicates the poverty situation of the village. Though literacy is quite high (94 %), a significant proportion of the adult population does not possess qualifications or skill that fetches livelihoods. So a majority of working population are engaged in agriculture, wage labour and domestic work. Agriculture in the village is mostly rain fed as there are no irrigation facilities. Some farmers having land close to streams and other local bodies do grow vegetables and other cash crops. Agriculture in the village is characterised by low productivity as compared to the national average as farmers mostly adopt traditional cultivation practices due to lack of irrigation facilities and smaller operational holdings. Livestock also contributes to the livelihood systems of the households in the village not only as a capital asset but also as a major source of draught power for cultivation (bullocks), food (milk and meat) and income from the sale of milk, meat and often livestock. Cows constitute the largest bovine livestock whereas goats are the largest ruminant population in the village. The number of livestock in the villages has declined significantly in recent years.

The households in the village depend extensively on the forest for a variety of products like firewood, fodder, leaf litter, small timber, bamboo and other NTFPs. These NTFPs include fruits and berries, leaves and vegetables, edible roots, fibres, honey, flowers and seeds for food and oil, varieties of wild mushrooms, medicinal plants and so on. Small timber and bamboo are used by the households for construction and repairing of houses, making agricultural implements and other domestic use. Though around 24 per cent of the households are reported to sell NTFPs for an income none of them sell firewood in the market. The marketable NTFPs collected by the villagers are mahua flower, tendu leaves, custard apple, wild mushroom, honey, sal seeds, barks, gums and resins. Among the different products, firewood, fodder and bamboo are the ones which most of the households collect in the village. Given this extensive dependence of households on the forest that they protect, sustainable use and extraction holds the key to conservation. The study made an attempt to assess the sustainability of extraction of forest resources by the villagers and found that the extractions of all these products are well within the sustainable limits. This is due to effective management practices adopted by the village forest committee to regulate the extraction/harvesting pattern of the villagers.

The village has a functional and active VSS (JFM committee) that organises the member households for several protection activities and also regulates the collection and use of various forest products. The VSS carries out activities like daily forest patrolling, cleaning

and thinning operations, maintaining of fire lines, planning and implementing forest conservation measures, design and enforcement of appropriation and provision rules, coordination with forest department and so on. The executive committee (EC) meets every month whereas the general body (GB) meets once in three months. The daily patrolling team comprises a group of 8 households with a team leader who takes a round of the forest daily and reports the status to the forest including the cases of illegitimate extraction by any of the member households or offenders from neighbouring village and there adequate mechanism in place to make these patrolling groups effective enough. This apart the VSS also undertakes activities like dowsing forest fire, catching offenders, emergency meetings. The members violating the rules face penalties in the form of fines, suspension from VSS membership and also often get ostracised socially. Apart from all these activities, the VSS too maintains several records like patrolling register, meeting proceeding register, extraction registers, accounts books, forest activities records books etc., very meticulously. The VSS could settle several conflicts as well as unsustainable extraction practices over time very amicably making the protection initiatives inclusive and also succeeded in inculcating a sense of ownership among the villagers towards the forest they manage.

The study has adopted a two pool method (Above Ground Tree Biomass (AGTB) and Below Ground Tree Biomass (BGTB)) of assessing carbon stock to discuss the temporal change (2012 over 1990 as base year) through the total carbon stock is estimated by adopting five pool (Above Ground Tree Biomass (AGTB), Below Ground Tree Biomass (BGTB), Deadwoods (DW), Leaf Litter (LL) and Soil Organic Carbon (SOC) measurement methods. Remote sensing based methodologies are combined with field data to estimate the carbon stock. The results of two pool biomass and carbon stock estimates for 1990 and 2012 indicates that there has been an increase both in biomass as well as carbon stock in the pilot site by 10 per cent. This is presented in table 17. The protection initiative of the local community has resulted in increased forest biomass and carbon stock. The total carbon stock in this 200 ha of forest managed by VSS has increased from 16533 tons to 18153 tons of carbon for the sustainable forest management practices. The per hectare carbon stock has also increased by 8 per cent.

So the protection measures and management initiatives of the local community has not only brought a f balance between the conservation of forest ecosystem and subsistence dependency of the local community on it but also resulted in increased carbon sequestration services. However, these conservation efforts also impose some costs on these poor villagers which can be partially compensated through REDD+ or other payment mechanisms. There are several initiatives around the world where the local communities are being paid for contributing to the reduced emission for controlling forest degradation. The emergence of a market to trade the carbon sequestration services will also incentivise the local communities. As the REDD+ payment mechanism is yet to be formalised, the conservation initiative by the local community in pilot site may be compensated by linking them to some voluntary carbon market. The institutional mechanism to facilitate the carbon trading and payment across the scales/levels and its implementation are the issues that the researcher and policy makers need to address.

Chapter 5 REDD Plus Assessment in West Chhindwara

Introduction

Selection of the site

The site selection in the West Chhindwara Forest Division in Madhya Pradesh has been done based on consultations with the State Forest Department where the two adjoining compartments (Compartment No. 164 – 162.33 ha and Compartment No.165 – 341.84 ha) in Delakhari Forest Beat from the Delakhari Forest Range have been suggested. The total area of these compartments is504.17 ha. These compartments are associated with Anjandhana and Khatuadhana villages and are part of the Joint Forest Management (JFM) programme in these villages. The villagers are predominantly dependent on these compartments to fulfill their subsistence needs of fuel, firewood, timber and a wide range of NTFPs namely *Achar (Buchanania lanzan), Mahua (Madhuca indica), Sal seeds (Shorea robusta), tendu patta (Diospyros melanoxylon),* etc.

General Approach

The approach of the pilot project development has been to undertake social survey and biomass assessment. The forest dependence of the local people along with the sustainable levels has been analyzed based on the primary survey and the options for bridging the gap between the sustainable limits and the demands beyond the sustainable harvests have been discussed. The ecosystem services received by the people mainly in tangible form such as fodder, timber, NTFPs have been documented based on the primary surveys and the literature such as the Working Plans.

Background

The West Chhindwara Forest Division is situated between the parallels of latitude 21^0 52′ to 22^0 42′ North and between meridians of longitudes 78^0 14′ 43′′ and 79^0 01′ 52′′ East. The tract of West Chhindwara Division is plain to undulating and most of the area is hilly and rugged. Main forests of this Division are confined to ranges of Satpura Hill and Chhindwara plateau. The western and north western part of the Division is mostly hilly whereas the eastern and southern parts are mostly plain. The highest place in the division is in Tamia range, Protected Forest Block P-196 (Kala Pahar) at 1211 mt. attitude and the lowest place is in Jhirpa range, Com. No. P-14 (near Anjaan Nala) at 387 mt. attitude. The tract enjoys a pleasant climate and receives sufficient amount of annual rainfall from the south-western monsoon. Average annual rainfall is 1288.89 mm. The average temperature of this area varies from 20.4^0C to 28.8^0 C. The rainy season is from Mid-June to September and Winter season is from October to mid March. The summer season is from mid-March to mid-June. During summer, the temperature reaches up to 41.3^0C & during winter the temperature goes to minimum of 8.2^0C. The region is susceptible to forest fire every year from the month of February to middle June. There are repeated instances of fire, which affect the ground flora and regeneration.

The grazing pressure is excessive in the areas especially in Protected Forest areas. The villages adjoining the forest are dependent on forests for small wood and fuel for their domestic requirement.

Composition of Forests – Vegetation/ fauna and Flora

The plan area mainly consists of Teak and miscellaneous forest. Sal forest is also found in some ranges. Bamboo is also available along with the above types. Teak and Sal species are found together in some compartments of Dhelakhari, Tamia, Sangakhera and Jamai range.

The forests have been classified on the basis of system developed by H.G. Champion and S.K. Seth (1964):

(i) South Indian Tropical Dry Deciduous Teak Forest - 5A/C-1b

(ii) South Indian Tropical Dry Deciduous Mixed Forest - 5A/C-3

(iii) Northern Indian Tropical Dry Deciduous Peninsular Sal Forest – 5B/C-1c

The important Non-Timber Forest Products found in the division is Tendu patta, Kulloo-Gum, Chironji, Amla, Mahua, Sitaphal, Bel, Dhawara Gum, Honey & Mahul Patta.

The rotation for teak has been decided as 80 years. Corresponding to this rotation the maximum girth of 120 cm. will be obtained. Hence the selection girth for teak has been decided as 120 cm. For Sal, it found that the C.A.I. & M.A.I. graph meets at the age of 150 years (for III quality). The corresponding average girth is 121 cm. Thus Sal tree will give maximum volume increment up to girth of 121 cm. Hence the selection girth for Sal has been decided as 120 cm.

Past and Present Forest Management

This area in the 17th century was under the Gond kingdom of Deogarh. After this, the area came under the rule of Aurangzeb. During this period, huge forest areas were deforested for human settlements and cultivations.

The area came under British administration in 1853. The forests were thrown open to the contractors, on royalty system. Teak, being the only timber of utility, was heavily exploited.. Indiscriminate felling of Teak & Sal trees were undertaken to meet the demand of railway sleepers.

The forests were declared reserved by notification no.917/C dated 22th February 1879 under revised Indian Forest Act of 1878. At first, forests were divided into 'A' & 'B' classes. 'B' class forests were later mostly exercised for cultivation. Only the remoter forest areas were reserved. Teak, *Mahua* and other fruit bearing trees were declared reserved. Forest protection measures were introduced soon after reservation in 1879. The forest were surveyed and mapped from 1887 to 1896.

The forest of Delakhari Range constitutes 23016.48 ha area where 22970.8 ha is under current forest management. This is Protected Forest zone. There forests were handed over to the State Govt. Forest Department, for management on 31st March 1951. These forests were declared protected forests in 1955. Due to the selective felling in the forests, young to middle aged trees were only left in these forests. In the first forest working scheme in 1957-58 for the Delakhari forests under the selection-cum-improvement working circle, the felling cycle was kept at 20 years. The selection girth for teak was fixed at 105 cm; for *sal* 120 cm, for *bija*, saja & *salai* at 105 cm & for *dhaora* & *lendia* at 75 cm. The felling cycle for bamboo was kept at 4 years.

In the second **selection-cum-improvement** working circle, in 1972-73 teak, *sal* & miscellaneous forests capable of producing large sized timber were included. The felling cycle was fixed at 30 years. The selection girth for teak was fixed at 105 cm, for *sal, saja, bija, haldu* at 120 cms., for *tinsa, shisham, dhaora, anjan, lendia* at 90 cm and for rest timber species at 75 cm.

The Working Plan for the duration 1995-96 to 2004-05 proposed the following activities:

1. Selection cum improvement Working Circle (WC) .: - It included good teak, misc., and *sal* forest where the density was from 0.5 to 0.7. Selection girth for *teak, sal, saja, beeja, haldu, salai* was 120 cm and 105 cm for other species. Pre selection girth trees were not to be marked. Felling cycle was 30 years. Maximum 25% of selection girth trees were prescribed for marking provided they are silviculturally available. Regeneration was affected due to non-cutting of lantana and shrubs. Some areas got opened due to felling of silviculturally unavailable trees.

2. Protection (WC): - It included all the areas which were in protection WC in earlier plans and schemes. Mainly soil moisture conservation works were prescribed. No felling was prescribed (except for bamboo). Only malformed growth in under stocked area was to be cut. Due to inadequate soil water conservation works soil erosion could not be controlled completely although at many places soil was deposited in check dams. In under stocked areas, due to non exercise of singling work, malformed regeneration existed. Due to lesser biotic pressure in inaccessible areas, 11 to 30 cm (girth) crop was found in plenty.

3. Rehabilitation W.C. :- It included degraded areas mainly of teak and miscellaneous forest. Due to inadequate soil water conservation works soil erosion could not be controlled completely. Due to biotic pressure and fire incidences regeneration was affected.

The compartment 164 has been treated for the Rehabilitation of the Degraded Forests according to the prescriptions of the previous Working Plan. The compartment 165 has been exposed to treatment in form of selection-cum-improvement treatment where the timber harvesting was done in 2006-07 and 2007-08. These areas are monitored for ensuring the regeneration every alternate year. Also at the same time various forest improvement measures along with soil and water conservation works have been taken up in the compartments under consideration. For the current Working Plan period 2006-07 to 2015-16 for Delakhari region the emphasis has been on restoration of degraded forests. The protection of the forests is done through the Khatuadhan Village Forest Committee (VFC).

Methodology of the biomass assessment and socio-economic survey

Vegetation sampling has been carried out in both compartments for assessing the biomass.

Socio-economic survey was conducted at the household level for both the villages. Door to door survey was conducted using a structured questionnaire (Refer Annexure 5.1).

Analysis of the socioeconomic survey

Demography of the Village – Social and demographic

The socio-economic profile of the villages suggests that the area is dominated by the tribals. The limited livelihood opportunities and poor skill sets compel the local communities to seasonally migrate.

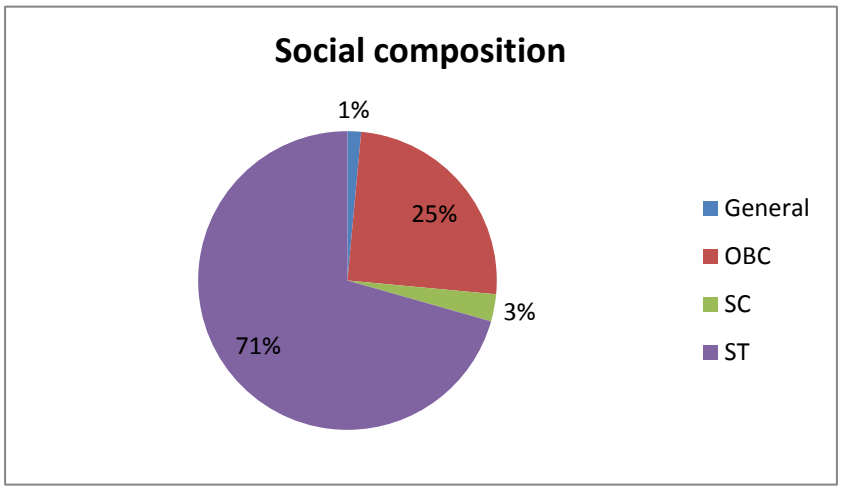


Figure 5.1 Social composition

As mentioned in Figure 5.1 about 71% of the households are ST followed by about 25% OBC households. .

Only about 17% of the poor families have BPL card but as per the survey approximately 55% of the households deserves BPL status due to poor income levels.

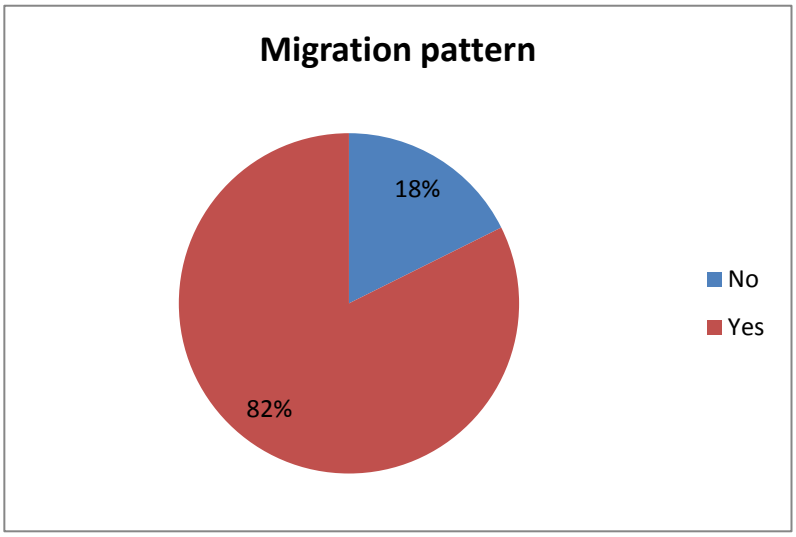


Figure 5.2 Migration pattern

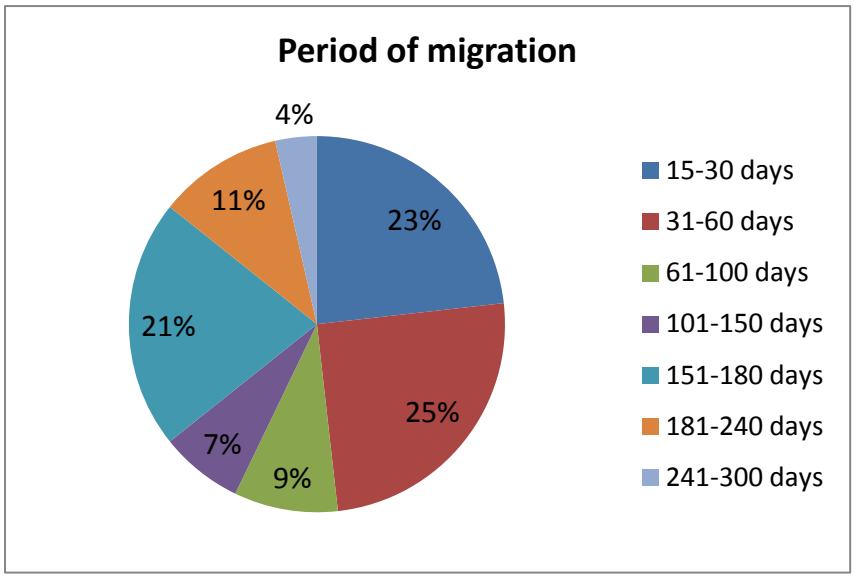


Figure 5.3 Periods of migration

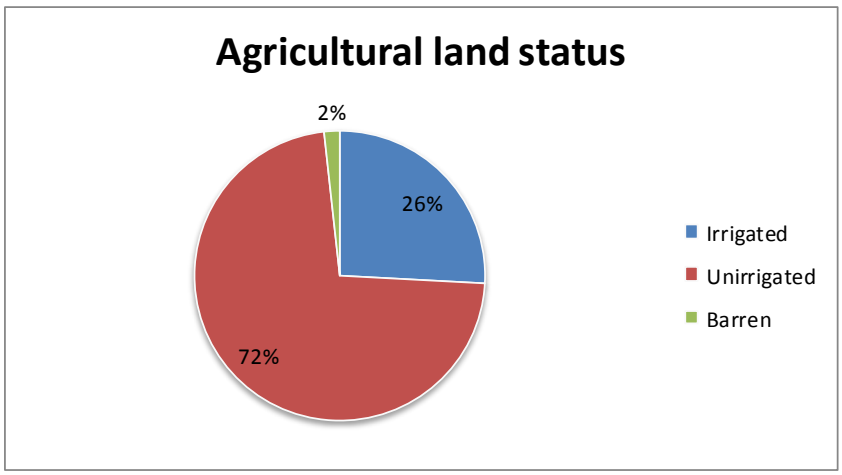


Figure 5.4 Status of agricultural lands

Migration for livelihood purposes has been a very common way of life in the region where almost 82% of the households migrate seasonally as shown in the Figure 5.3. The entire migration happens in form of unskilled labour. The inflows from the migration is mainly in form of cash and at times its in kind such as food grains.

The majority (72%) of agriculture is rainfed and about 26% of the agricultural land is irrigated. This irrigation is mainly done through the seasonal streams and well. The cropping pattern suggests that the irrigated lands grow rice and other cash crops such as Til, Soybean whereas the rainfed areas continue with the subsistence farming in form of Maize, *Sama, Javri, Koda, Kutki,* etc.as shown in the Table 5.1. Except for few families who have access to the irrigation most of the agricultural produce from the villages is used for self consumption. Also it is important to mention that the available production of food grains is not necessarily sufficient for the household consumption. Thus, the agriculture in this context does not meet the subsistence requirements.

Table 5.1 Agricultural production

Crop	Production/ Self Use	Quantity (kg/year)
Rice	Production	1895
	Self use	1770
Maize	Production	7333
	Self use	5573
Tur	Production	4630
	Self use	3170
Sama	Production	3815
	Self use	2955
Javri	Production	3755
	Self use	2895
Soybean	Production	4705
	Self use	3845
Til	Production	1640
	Self use	1625
Koda	Production	1625
	Self use	1625
Kutki	Production	1575
	Self use	1575
Dal	Production	355
	Self use	268
Chana	Production	1287
	Self use	1190

The table 5.1 suggests that the majority of the agriculture is subsistence and very marginal surplus food grains are produced.

Income and Expenditure status

The survey also tried to capture the various sources from where the local people generate the income as well as the various items of expenditure. .

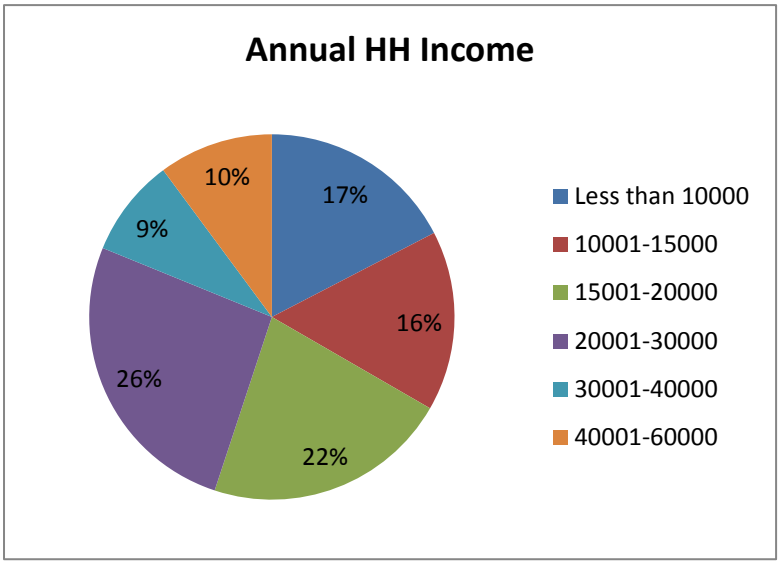


Figure 5.5 Annual Income of the households (Rs)

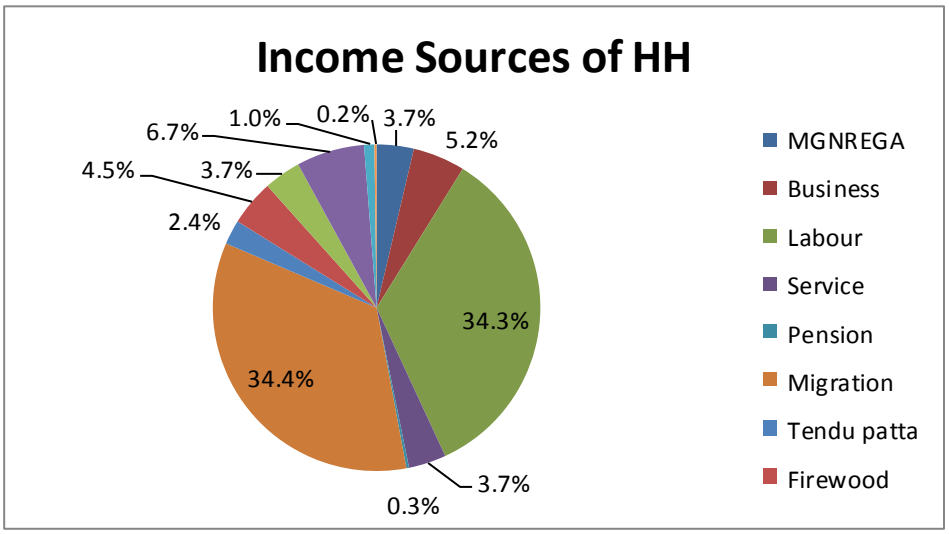


Figure 5.6 Contribution of various income sources to the household economy (%)

In the context of the income levels of the households the majority (55%) of the households earn annually below Rs 20000, about 30% of the households earn between Rs 20000 to Rs 40000 annually and about 10% of the households earn above Rs 40000. As regards the various sources of the income generation, the majority of the income is generated by labour (68%) either by residing in the village or by migrating seasonally. Forests provide about

18.5% of the share of the financial economy at the household level which includes collection of firewood and a variety of important non-timber forest produce (NTFPs). Considering the rapid nature of the survey it can be safely assumed that about 1/5 of the village economy is solely provided by the forests.

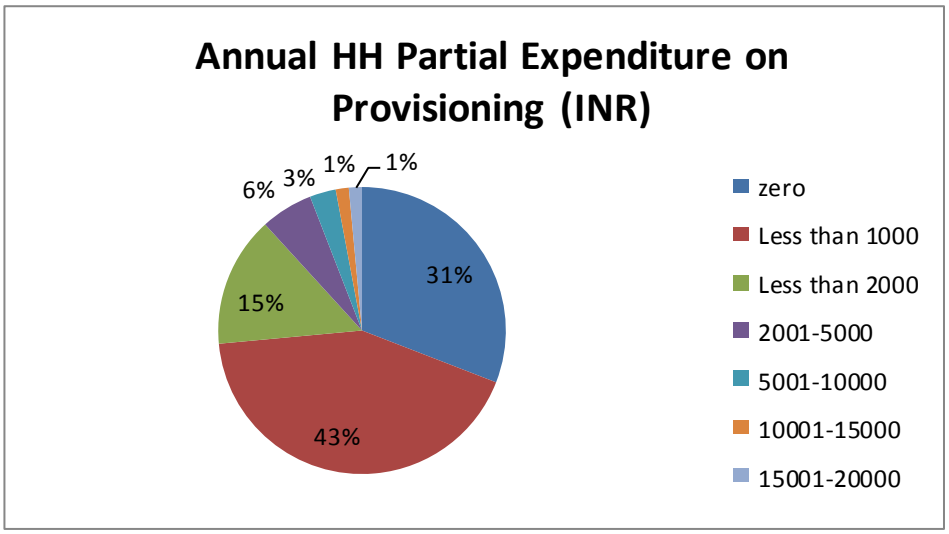


Figure 5.7 Household expenditure on provisioning for agriculture, grazing and kerosene

As shown in Figure 5.7 the majority of the household (43%) spends less than Rs 1000 per year on agriculture, grazing and kerosene followed by about 15% of household spending about Rs 2000 for these provisions. Rest about 11% of the household possibly having irrigated agriculture is capable of spending larger of sums about Rs 5000 for these provisions. The expenditure levels are also the function of land size and the household size. During the survey it was observed that the household members from the families having higher landholdings along with irrigation facilities also seasonally migrate for the work to strengthen the household economy. (We have included only those items of expenditure that are directly relevant to our assessment, and excluded routine expenditure on food and general provisions. This is therefore an estimate of partial provisioning expenditure.)

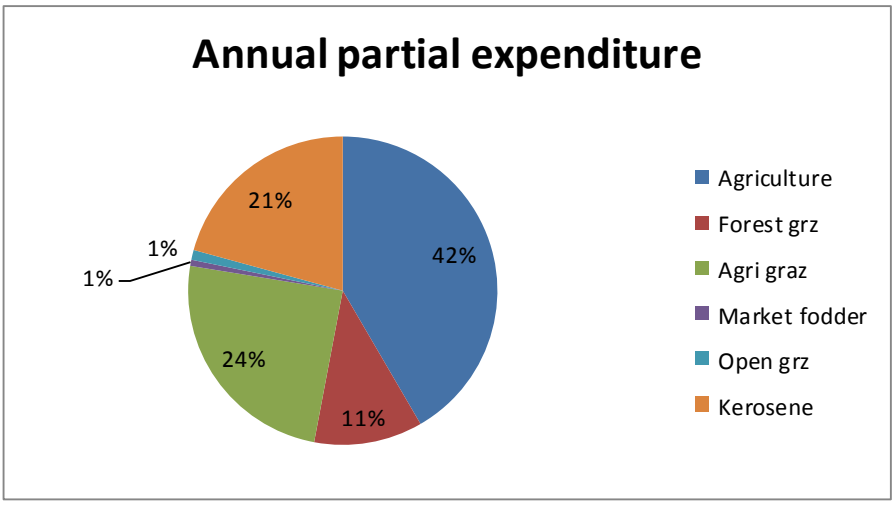


Figure 5.8 Annual Expenditure for provisioning

As shown in figure 5.8 one of the major expenditures is on procuring fodder from various sources which is about 37%. The agricultural work demands about 42% of the household expenditure whereas external fuel in form of kerosene contributes to about 21% of the expenditure.

Dependence on forests

The forests play a central role in providing a range of services in these villages. The financial economy is also greatly contributed by the forests in form of NTFPs sale. At the same time forest dependence has been possibly a main cause of forest resource degradation. This section analyses dependence on forests for various resources.

Firewood

Collection of firewood forms an important household activity since there is no other alternative fuel available at an affordable price. Also the area inherits a legacy of dense forests with abundance of timber trees such as *Sal*. But over the period the changing scenario of degradation cannot be neglected.

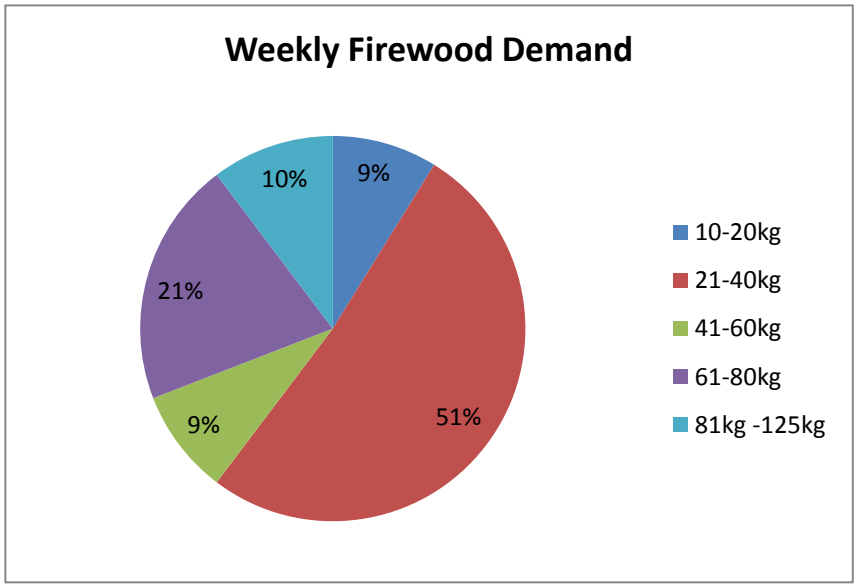


Figure 5.9 Weekly firewood demand (kg)

As shown in the figure 5.9 about half of the households have a weekly demand of about 21-40 kgs of the firewood followed by about 21% of the households consuming about 61-80 kg per week and another 10% of the household having about 81-125 kg per week demand. As per the survey on an average upto 40 kg of firewood could be assumed for household consumption. It is evident from the demand of the firewood that about 60% of the households depend on the firewood for domestic use whereas the rest 40% of the households also depend on the sale of the firewood.

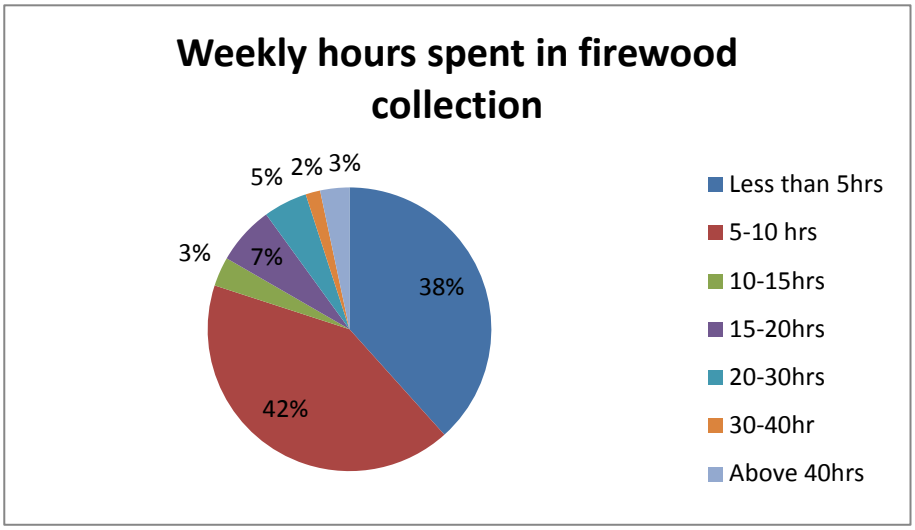


Figure 5.10 Weekly hours spent in firewood collection

The firewood is collected only from the forest floor and no tree felling is done for the purpose. Hence, the extent of firewood available will depend upon the health of the standing stock and the available mature trees. The degradation of forest would be realised by the firewood collectors immediately since the efforts for collection would be intensified and the time required for firewood collection would increase. The local people have the same perception as depicted in the Figure 5.10. Almost 65% of the households perceive that they need to walk more distance to collect the firewood (Figure 5.11)

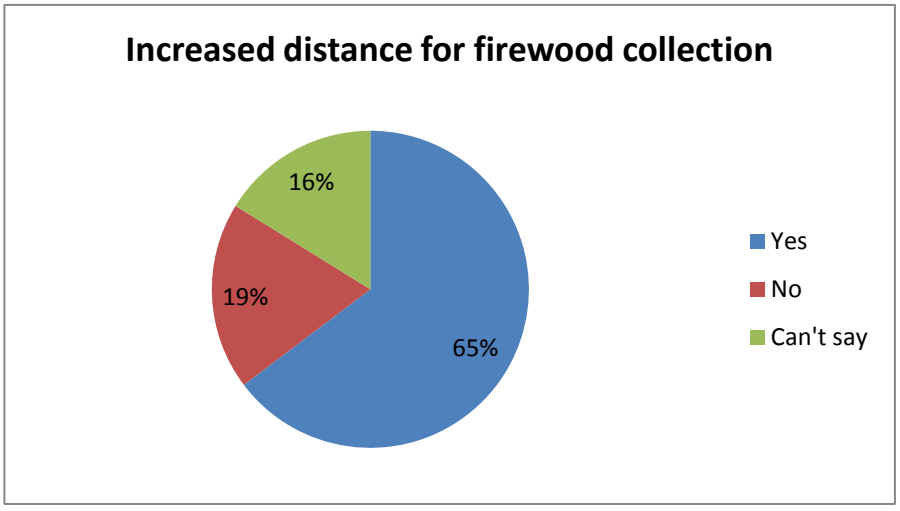


Figure 5.11 Increased distance for firewood collection

Grazing

The livestock population in the form of cows (milking and non-milking), bull and calves are an important feature of the village economy. About 37% of the household expenditure is on procuring fodder. The need to procure the fodder itself suggests the imbalance between availability and the demand.

Table 5.2 No. of livestock in the study area

Cows			Bull	Goat
Milking	Non-milk	Calf		
9	44	49	67	4

As mentioned in the table 5.2 there are about 169 cattle in the study area along with 4 goats at the time of the survey. The milk and milk products are all used at the household level and the beneficiaries of the goatery and poultry are one family each. As per the survey there is a fodder demand of about 3012kg /week. As mentioned in the graph 13 below it's noteworthy that about 50% of the demand is fulfilled from the market and rest 50% from the forest and the village surroundings. The extreme dry weather during summer would have an important impact on availability of the nutritious fodder from the village surroundings.

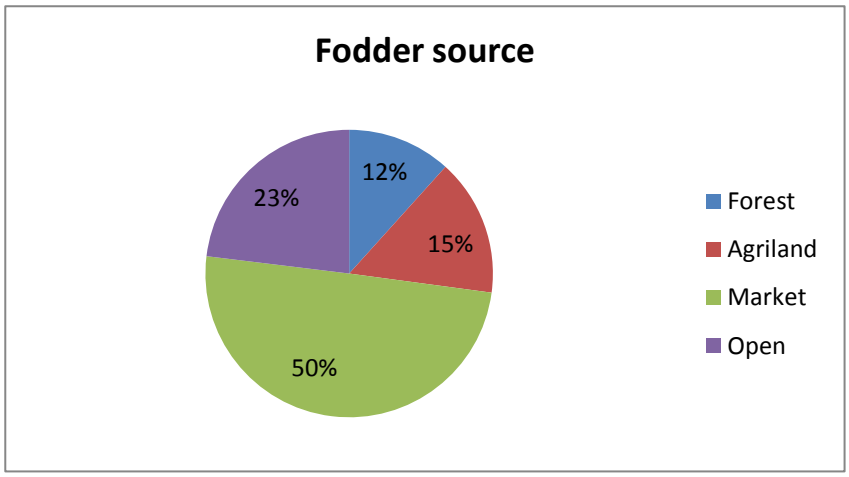


Figure 5.12 Fodder sources for cattle

Non-timber forest produce (NTFPs)

The forests provide an important source of a range of NTFPs used at household level as well as sold at the market to bring cash for the household economy in the villages of Chhindwara.. For this study the inventory of key NTFPs has been done such as Tendu patta, Mahua, *Achar*, *Sal* seeds, etc.

A large number of families are involved in collection of the NTFPs such as Tendu patta, *Mahua*, *Achar* as mentioned in the table 5.3 below:

Table 5.3 No. of Households involved in collection of NTFPs

	Mahua (HH)	Achar (HH)	Tendu (HH)
Self use	23	4	0
Sale	48	36	35

Out of total 68 families surveyed from both the villages almost 70% of the households are involved in the collection of Mahua, Achar and Tendu patta. Mahua is also extensively consumed at household level for various purposes and the collectors tend to retain certain amount of the produce for such use.

Table 5. 4 Quantity of NTFP collection per year

Mahua (kg)	Achar (kg)	Tendu (bundles)
5838	837	33906

As regards the quantities of collection of NTFPs, 5838 kg of Mahua flowers, 837 kg of Achar seeds and 33906 bundles of Tendu patta are been harvested annually from the forests. These quantities are collected from the available number of trees spread over about 504 ha of the JFM area as mentioned in Table 5.4.

Table 5. 5 Population of NTFP trees

Species	Trees/ha	Estimated population
Achar	68	34272
Tendu patta	136	68544
Mahua	52	26208

The figures 5.13 and 5.14 are evident about the status of the population of Achar, Mahua and Tendu. The GBH classes show that the maximum number of trees is available between 11-20 cm class and in further classes the population is decreasing. But with respect to the available number of trees/ha about 60% of Tendu trees are available only within 20 cm GBH class and rest 40% trees are thinly distributed between 21 to 120 cm GBH. Similarly about 88% of the population of Achar trees is available only within 40 cm GBH and 12% are distributed between 41 to 120 cm GBH. This suggests that there is a need of protecting these species from any form of cutting so as to assure the productivity of the NTFPs in the long term.

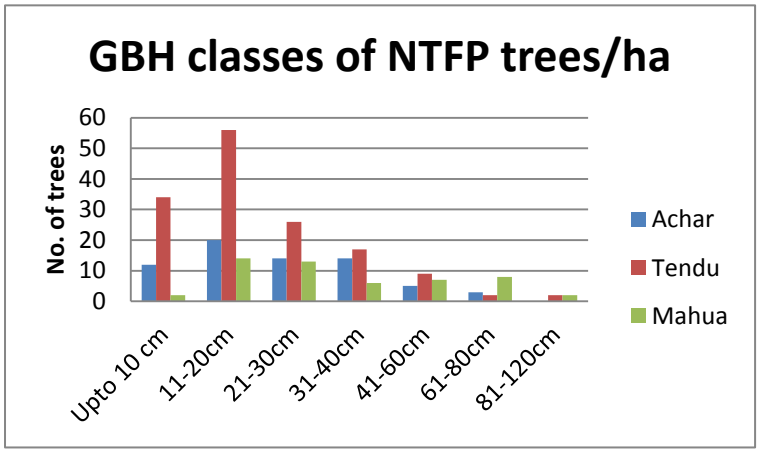


Figure 5.13 GBH class distribution of NTFP trees

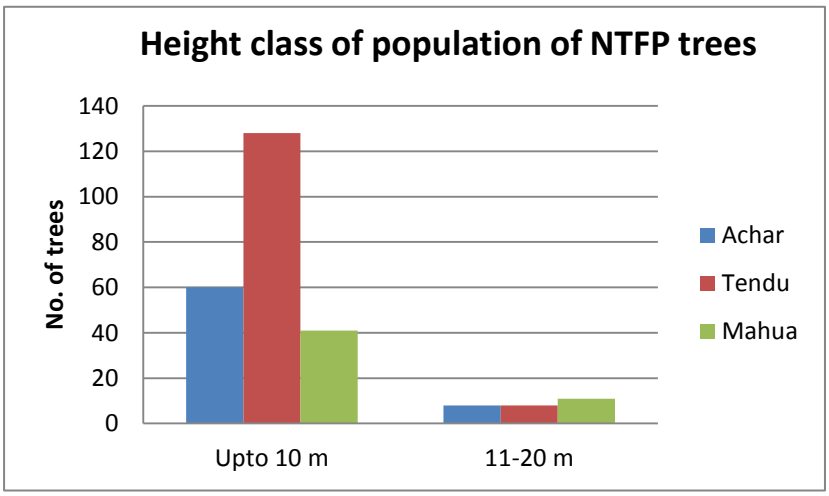


Figure 5.14 Height class of population of NTFP trees per hectare

Sustainability of the harvested resources

The dependence of the local people over generations along with other pressures on forest with respect to increased population of humans and cattle, logging, possible increase in agricultural area etc. lead to an important issues of sustainability of the resources and the methods of harvesting.

Mahua

An average sized tree yields about 50 – 100 kg of flower in a season that lasts around a month. One Mahua tree has an annual average yield of 62.5 kg of flower and 59 kg of *gully* /fruits as per one study. Another study done by SFRI, Jabalpur finds that yield per tree varies between 11.43 to 76.8 Kg a year Source (Panda, Mishra and Thakur *undated*).

Table 5.6 Productivity of Mahua flower at different ages of Mahua Tree/yr (units)

Age in Years	Quantity (Kg/Tree)
10	10
20	30
30	60
40	90
50	135
60	140

Source (Panda, Mishra and Thakur *undated*)

The collection of Mahua flowers is certainly harmless in terms of forest degradation but the method of collection especially by burning the forest floor causes forest fires. The survey also reveals that during the season of Mahua flower collection the incidences of forest fires are common leading to the loss of vegetation and leading to the degradation of forests.

Achar

Chauhan et al 2012 mention that about 40 kg of seeds are produced from a full grown tree. Generally, a full grown plant may produce 1.0 q of fresh fruits with a bulk yield of 40 kg of stones and 7-8 kg of kernels in a year. However, 3-4 kg kernels per tree are collected every year (Chauhan P. S. Jitendra S m Kavita A. 2012 HortFlora Research Spectrum, 1(3): 375-379 (2012). There are about 68 trees/ha of Achar in the area and there is about 837 kg of *achar guthali* being sold by the local people as revealed by the survey. This seems to be an important NTFP where a number of issues if managed in an organized manner could fetch excellent returns to the villagers as mentioned below: –

- There could be existence of about 350 trees spread over 504 ha of JFM area amounting to more than 2000 kg of *achar guthali* production potential. This could generate about Rs 220000 income for the VFC.
- There is a need for the community to define the collection time and proper selection of the *achar guthali* while collecting to fetch proper price as early plucking of the fruit leads to loss of quality. Traditionally in the region collection of Achar used to begin after the *Chait* festival (Kala 2012).
- This activity could provide an excellent opportunity for developing livelihood options for the unskilled labour in the villages who otherwise migrate seasonally.

Tendu patta

Tendu trees are the highest in number in the height class upto 10 m. Tendu constitutes third dominant species occupying about 14% of the total individuals/ha in the JFM area. But ecologically, Tendu is a fire prone species and hence, more incidences of fire would increase the density of the species over the long run at the cost of other species. But even in the present situation and with a controlled fire management the species provides an excellent potential which is well tapped by the local people. The excellent marketing mechanism offered by the State Forest Department has been a crucial aspect of the Tendu patta trade.

Firewood collection

The survey reveals that the firewood collected is mainly from the forest floor and no green felling is done by a majority of the households. The most preferred species for firewood is Sal. Table 5.7 below shows the abundance levels of species from the sampling. The productivity of this species composition has been calculated by considering the volume table of Sal as mentioned in Table 5.8.

Table 5.7 Abundance levels of the species / ha

Species	No. of Individuals	Percentage
Miliusa tomentosa	248	27
Shorea robusta	149	16
Diospyros melanoxylon	136	15
Lagerstroemia parviflora	78	9
Buchanania lanzan	68	7
Emblica officinalis	56	6
Hardwickia binata	55	6
Madhuca indica	52	6

The Volume, Mean Annual Increment (MAI) according to the GBH (cm) for Sal is developed by referring to the Working Plans for West Chhindwara Forest Division and Mussorie Forest Division as mentioned in the Table 5.8 below.

Table 5.8 GBH wise volume and MAI for Sal.

GBH (cm)	Volume (cum)	MAI (cum))
30	0.042	0.00566
40	0.096	0.006
60	0.114	0.0067
80	0.254	0.008
125	0.904	0.014

Table 5.9 Calculation of sustainable harvest of firewood

Species / GBH classes	Upto 10 cm	11-20cm	21-30cm	31-40cm	41-60cm	61-80cm	81-120cm
Miliusa tomentosa	86	115	39	6	0	0	2
Shorea robusta	27	45	41	17	13	6	0
Diospyros melanoxylon	34	56	26	17	9	2	2
Lagerstroemia parviflora	25	32	14	5	2	0	0

Species / GBH classes	Upto 10 cm	11-20cm	21-30cm	31-40cm	41-60cm	61-80cm	81-120cm
Buchanania lanzan	12	20	14	14	5	3	0
Emblica officinalis	0	13	13	9	13	5	3
Hardwickia binata	54	1	0	0	0	0	0
Madhuca indica	2	14	13	6	7	8	2
No. of trees (per ha)	240	296	160	74	49	24	9
No. trees X Volume*0.67			4.5024	4.75968	3.74262	4.08432	5.45112
Biomass X MAI of respective GBH class			0.896	0.444	0.3283	0.192	1.26
2% of MAI ton/ha			0.01792	0.00888	0.006566	0.00384	0.0252
Sustainable harvest tons / ha/ yr	0.062						

Based on the volume table assumptions of Sal as shown in Table 5.9 the sustainable harvest of firewood is about 0.062 tons / ha/ yr amounting to about 31.45 tons / yr from the entire study area of about 504 ha. The sustainable harvest is calculated as 2% of the Mean Annual Increment. The annual demand of the fuelwood from the study area is about 175 tons/yr. Thus there has been an on-going unsustainable harvest of about 144.46 tons/yr.

Grazing

The calculation of sustainable grazing for the study area could be done with the help of the primary survey of demand and supply of fodder from the forest and comparing it with the annual productivity of the herb layer / grasses of the coppicing Sal forests.

The survey suggests there is an annual demand of 156.52 tons of fodder where almost 1/3rd of the demand is met from the forest area of about 504 ha. The Protected Forests in the area according to the Working Plan are allow 2 cattle unit /ha for grazing. The total area allowed for grazing annually is about 50.4 ha out of the 504 ha (10%). This area is calculated based on the available open forest area in the sampling plots as Working Plan does not have any prescription on grazing area. Also the VFC has a right of grazing their cattle in the area amounting to about 146 cattle units equivalent to about 73 ha of grazing area. But as calculated earlier the ecologically the area can only support about 50.4 ha of grazing area equivalent to about 100 cattle units in ideal conditions. Hence, the sustainable grazing limits can be calculated using the following formula:

Animal units / ha (carrying capacity for grazing) 25 kg (dry weight of grass) 275 (number of days in a year) = sustainable limit of grass that can be extracted from VFC compartments (164, 165) in a year = 50.4*2*25*275 = 693000 Kgs.

Table 5.10 Grazing demand – supply from VFC area

Grazing annual demand - supply	Quantity(kg)
Total demand (kg/yr)	156624
Total supply from forests (kg/yr)	54080
Potential fodder production over 504 ha (50.4 ha of open forests) kg/yr	693000
Difference in potential – total demand kg/yr	536376
Difference in potential – demands met by forests kg/yr	638920

The calculations suggest that there is a huge gap of fodder quantity between the potential sustainable limit and the present demands. The major reasons for this gap between potential productivity of the forests and the available fodder from the forests is the unsustainable pressure on the compartments under study by the cattle beyond the villages under the VFC. Delakhari village cattle also graze in the same area due to lack of any control.

Carbon Stock Assessment

As discussed earlier a five pool (Above Ground Tree Biomass (AGTB), Below Ground Tree Biomass (BGTB), Deadwoods (DW), Leaf Litter (LL) and Soil Organic Carbon (SOC)) measurement methods have been used for the assessment of carbon stock in pilot area based on the data collected from pilot site for 2012(Please refer to Chapter 3). The results of the estimate of biomass as well as carbon stock for all five pools in the pilot site in Delakhari are presented in table 5.11. Similar assessment of carbon stock for the time period 1990 has been done and the comparison with 2012 figures is shown in table 5.12.

Table 5. 11 Carbon Stock of the Pilot Forest Area (200 ha.) in 2012

		Biomass (in ton/ tdm)		Carbon Stock (in ton)	
		Ha^{-1}	**Total**	**Ha^{-1}**	**Total**
Above Ground Tree Biomass (AGTB)		194.32	52856.50	87.45	44072.91
Below Ground Tree Biomass (BGTB)		52.46	14271.26	23.60	11899.69
Deadwoods (DW)		3.17	1597.68	1.43	718.95
Leaf Litter (LL)		3.12	1572.48	1.40	707.62
Soil Organic Carbon (SOC)	0-15 cm			22.41	11294.64
	16-30 cm			14.75	7434
	31-45 cm			18.14	9142.56

Table 5.12 Net Carbon change from AGTB and BGTB

Total Carbon (ton) from AGTB and BGTB		
1990	2012	Change
30207.49	55972.6	25765.11 (85.29%)

Discussion

The case provides an opportunity for improved forest management regime because of the following reasons:

a) In spite of high pressure on the forests for fodder and firewood, there has been net increase in carbon between 1990 and 2012 as seen in table 5.12 suggesting very high resilience of the forest stocks.

b) There is a need of employing better harvesting practices for several NTFPs so as to tap the available potential and allowing the NTFPs to reach upto harvestable size, maturity and time

c) The efforts to improve agricultural productivity through soil and water conservation works in forests and outside forests would create opportunities for large number of unskilled people.

The rapid questionnaire survey conducted has revealed many facts on the dependence, utilization over natural resources, major sources of expenditure related to livelihood, role of forests in sustaining the household economy and to an extent the status of the forest resources. The analysis reveals that the focus of the livelihood activities in theses villages revolves around rain-fed agriculture and seasonal migration. Ecosystem goods and services received from forests in the form of food, fodder and firewood, are important pillars of the subsistence household economy. The commercially important NTFPs provide cash to the households within a window of about 2-3 months period.

The socio-economic analysis suggest that the local households lack long term livelihood options as substantial number of households migrate seasonally and the left over households are engaged in agriculture which hardly meets the household requirements. The lack of skill to take up any skilled job during the migration does not allow the local people to fetch any significant financial benefit to enhance the local economy.

The pressures on forests in the form of cattle grazing and fuelwood extraction are contributing to the substantial degradation of the forests as shown by the analysis. The lack of livelihood opportunities force many people to sell firewood for running the households.

NTFPs such as Achar, Mahua and Tendu patta have been important sources of livelihood to the local communities. The analysis suggests that the potential of NTFPs has not been tapped effectively even in terms of collection.

Way Forward

The development of livelihood opportunities has been the main priority of the local communities which is evident form the analysis as well. The lack of livelihood opportunities to sustain the household economy is making the local people increasingly dependent on the natural forests, subsistence agriculture and seasonal migration. But at the same time there could be possible interventions developed through the VFC on the following aspects:

1. Introducing fuel efficient technologies for cooking purposes: Multiple options in the form of solar cooking stoves and improved stoves need to be provided to the local communities along with the training for maintenance of these devices.
2. Developing productive agriculture: The rainfed agriculture has been insufficient to produce the enough food grains as well as associated livelihood opportunities. Developing irrigation facilities in the form of soil and water conservation works in the catchment areas and connecting the fields with the irrigation facilities will be important.
3. NTFP-based livelihood: A large number of NTFPs are being sold in raw form without any value addition at the local level. A value addition unit for selected NTFPs could be thought of at the level of cluster of VFCs in the area. The value addition activities could be in form of grading, packaging and marketing through the existing channels of the State Forest Department. NTFPs such as Mahua require access to storage technologies along with model examples of Mahua flower trade through Women's Self Help Groups similar to the ones in the neighbouring Maharashtra state. There is also a need of introducing sustainable harvesting of the NTFPs by conducting training of the collectors through the VFC.
4. Grazing control: The enormous pressure of grazing needs to be reduced by having multiple strategies for controlled grazing in form of improving cattle breed through natural bull service or Artificial Insemination Facility and to reduce the number of unproductive cattle. Fodder plantations on the fallow lands could be done to increase the fodder availability.

Many of these activities need to be implemented in a co-ordinated fashion in the adjoining habitations along with the study villages.

This site has potential for obtaining finance through REDD+ provided drivers of deforestation and forest degradation, and safeguards are addressed. Unsustainable harvest of minor forest produce is the major driver of forest degradation. There is a need to address it before designing a project to obtain finance through REDD+.

References

Chauhan P. S. Jitendra S m Kavita A. 2012 Hort Flora Research Spectrum, 1(3): 375-379 (2012)

Panda B. B., Mishra P. K. and Thakur R *undated* Report of the Study on Mahua Sub Sector. Submitted to Chhattisgarh State Institute of Rural Development, submitted by The Livelihood School, Bhopal

Chapter 6 REDD Plus Assessment in Mussourie

Introduction

The pilot REDD+ site in Mussourie Forest Division is Maghra 5 Forest Compartment located in the Jaunpur Forest Range. As per the Mussourie Forest Division Working Plan, the Compartment has 91 ha as Gross Area and 89.90 ha as Net Area. Nearly 78% (70.90 ha) of the Forest Compartment is dominated by one species, that is, Oak and it also has mixed broad leaved species.

There are three villages that are mainly dependent on Maghra 5 Forest Compartment in the selected site :

a) Raoton ki Beli (122 households)

b) Jhalki (14 households)

c) Suwa Kholi (5 households)

The village Raoton ki Beli fall under the same Gram Panchayat (Raoton ki Beli) in Jaunpur Block of Tehri (Garhwal) District. Jhalki fall under Nalikala Gram Panchayat in Raipur Block, Dehradun District. Additionally, only 5 households in village Suwa Kholi also make use of this Forest Compartment. Suwa Kholi is a small market centre on the road to Dhanaulti and marks midway between Mussourie and Dhanaulti. It also fall under Nalikala Gram Panchayat in Raipur Block, Dehradun District. Thus, a total 141 households were surveyed that constitute villages around Maghra 5 and are dependent on it. The villages are dependent on Maghra 5 for: i) Fodder (Oak) leaves, ii) Fuel wood and iii) Grass.

As part of the socio-economic and institutional assessment, data on different relevant aspects was collected through a detailed household level questionnaire, focused group discussions and village level meetings during July 2012. This survey was designed to be undertaken with the following objectives: To assess a) Socio-economic profile of the site (including existing livelihoods), b) Dependence on and use of forest resources (and determine whether the extraction of the resources is sustainable), c) Local forest management and institutional arrangements, and d) Gendered role distribution in extraction of forest resources, other sources of livelihood and decision making over forest resources. The purpose of the survey is to gather data in a one-time scenario (at present) and use this to serve as a baseline for a future scenario of measuring impact or change over this. The study has adopted census method for household survey covering different aspects like household composition, household assets, livelihood patterns, dependence on forest, and participation in collective activities related to forest protection/management. Thus all the 141 households were enumerated for the household survey . The methodology for carbon stock assessment is elaborated in Chapter 3.

There were many limitations and problems faced during the course of the study. Apart from the general limitations of the carbon stock assessment methodologies, this pilot site had some other limitations concerning the estimation of extractions and the sustainable level. The extraction data is based on a onetime household survey conducted in the month of May-June 2012. The fuel wood and fodder use was mostly based on recall or an approximation based on the average daily use by the villagers. The productivity of fuel wood was estimated based on the available productivity data for the entire Division as provided in the Working Plan and in consultation with the DFO, Mussourie.

Demographic and Socio-economic profile of the site

There are 141 households in total spread over three villages. Village Raoton ki Beli has 122 households. Agriculture is the mainstay, but is completely rain fed; 60% of the agricultural land is situated in the valley, while 40% is upland. Village Jhalki has 14 households whereas Suwa Kholi has 5 households.

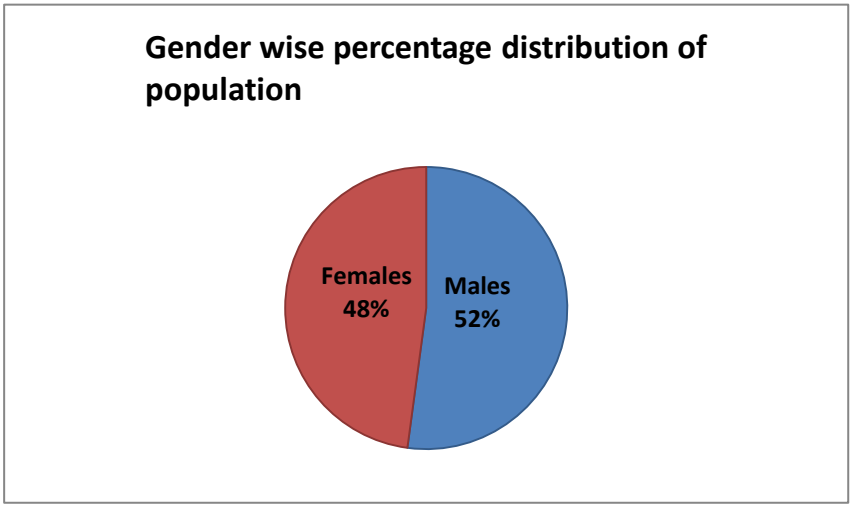
Demography

The total population of the three villages is 892, of which 47.9% is constituted of women, while 52.1% is constituted of men. The gender wise population distribution is given in table 6.1 and figure 6.1 below.

Table 6.1 Gender wise population distribution

	Number
Males	465
Females	427
Total	892

Source: TERI primary survey, 2012



Source: TERI primary survey, 2012

Figure 6.1 Percentage distribution of male and female

The average household size (number of members in each household) is 6, with the maximum being reported as 28, and a minimum of 1. Table 6.2 gives the village-wise average household size.

Table 6.2 Household size

Village	HH size (Average)	Max	Min
Raoton ki Beli	7	28	1
Jhalki	5	10	1
Suwa Kholi	7	9	4
Total	6	28	1

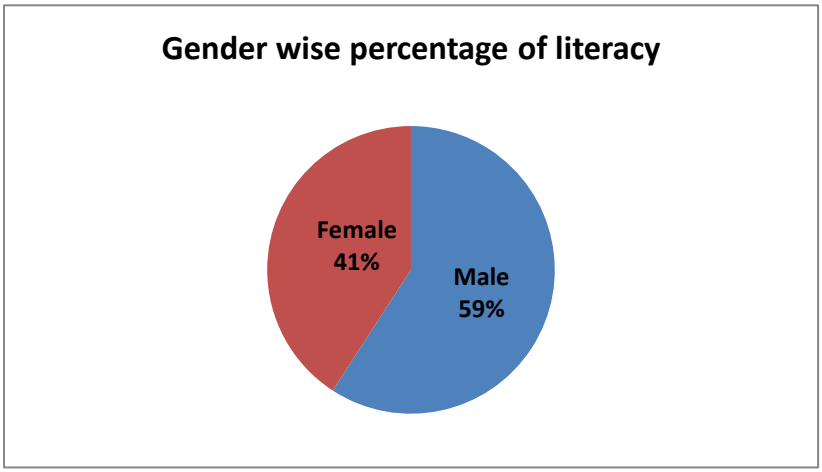
Source: TERI Primary survey, 2012

A high level of literacy was noted among the population, with 91% being the rate among men, and 63% among women (figure 6.2). The village-wise break up of percentage of those literate is given in table 6.3 below.

Table 6.3 Gender wise percentage of literacy

Village	Literacy (%)	
	Male	Female
Raoton ki Beli	91.7	61.1
Jhalki	81.1	75.8
Suwa Kholi	94.1	75
Total	**91.0**	**62.8**

Source: TERI primary survey, 2012



Source: TERI primary survey, 2012

Figure 6.2 Gender wise percentage of literacy

Caste distribution

The caste composition of the population shows dominance of General Caste category, with 91.5% of the total 141 households falling under General Caste while 8.5% falling under Scheduled Caste (figure 6.3). There is no household under Scheduled Tribe and Other Backward Class. Among the General Caste, Rajputs are the pre-dominant sub-caste; there are also a few Brahmin households; while the Scheduled Caste households belong to the Das sub-caste. The village wise break-up of caste distribution is given in the table 6.4 below. Jaunpur Block under which the village Raoton ki Beli comes, however, is a Backward Block of Uttarakhand.

Table 6.4 Caste-wise household distribution

Village	General Caste	Scheduled Caste
Raoton ki Beli	118	4
Jhalki	6	8
Suwa Kholi	5	-
Total	**129**	**12**

Source: TERI primary survey, 2012

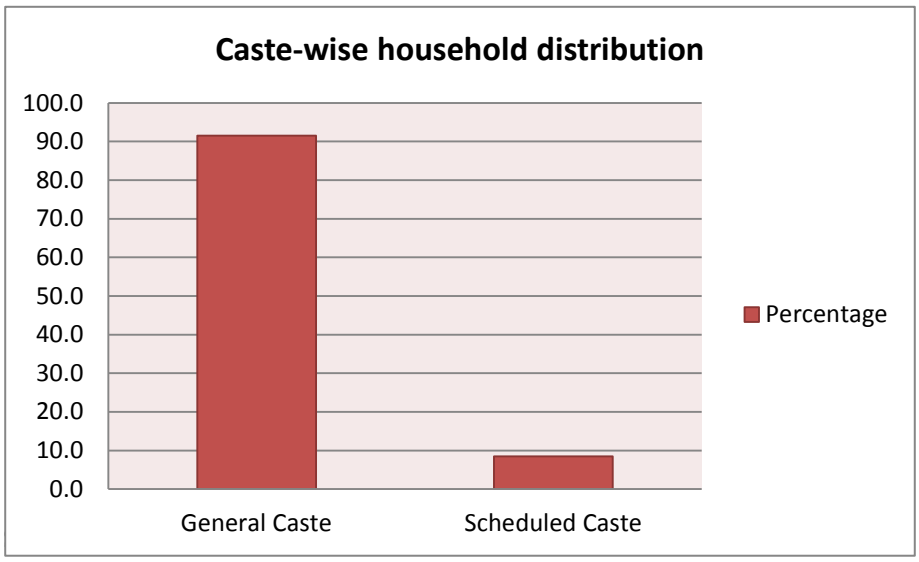


Figure 6.3 Percentage distribution of households caste-wise

A total 77 households (54.6%) fall under BPL category. The number of households with the category of BPL card is shown in table 6.5 below.

Table 6.5 Number of BPL households

Type of BPL Card[3]	Number of Households
Red	53
Yellow	2
White	22
Total	**77**

Source: TERI primary survey, 2012

Occupational structure

Agriculture is the mainstay occupation for 42% of the population; there is also a large number of young population and 42% of the population is constituted of students. In terms of secondary occupation, unskilled labour involves 71% of the population. Table 6.6 below shows the overall population distribution in various occupations, while Table 6.7 shows the gender wise distribution.

Table 6.6 Percentage of population engaged in various occupations

Occupation	Main occupation	Secondary occupation
Agriculture	42	3
Regular business	2	11
Unskilled labour	1	71
Skilled labour	-	14
Temporary service	2	-
Domestic work	1	-
Student	42	-
Infant/elderly	9	-

Source: TERI primary survey, 2012

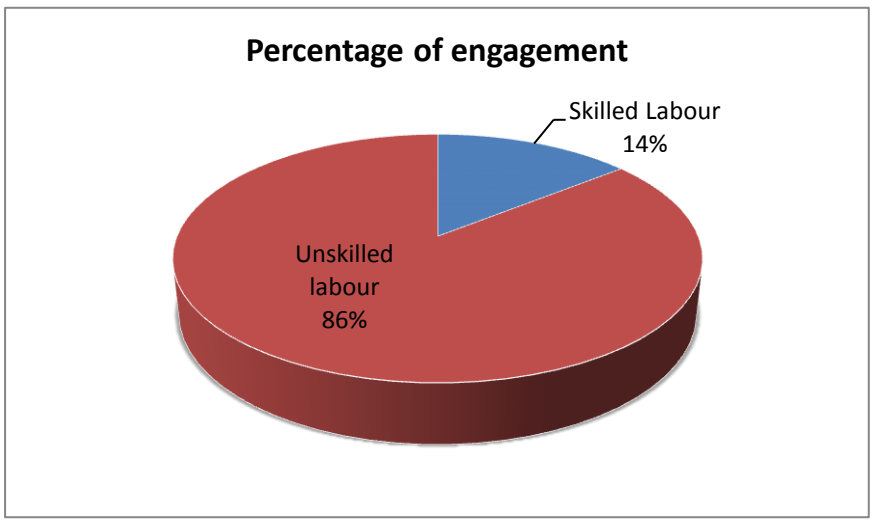
[3] Annapurna (White card), Antodyaya (Yellow card), BPL (Red card)

Table 6.7 Gender-wise engagement of population in various occupations

Occupation	Main Occupation			Secondary Occupation		
	Males	Females	Total	Males	Females	Total
Agriculture	124	204	328	-	1	1
Regular Business	16	-	16	4	-	4
Seasonal Business	1	-	1	-	-	-
Skilled Labour	2	-	2	5	-	5
Unskilled Labour	11	-	11	25	-	25
Temporary service	9	3	12	-	-	-
Permanent Service	2	-	2	-	-	-
Domestic Work	-	10	10	-	-	-
Student	177	151	328	-	-	-
Infant/Elderly	34	36	70	-	-	-
Total	**376**	**404**	**780**	**34**	**1**	**35**

Source: TERI primary survey, 2012

Work related migration is not a significant phenomenon in the area with only 5% of the households having family members who migrate for work. An average 105 days are spent in a year on migration for work by the respective members; 84% of those who migrate engage in unskilled labour, while 14% in skilled labour (figure 6.4).



Source: TERI primary survey, 2012

Figure 6.4 Work engaged in during migration

Sources of livelihood

Agriculture is the mainstay occupation; besides there is dependence on livestock. A large number of households also rely on labour and service for livelihoods. The section below discusses agriculture, livestock and other sources of income.

Agriculture

A total of 1491 nalis (29.82 hectares) of land is agricultural; of which 14% is irrigated, 86% is un-irrigated, while 4% is barren. Most of the agricultural land is rain fed. Details of agricultural land ownership are given in table 6.8 below.

Table 6.8 Ownership of agricultural land

Land Type	Owned (in Nalis)		Leased in (in Nalis)		Leased out (in Nalis)	
	Total	Average	Total	Average	Total	Average
Irrigated	211	3.9	2	1	5	1.7
Un-irrigated	1281.5	9.8	18	3.6	5	2.5
Barren	61.5	3.4	6	2	-	-
Total	**1491**		**26**		**10**	
Total (in ha)	**29.82**		**0.52**		**0.2**	

Source: TERI primary survey, 2012 (50 nali = 1 hectare)

The major crops grown are vegetables, namely potato, radish, peas and cauliflower. The production of rice and wheat is less than that of vegetables. Table 6.9 below shows the annual production of major crops. The detailed annual production, consumption and income from agriculture is given in table 6.10 below crop-wise, and season-wise.

Table 6.9 Annual production of major crops grown

Crop	Prod (Quintal)
Potato	1293.55
Radish	944.8
Peas	308
Cauliflower	257
Rice	51.4
Wheat	114.55

Source: TERI primary survey, 2012

Table 6.10 Annual production, consumption and income from agriculture

	Crop	Annual Production (kg/year)				Self-Consumption (kg/year)				Total Income (Rs./year)	
		Total		Per HH		Total		Per HH		Total	Per HH
		Kgs	Quintals	Kgs	Quintals	Kgs	Quintals	Kgs	Quintals		
A.	**KHARIF**										
	Rice	5140	51.4	160.6	1.6	5090	50.9	164.2	1.6	42980	1868.7
	Potato	2600	26	1300	13	100	1	100	1	12000	12000
	Cauliflower	500	5	500	5	50	0.5	50	0.5	4000	4000
	Radish	505	5.1	252.5	2.5	55	0.6	27.5	0.3	1750	875
	Turnip	200	2	200	2	0	0	0	0	1000	10
B.	**RABI**										
	Wheat	11455	114.6	148.8	1.5	115515	1155.2	1626.97	16.3	117180	1046.3
	Potato	117180	1171.8	1046.3	10.5	11771	117.7	113.2	1.1	709830	6453
	Peas	15400	154	213.9	2.1	2821	28.2	42.7	0.4	230725	3296.1
	Radish	88575	885.8	868.4	8.7	6253	62.5	70.3	0.7	261145	2611.5
	Cauliflower	7850	78.5	523.3	5.2	900	9	60	0.6	63950	4263.3
C.	**SUMMER CROP**										
	Cauliflower	17350	173.5	667.3	6.7	1520	15.2	69.1	0.7	125400	4823.1
	Potato	9575	95.8	870.5	8.7	775	7.8	96.9	1	54225	4929.5
	Peas	15400	154	213.9	2.1	2821	28.2	42.7	0.4	230725	3296.1
	Radish	5400	54	675	6.8	140	1.4	46.7	0.5	15780	1972.5
	Chilly	155	1.6	51.7	0.5	35	0.4	11.7	0.1	6350	2116.7
	Capsicum	600	6	200	175	1.75	2	58.3	0.6	7000	2333.3
	Cabbage	24380	243.8	541.8	5.4	3565	35.7	89.1	0.9	183700	4082.2
	Dal	45	0.45	22.5	0.2	45	0.5	22.5	0.2	4750	2375

Source: TERI primary survey, 2012

Livestock

A total number of 532 livestock is owned, at an average of 4 per household. Table 6.11 below shows that category wise livestock owned.

Table 6.11 Livestock owned

Cows			Buffaloes			Calf		Bull	Mule	Sheep	Goat	Total
Milch	Non-milch	Total	Milch	Non-milch	Total	Cow	Buffalo					
48	35	83	45	41	86	64	36	131	17	5	110	532

Source: TERI primary survey, 2012

Sale of livestock products forms a good source of income for many households. Among the various livestock products the maximum income is from milk production, followed by wool production and ghee.

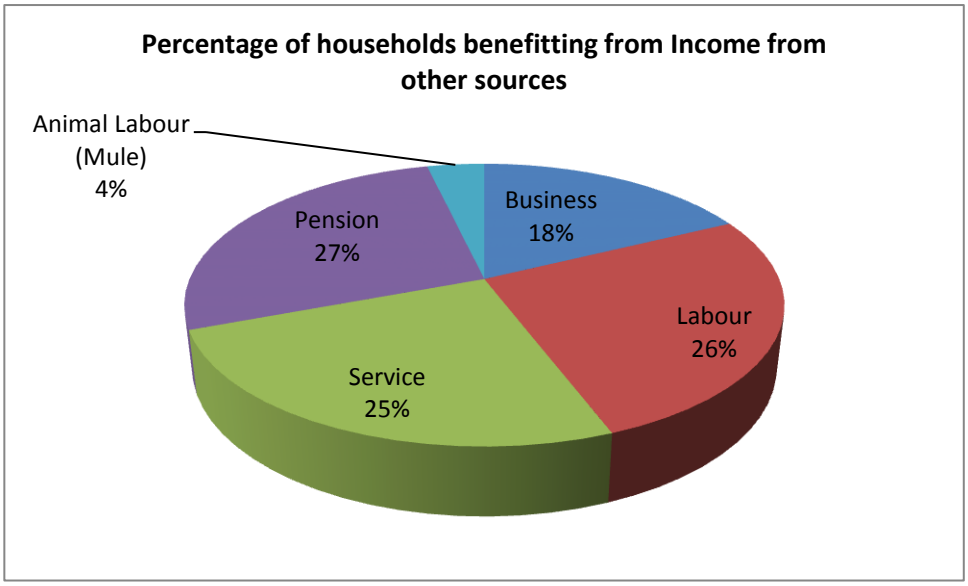
Table 6.12 Income from livestock products

Product	Unit	Production (Unit/month)	Sale (Unit/month)	Self-consumption (Unit/month)	Market Price (Rs./Unit)	Average Income (Rs./year)
Milk (litr)	Ltr	83.3	81.0	54.6	14.9	14050.3
Ghee (kg)	Kg	36.3	42.5	24	260	8300
Wool (kg)	Kg	3017.2	3796.6	4146.1	5804.2	9714.5
Goat (kg)	Kg	1606.4	1490.0	1421.2	1484.7	1776.5
Egg (no.)	No.	1655.0	1628.8	1587.1	1537.9	1455.8
Chicken (no.)	No.	1297.0	1490.2	1676.3	1682.7	1454.7
Buffalo (no.)	No.	594.8	554.1	512.7	471.4	430.4

Source: TERI primary survey, 2012

Income from other sources

Among other income sources, 27% of the total 141 households reap the benefits of pension; there is also reliance on income from labour and service, 26% and 25% respectively and 18% households depend on business. A small number of households, 4% draw income from hiring of animal (mule) services for labour (figure 6.5). Table 6.13 gives the details of income from other sources.



Source: TERI primary survey, 2012

Figure 6.5 Income from other sources

Table 6.13 Income from other sources

Source	No. of HH dependent	Income per month	No of months	Annual Income
Business	29	8793.3	12	105520
Labour	43	8086.4	9	54009.1
Service	41	9863.4	11	105190.5
Pension	44	1568.9	12	18613.3
Animal Labour (Mule)	6	3657.1	11	45714.3

Source: TERI primary survey, 2012

Dependence on forest

The main forest products that are extracted from Maghra 5 are fodder (oak) leaves, grass and fuel wood. The product wise dependence on the forest and the amount of extraction is discussed below. All the households that are dependent on and use Maghra 5 Forest Compartment are not relying solely on it. They also use the above mentioned products from other forest compartments of Maghra Forest Block, and also outside of it.

Grass

Grass is harvested for a period of 2 months in a year. Of the total 141 households, 77% (109) extract grass from the forest. All these 109 households are necessarily dependent on Maghra 5 for grass extraction. The dependence on various compartments is shown in table 6.14 below.

Table 6.14 Number and percentage of households dependent on forest for grass

Village	Forest Compartment						
	Maghra 1	Maghra 2	Maghra 3	Maghra 4	Maghra 5	Maghra 6	Non-Maghra
Number of households that extract grass							
Total	16	11	30	102	109	84	5
Village Raoton ki Beli	16	11	29	101	99	73	-
Village Jhalki	-	-	-	-	5	6	-
Village Suwa Kholi	-	-	-	-	4	4	-
Percentage of households that extract grass							
Total	14.7	10.1	27.5	93.6	100	77.1	4.6
Village Raoton ki Beli	15.8	10.9	28.7	100	98.0	72.3	-
Village Jhalki	-	-	-	-	83.3	100	-
Village Suwa Kholi	-	-	-	-	100	100	-

Source: TERI primary survey, 2012

Extraction

The grass extracted is used for self-consumption as fodder to feed livestock. While the total amount extracted from Maghra 5 is 131024 kgs (1310.24 Quintals) in a year, an average 3201 Kgs (32 Quintals) is extracted for self-consumption annually. The village wise break up is given in tables 6.15 and 6.16 below. Around 31% of the total quantity of grass used for self-consumption is extracted from Maghra 5.

Table 6.15 Quantity of grass extracted from Forest (Total) annually

Village	Total Quantity of Grass used for Self Consumption (Kgs)						
	Maghra 1	Maghra 2	Maghra 3	Maghra 4	Maghra 5	Maghra 6	Total
Raoton ki Beli	39896	398959	39896	119688	119688	39895.9	398959
Jhalki	-	15340	-	-	7670	7670	15340

Village	Total Quantity of Grass used for Self Consumption (Kgs)						
	Maghra 1	Maghra 2	Maghra 3	Maghra 4	Maghra 5	Maghra 6	Total
Suwa Kholi	-	12220	-	-	3666	4888	12220
Total	39896	428967	39896	119688	131024	52454	428967

Source: TERI primary survey, 2012

Table 6.16 Quantity of grass extracted from Forest (Average) annually

Village	Average Quantity of Grass used for Self Consumption (Kgs)						
	Maghra 1	Maghra 2	Maghra 3	Maghra 4	Maghra 5	Maghra 6	Total
Raoton ki Beli	335	335	335	1006	1006	335.3	3352.6
Jhalki	-	-	-	-	1278.3	1278.3	2556.7
Suwa Kholi	-	-	-	-	916.5	1222	3055
Total	335	335	335	1006	3201	2836	3299.7

Source: TERI primary survey, 2012

Sustainable or unsustainable use

The sustainable limit of grass utilisation is derived using the following calculation:

Number of livestock that can graze over the given forest unit (in this case Maghra 5) or the grazing carrying capacity dry weight of grass (which is taken as 35 Kgs as a standard[4]) 365 (days in a year)

The Maghra 5 Forest Compartment, with an area of app. 90 ha, has 30 ha as grazable area (Source: Forest Department).

As per Para No. 14.5.2 and S.No. 14.13 of the Mussourie Forest Division Working Plan, the maximum animal unit is 1.67.

Thus, the livestock grazing capacity is determined as 30 ha (of 90 ha) × 1.67 = 50 animal units.

Thus, now using the above calculation, we derive:

50 animal units (carrying capacity for grazing) × 35 (dry weight of grass) × 365 (number of days in a year) = sustainable limit of grass that can be extracted from Maghra 5 in a year = 6,38,750 Kgs.

[4] After discussion with DFO Mussoorie

The present usage, as given in table 9 above is 1,31,024 Kgs, thereby, showing a positive difference of 5,07,726 Kgs, indicating that this much amount of grass (from the sustainable limit) is not being extracted, or in other words there is a capacity to extract this much more. It is inferred, thereby, that the extraction of grass is well within the sustainable limit.

Fodder leaves

Fodder (oak) leaves are harvested for a period of 10 months in a year, barring the autumn months. As seen in table 6.17 below, of the total 114 households that extract fodder leaves, 100% depend on Maghra 5. Fodder leaves are also used for self-consumption.

Table 6.17 Number and percentage of households dependent on forest for fodder leaves

Village	Forest Compartment					
	Maghra 1	**Maghra 2**	**Maghra 3**	**Maghra 4**	**Maghra 5**	**Maghra 6**
Number of households that extract fodder leaves						
Total	2	6	48	107	114	58
Village Raoton ki Beli	2	6	48	106	103	47
Village Jhalki	-	-	-	-	6	6
Village Suwa Kholi	-	-	-	-	4	4
Percentage of households that extract fodder leaves						
Total	1.8	5.3	42.1	93.9	100.0	50.9
Village Raoton ki Beli	1.9	5.7	45.3	100	97.2	44.3
Village Jhalki	-	-	-	-	100.0	100
Village Suwa Kholi	-	-	-	-	100	100

Source: TERI primary survey, 2012

Extraction

The quantity of fodder leaves used from Maghra 5 totals 2,84,500 Kgs (2,845 Quintals) in a year, and an average of 7,359 Kgs (73.6 Quintals) (tables 6.18 and 6.19). Around 31% of the total quantity of fodder leaves used for self-consumption is extracted from Maghra 5.

Table 6.18 Quantity of fodder leaves extracted from Forest (Total) annually

Village	Total Quantity of Fodder leaves used for Self Consumption (Kgs)						
	Maghra 1	Maghra 2	Maghra 3	Maghra 4	Maghra 5	Maghra 6	Total
Raoton ki Beli	85761	85761	85761	257284	257284	85761.4	857614
Jhalki	-	-	-	-	19500	19500	39000
Suwa Kholi	-	-	-	-	7716	10288	25720
Total	85761	85761	85761	257284	284500	115549	928046

Source: TERI primary survey, 2012

Table 6.19 Quantity of fodder leaves extracted from Forest (Average) annually

Village	Average Quantity of Fodder leaves used for Self Consumption (Kgs) -						
	Maghra 1	Maghra 2	Maghra 3	Maghra 4	Maghra 5	Maghra 6	Total
Raoton ki Beli	727	727	727	2180	2180	726.8	7267.9
Jhalki	-	-	-	-	3250	3250	6500
Suwa Kholi	-	-	-	-	1929	2572	6430
Total	727	727	727	2180	7359	6549	7194.2

Source: TERI primary survey, 2012

Sustainable or unsustainable use

In an oak tree, 2/3rd is constituted of fodder leaves. Further 1/3rd of the total amount of fodder leaves in an oak tree serves to be used for fodder in a year.

The sustainable limit of fodder leaves is derived using the following method:

1/3rd quantity of fodder leaves in an oak tree (in Maghra 5) × Number of oak trees in the given Forest Compartment (Maghra 5) × 20% (taking a cycle of 5 years)

The following measurements were derived during primary survey:

a) Tree with 70 cm girth, 15 m height, gives 19 kgs fodder leaves (1/3rd)

b) Tree with 60 cm girth, 12 m height, gives 14 kgs fodder leaves (1/3rd)

The approximation of 1/3rd Quantity of fodder leaves is taken as an average of the above two, that is, 16.5 Kgs.

The average number of trees per hectare in Maghra 5 is approximately 200. Thus, in 90 ha of Maghra 5, there are a total of 18000 trees.

Thus, based on the above method, we have:

16.5 Kgs of fodder leaves (1/3rd quantity of an Oak tree in Maghra 5) ×18000 (number of trees)× 20% = 59400Kgs

This is the sustainable amount of fodder leaves that should be used from the forest. The present usage, however, is 2,84,500 Kgs. This far exceeds the sustainable limit of extraction. An additional amount of 2,25,100Kgs is being extracted above the sustainable limit.

Substitution for unsustainable extraction

Results show a highly unsustainable use of fodder leaves from Maghra 5 and a very heavy reliance on this compartment for this forest product. In order to minimise the burden of unsustainable extraction, it is suggested, firstly, that reliance on other Forest Compartments, be encouraged, especially Maghra 1, 2, 3 and 6, as Maghra 4 (see table 12 above) also sees a heavy extraction of fodder leaves.

Secondly, households may invest more in purchasing commercial feed / fodder to reduce pressure on the forest.

If the additional load being extracted is directed 50% into the above two suggested options, the pressure on Maghra 5 would be reduced, drawing the extraction within sustainable limit.

Fuel wood

Fuel wood, mainly, dead and fallen, is also harvested over a period of 10 months in a year and used for household needs. As seen in table 6.20 below, of the total 109 households that collect fuel wood, 100% depend on Maghra 5.

Table 6.20 Number and percentage of households dependent on forest for fuel wood

Village	Forest Compartment						
	Maghra 1	Maghra 2	Maghra 3	Maghra 4	Maghra 5	Maghra 6	Non Maghra
Number of households that extract fuel wood							
Total	16	11	30	102	109	84	5
Village Raoton ki Beli	48	1	7	105	103	48	-
Village Jhalki	-	-	-	-	11	12	-
Village Suwa Kholi	-	-	-	-	5	5	-
Percentage of households that extract fuel wood							
Total	14.7	10.1	27.5	93.6	100	77.1	4.6
Village Raoton ki Beli	45.7	1.0	6.7	100	98.1	45.7	-
Village Jhalki	-	-	-	-	91.7	100	-
Village Suwa Kholi	-	-	-	-	100	100	-

Source: TERI primary survey, 2012

Extraction

The quantity of fuel wood collected from Maghra 5 totals 1,56,855 Kgs (1568.5 Quintals) in a year, and an average of 1,569 Kgs (15.7Quintals) (tables 6.21 and 6.22). Around 38% of the total quantity of fuel wood collected for self-consumption is extracted from Maghra 5.

Table 6.21 Quantity of fuel wood extracted from Forest (Total) annually

Village	Total Quantity of Fuel wood used for Self Consumption (Kgs)						
	Maghra 1	Maghra 2	Maghra 3	Maghra 4	Maghra 5	Maghra 6	Total
Raoton ki Beli	3052	3052	3052	9156	9156	3052	30520
Jhalki	-	-	-	-	8920	8920	17840
Suwa Kholi	-	-	-	-	138778.7	185038.3	462595.8
Total	3052	3052	3052	9156	156855	197010	410875.8

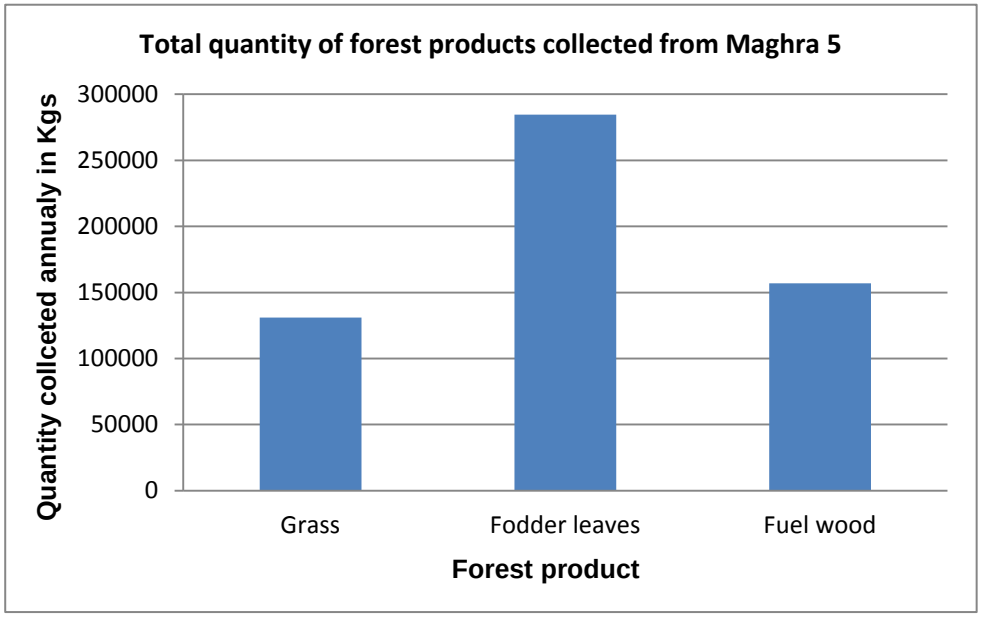
Source: TERI primary survey, 2012

Table 6.22 Quantity of fuel wood extracted from Forest (Average) annually

Village	Average Quantity of fuel wood used for Self Consumption (Kgs)						
	Maghra 1	Maghra 2	Maghra 3	Maghra 4	Maghra 5	Maghra 6	Total
Raoton ki Beli	31	31	31	92	92	30.52	305.2
Jhalki	-	-	-	-	89.2	89.2	178.4
Suwa Kholi	-	-	-	-	1387.7874	1850.3832	4625.958
Total	31	31	31	92	1569	1970	4108.758

Source: TERI primary survey, 2012

Among the various forest products collected from Maghra 5, the maximum dependence is for fodder leaves (figure 6.6).



Source: TERI primary survey, 2012

Figure 6.6 Quantity of various forest products used from Maghra 5

Sustainable or unsustainable use

Maghra 5 is a mixed forest of Oak and Deodar. The average growing stock (for mixed forest) is taken as 300 cubic meter per hectare. The conversion of this volume into weight is as follows:

300 (cubic meter per ha) × 0.67 (density) = 201 tonne

The annual productivity of Temperate Forests is taken at 3% per hectare, and so in this case,6.01 tonne per hectare. The average productivity of Maghra 5, thereby is taken as 6.01 tonne per ha.

Further, 10% of the average productivity per hectare is taken as fuel wood produced per hectare per year.

Maghra 5, as mentioned above is a mixed forest of Deodar and Oak, of which 30% trees are Deodar.

Thus, the productivity of Deodar is approximately 2 tonne per hectare (i.e. 30% of 6.01 tonne), and that of Oak is app. 4 tonne per hectare (70% of 6.01 tonne).

10% of 2 tonne is fuel wood from Deodar (= .2 tonne), and

10% of 4 tonne is fuel wood from Oak (= .4 tonne)

Thus, 0.6 tonne of fuel wood per hectare is produced annually from Maghra 5.

And a total, 0.6×90 hectares = 54 tonnes, or 540 quintals, or 54,000 Kgs of fuel wood from Maghra 5 annually

This is taken as the sustainable limit of fuelwood from Maghra 5.

The present extraction (as seen in table 6.23) is 1,56,855 Kgs. Thus, an additional (1,028.55 Quintals) of fuel wood is being extracted over and above the carrying capacity or the sustainable limit of fuel wood for the Maghra 5 Compartment. This shows a high level of unsustainable extraction from the forest.

Substitution for unsustainable extraction

In order to reduce the excessive unsustainable extraction of fuel wood from Maghra 5, it is suggested that the provision of LPG is seen as the alternative. At present, 41 households use LPG. These households too are not solely dependent on LPG. LPG is used in addition to fuel wood.

On an average 1 household with an average family size of 6 (the average household size here) uses almost 10kgs of LPG on a daily basis. Thus, 1 household will require 365 x 10 kgs = 3,650 kgs of LPG on a yearly basis.

The amount of unsustainable extraction of fuel wood is 1,02,855 Kgs.

In order to cover this amount, 28 households (1,02,855/3,650) need to completely take up LPG.

In addition, fuel wood can also be bought from commercial feeds so as to reduce dependence on Magra 5 forest compartment and encourage use of fuel wood in a more sustainable manner. Also, green cook stoves can be distributed amongst the villagers in collaboration with the Uttarakhand Forest Department. The use of alternative sources of energy such as solar energy and biogas may further help villagers to limit the harvest of fuel-wood and maintain it under sustainable limit.

Institutional Mechanisms and Gender Assessment

The following section discusses specific gender dimensions viz. a) Gendered division of labour in extraction of the site specific forest products viz. harvesting, sale, collection and maintenance, b) role of men and women in decision making over shortage of forest products, c) involvement of men and women in existing forest management and institutional arrangements, and d) gendered division of labour in other sources of livelihood.

Forest products

There is no sale of any of the forest products (grass, fodder leaves or fuel wood), which as mentioned in the previous sections are used for self-consumption. It is seen that the harvesting of each product is done by womenfolk. Households where men are involved are in addition to the involvement of women of the household. Table 23 shows the number of households where men and women are involved in extraction of forest products.

Table 6.23 Household wise gendered division of labour in extraction of forest products.

Product	Harvesting	
	Male	Female
Grass	8	131
Fodder leaves	7	130

Product	Harvesting	
	Male	Female
Fuelwood	48	139

Source: TERI primary survey, 2012

Fodder collection and maintenance

Table 6.24 shows the collection and maintenance of fodder from various sources of division of labour.

Table 6.24 Number of households where women and men are involved in collection and maintenance of fodder from various sources

Source	Collection		Maintenance	
	Male	Female	Male	Female
Forest	23	129	2	114
Agriculture	-	11	-	11
Market	33	28	1	38
Open grazing	4	1	3	3

Source: TERI primary survey, 2012

Although women are the ones who are involved in collection of fodder, when it comes to taking decisions on the use of alternatives of shortage of fodder, it was largely the male members of the household who dominated the decision making (table 6.25).

Table 6.25 Number of households seeking options for fodder shortage and role of men/women in its decision making

Options resorted to - due to shortage of fodder felt	Yes	No	Household member/s involved in decision	
			Male	Female
a) Increase no. of fodder trees in farm land	6	109	77	45
b) Go long distance to collect forest products	92	26	81	46
c) Reduce livestock herd size	106	12	85	40
d) Sell farmland	2	113	77	44
e) Increase use of chemical fertilizer for soil fertility	28	90	81	43
f) Purchase commercial feed from nearest market	45	72	82	40

Options resorted to - due to shortage of fodder felt	Yes	No	Household member/s involved in decision	
			Male	Female
g) Shift from large livestock to small livestock	66	52	77	44
h) Start poultry farming for manure and HH income	1	116	79	43
i) Plant other leguminous grasses in riser and bunds	4	112	78	42
j) Other	-	43	34	14

Source: TERI primary survey, 2012

Fuel wood collection and maintenance

As in the case of fodder, and even in the case of fuel, women are largely involved in collection and maintenance of fuel from various sources, with the exception of LPG where men play a more dominant role (table 6.26). However, when it came to taking decisions on the use of alternatives of shortage of fuel wood, the results show that male members of the household dominated the decision making (table 6.27).

Table 6.26 Number of households where women and men are involved in collection and maintenance of fuel from various sources

Source of fuel	Collection		Maintenance	
	Male	Female	Male	Female
Forest	57	138	11	121
Improved cooking stove	1	1	1	1
LPG	31	7	9	24
Kerosene	7	1	5	2

Source: TERI primary survey, 2012

Table 6.27 Number of households seeking options for fuel shortage and role of men/women in its decision making

	Options resorted to - due to shortage of fuel felt	Yes	No	Household member/s involved in decision	
				Male	Female
a)	Plant more trees in private land	8	121	83	55

	Options resorted to - due to shortage of fuel felt	Yes	No	Household member/s involved in decision	
				Male	Female
b)	Begin use of livestock dung	3	128	85	52
c)	Shift from fuelwood to kerosene (lighting, cooking, heating)	6	125	82	55
d)	Shift from fuelwood to electricity (lighting, cooking, heating)	1	130	83	54
e)	Introduced bio gas plant (lighting cooking heating)	1	130	81	56
f)	Increase improved stoves to save fuel wood consumption	2	127	82	54
g)	Introduce fuel saving utensils (pressure cooker etc.)	122	11	89	55
h)	Reduce cooking time	115	12	85	56
i)	Other (LPG)	9	32	32	12
j)	Other	3	0	3	0

Source: TERI primary survey, 2012

Livestock products

The gendered division of labour in the production and sale of livestock products shows the pre-dominant involvement of women (table 6.28).

Table 6.28 Gender Division of Labour in the production and sale of livestock products

Product	Production		Sale	
	Male	Female	Male	Female
Milk	9	76	18	4
Ghee	2	2	1	-
Wool	-	-	-	-
Goat	7	3	7	-

Source: TERI primary survey, 2012

Other sources of income

In terms of earning from other sources of income, the engagement of men is higher than that of women. In all the other sources of income, namely, labour, service, business, drawing of animal labour, men are the bread winners; while among the pension holders the number of women is higher than that of men. Table 6.29 shows this distribution.

Table 6.29 Number of households with gender wise distribution of household members earning from other sources of income

Source	HH members involved	
	Male	Female
Business	29	-
Labour	42	1
Service	36	3
Pension	22	25
Animal Labour (Mule)	6	-

Source: TERI primary survey, 2012

Existing forest management and institutional mechanism

A Joint Forest Management Committee (JFMC) had been formed in Raoton ki Beli, in 1990s, which, however, is dysfunctional now.

A Van Panchayat was started in the same village in 2006. The Van Panchayat forest is 5 ha. The elected body is constituted of 10 members (3 women). However, the village population has no dependence, at present, on the Van Panchayat forest as the state of these forests is very poor. These are mostly constituted of pine trees. The Van Panchayat was recently given a pine briquette machine , with a view to reducing of forest fires by making use of pine needles.

Other than the Van Panchayat in village Raoton ki Beli, there is no local community-based forest management institution.

Forest Management Principles in the site

Following are the forest management principles as mentioned in the working plan of Mussourie that are followed in the region and in the site of Magra 5 in particular:

- Reduce environmental pollution, increase water conservation and increase in groundwater levels, afforestation for soil conservation and flood control.
- Without going against the first principle, fulfilling the domestic demand for fuelwood and other forest resources of the nearby villagers
- Increase in productivity of important species through natural regeneration

- Move towards sustainable forest management through enrichment of forest
- Landslide control and land conservation in the reserve forest areas through appropriate measures and actions
- Increase in awareness about forest conservation and development through appropriate communication and information techniques

These principles clearly reflect that the selected site has provisions inbuilt in the working plans that will encourage natural regeneration of local species, water conservation, reduce deforestation and pollution; thus leading to increase in the forest cover of the site. Magra 5 site fall within the protection circle of the Uttarakhand Forest department that does not allow for felling of green mature trees. This law does not permit the felling of green mature trees falling above 1000 metres above sea level. This practice has resulted in low productivity and low regeneration capacity of the region. Field visits to the site revealed that the unsustainable harvest of fodder leaves and fuelwood is leaving the forest at site in a degraded condition. If such unsustainable harvesting practices continue, then the regeneration of this site will become a difficult task for the forest department to achieve. The main sufferers of this outcome will be the villagers who depend on this forest compartment for their daily needs and requirements.

Need for better community management of forests

There is a need to strengthen the local community based institutional arrangement, so that both the Forest Department and the community can work in partnership, with the Forest Department providing scientific knowledge and the village community using their traditional knowledge to protect the forests. This will contribute to better management of the forest resources and make availability of fodder and fuel wood a sustainable practice amongst the villagers. The Van Panchayat that is at present existing only on paper needs to have a set of clearly defined provisions and appropriation rules for the management of the forests. A list of activities should be formulated that should be religiously followed by the Van Panchayat and the villagers. Rules regarding extraction and use of forest resources should be drafted and enforced strictly by the villagers.

Carbon Stock Assessment

The pilot site of Mussourie Magra 5 Forest Block in Jaunpur Forest range of Mussourie Forest Division in Uttarakhand comprises of Chir pine and Oak forests. The area delineated for carbon assessment is of 95 hectares. A total of 30 sample plots, each measuring 10m x 15m for tree species, 2m x 2m for deadwood and 1m x 1m for leaf litter were laid out in the site. These sizes were chosen due to the undulating terrains and hilly slopes of the region. Figure below shows the sample plots laid out in the site.

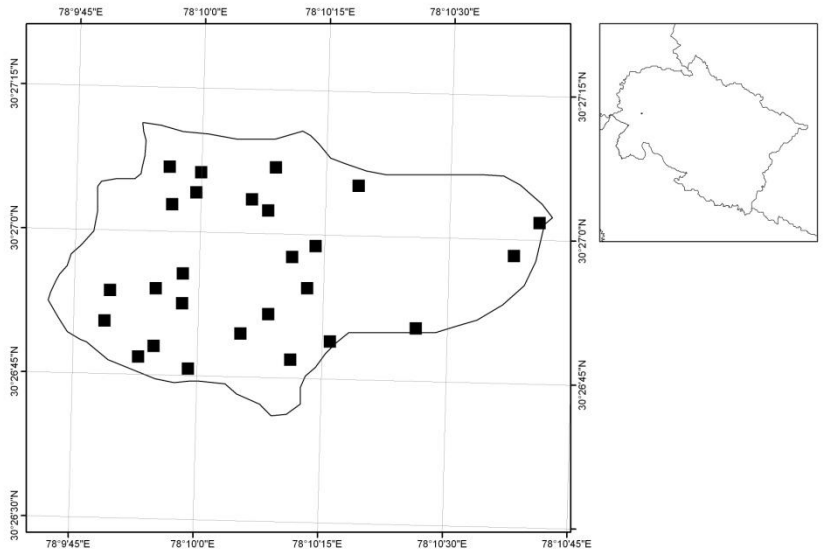


Figure 6.7 Sample plots laid out at Mussourie site

Five pools of carbon (Above Ground Tree Biomass (AGTB), Below Ground Tree Biomass (BGTB), Deadwoods (DW), Leaf Litter (LL) and Soil Organic Carbon (SOC)) have been used to assess the carbon stock in the pilot area based on the data collected from the pilot site in 2012. The results of the estimate of biomass as well as carbon stock for all five pools in the pilot site of Mussourie are presented in table.

Table 6.30 Carbon Stock of pilot Forest Area (95 ha) in 2012

Measurement Method	Biomass (in ton/tdm)		Carbon Stock (In Ton)	
	Ha-1	Total	Ha-1	Total
Above Ground Tree Biomass (AGTB)	3030.53	29091.38	136.59	12975.91
Below Ground Tree Biomass (BGTB)	81.68	7785.54	36.87	3503.49
Deadwood (DW)	1.75	166.25	0.79	74.81
Leaf Litter (LL)	2.23	211.85	1.01	95.33
Soil Organic Carbon				
0-15 cm			46.2	4389
16-30 cm			12.18	1157.1
1-45 cm			25.14	2388.3

Apart from that, linear fit equations were developed through correlating the biomass values obtained from the field survey with the NDVI values of same coordinates (pixel) in 2012 satellite imageries for the pilot site at Mussourie. Using the linear fit regression equation, biomass for entire project site was calculated for 2012. Similarly, with the help of this regression equation, biomass values of the same site for 1990 were estimated. The present interpretation scale of 1:50,000 along with improved spatial resolution made it possible to capture forest cover patches up to 1 ha area. Carbon estimation from soil, deadwoods, leaf litter and decomposed material were estimated based on the field data, and it can be further compared with future projects of the same area. The details of the regression for the site are provided below.

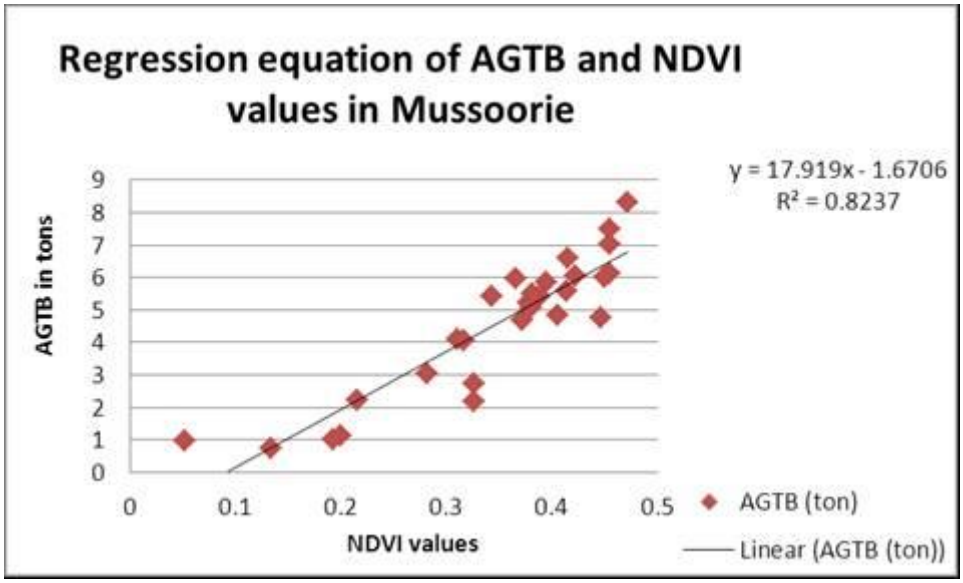


Figure 6.8 Regression equation of AGTB and NDVI in Mussourie

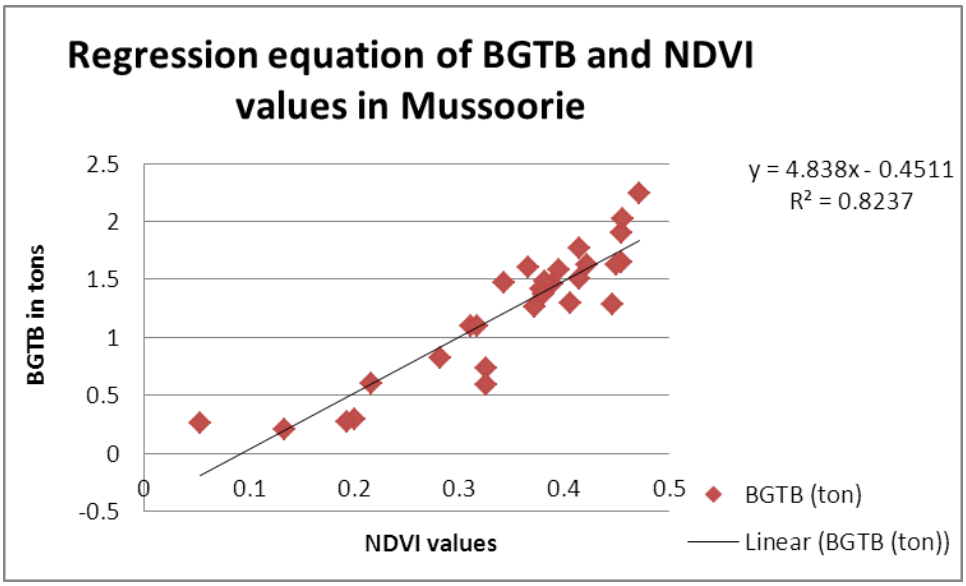


Figure 6.9 Regression equation of BGTB and NDVI in Mussourie

From the regressions equation figures above, it is evident that RS/ GIS based methodology helped in estimating carbon stock of the benchmark year as well as in estimating future stock at periodic intervals.

Table 6.31 Change in Biomass and Carbon Stock 1990-2012 in Mussourie Pilot Site

Measurement Method	1990	2012	Change	1990	2012	Change
	Biomass (ton Ha-1			Total Biomass (ton)		
Above Ground Tree Biomass (AGTB)	306.22	303.53	-2.69	29091.38	28835.35	-256.02
Below Ground Tree Biomass (BGTB)	82.68	81.95	-0.72	7854.67	7785.54	-69.12
Total (AGTB+BGTB)	388.9	385.48	-3.41	36946.05	36620.89	-325.14
	Carbon (ton ha-1)			Total Carbon (Ton)		
Above Ground Tree Biomass (AGTB)	137.8	136.59	-1.21	13091.12	12975.91	-115.21
Below Ground Tree Biomass (BGTB)	37.2	36.87	-0.32	3534.6	3503.49	-31.1
Total (AGTB+BGTB)	175	173.46	-1.53	16625.72	16479.4	-146.31

**Values in parenthesis are the percentage change from the baseline year to the present year*

In the case of Mussoorrie pilot site, standing biomass of the selected site is high due to the presence of Chir pine and Oak forests as compared to other sites. However, biomass from the base line year shows a decrease. This is mainly due to illegal and over extraction of fuel wood and unsustainable grazing. The major forest products extracted from Maghra - 5 are fodder i.e. Oak leaves, grasses and fuel wood etc. Grasses are harvested for a period of 2 months in a year. The grasses extracted are used for self-consumption as fodder to feed livestock. While Oak leaves for fodder are harvested for a period of 10 months in a year, barring the autumn months. Fuel wood, mainly, dead and fallen, is also harvested over a period of 10 months in a year and used for household needs. In order to reduce the excessive unsustainable extraction of fuel wood from Maghra 5, it is suggested the provision of LPG is seen as the alternative.

A Joint Forest Management Committee (JFMC) had been formed in Raoton ki Beli, in 1990s, which, however, is dysfunctional at present. There is a need to strengthen and empower the local community, so that they can work together with State Forest Department to enhance the existing forest cover.

Summary and Conclusions

The report makes a detailed and comprehensive assessment of the socio-economic status, forest management practices, dependency and level of extraction of the local communities and carbon stock of the forest managed by the Van Panchayat in the pilot site of Mussourie forest division in the state of Uttarakhand. As part of the pilot for REDD Plus project, the pilot site of Magra 5 in Mussourie forest division has been selected for the detailed assessment. There a Van Panchayat that is taking care of 5 hectares of forest. Other than that there is no other institutional arrangement at the site. There are 141 households in the three selected pilot villages with majority of the population engaged in agriculture as their primary occupation (42%), followed by another 42% engaged in education and 71% engaged in unskilled labour as their secondary occupation. Further the listing of 54.6 per cent of the households as below poverty line (BPL) households in the village indicates the poverty situation of the village. Literacy rate is quite high (91% for males and 68% for females). Agriculture in the site is mostly rain fed as there are no irrigation facilities. Of the total agriculture land, 14% is irrigated, 86% un –irrigated and 4% barren. The main crops cultivated by the farmers are potato, cauliflower, peas, rice, radish and wheat. Livestock also contributes to the livelihood systems of the households in the village through sale of milk production, wool production and ghee. Cows constitute the largest bovine livestock whereas goats are the largest ruminant population in the village. The number of livestock in the site is 4 per household on an average

The households in the site depend extensively on Magra 5 forest compartment for grass, fodder leaves and fuel wood. Given the extensive dependence of households on the forest of this site, sustainable use and extraction holds key to the conservation. The study made an attempt to assess the sustainability of extraction of forest, fodder and grass by the villagers and found that while the extraction of grass was well within the sustainable limits, that of fodder leaves and fuel wood was well outside the sustainable limit of harvest. This is due to ineffective management practices adopted by the villagers affecting the extraction/harvesting pattern.

The site has a functional Van Panchayat that covers an area of 5 hectares under its protection regime. The committee consists of 10 members of which 3 are women. The working plans of the site clearly elaborate sustainable management systems. They give high importance to water conservation, pollution control, sustainable harvesting and peoples' management. The study has adopted a two pool method (Above Ground Tree Biomass (AGTB) and Below Ground Tree Biomass (BGTB)) of assessing carbon stock to assess the temporal change (2012 over 1990 as base year) though the total carbon stock is estimated by adopting five pools (Above Ground Tree Biomass (AGTB), Below Ground Tree Biomass (BGTB), Deadwoods (DW), Leaf Litter (LL) and Soil Organic Carbon (SOC) measurement methods. Remote sensing based methodologies are combined with field data to estimate the carbon stock. The results of two pool biomass and carbon stock estimates for 1990 and 2012 indicate that there has been a decrease both in biomass as well as carbon stock in the pilot site by less than 1 per cent. There is need to improve the protection initiative of the local community so that it can result in an increased forest biomass and carbon stock. The total carbon stock in this 95 ha of forest has decreased from 16625 tons to 16479 tons of carbon. . The per hectare carbon stock

has decreased by 1.53 per cent. However, it may be noted that even though there has been a marginal decrease, it has been community efforts that resulted in the maintenance of 173 t/ha of carbon stock, which in itself is a high value as compared with other pilot sites. .

It is imperative that the protection measures and management initiatives of the local community and the forest department are streamlined to bring about a balance between the conservation of the forest ecosystem and subsistence dependency of the local community on it. The sustainable limit for fodder leaves is 59.4 tonnes per year while extraction is 284.5 tonnes thus showing an over extraction of 225.1 tonnes per year. The extraction of fuel-wood is 156 tonnes while the sustainable limit to extract fuel wood is only 54 tonnes per year. There is unsustainable harvest of 102 tonnes of fuel wood which has led to forest degradation and is adversely impacting the productivity of the site. The grazing and harvest of grasses is well within the sustainable limit i.e.131 tonnes per year. The present extraction greatly exceeds the sustainable harvesting limit and measures need to be taken to reduce the dependence of the villagers on the forest of the pilot site. To substitute for the over extraction of fuel wood from the forests, 28 households (other than the present 41 households) have been suggested to completely shift to LPG consumption. Also, green cook stoves can be distributed amongst the villagers in collaboration with the Uttarakhand Forest Department. The use of alternative sources of energy such as solar energy and biogas may further help villagers to limit the harvest of fuel-wood under sustainable limit. The unsustainable harvest of Oak leaves is due to the livelihood dependence of the villagers through milk production of the livestock. Increasing awareness amongst the villagers and also providing them with alternative sources of income would help in reducing the unsustainable harvest of oak leaves. Better public distribution of food grains and improvement in agricultural practices would further enhance the possibility of other sources of income which would help villagers to keep harvest of oak leaves under sustainable limit The study shows that there has been a decrease in the carbon stock of the Mussourie site which is mainly due to unsustainable harvest of oak leaves and fuel wood from the forest at site. Since there is over dependence of on fodder leaves for livelihoods and on fuel wood for domestic use, severe degradation of the forests is occurring, accompanied by fall in the productivity in the area. Also the practice of non-felling of green mature trees in the site is resulting in low natural regeneration levels as well as less carbon stored in the trees. Uttarakhand Forest Department should aim at providing other sources of livelihood to the community through forest based programmes and other poverty alleviation and rural development programmes. The working plans of the site reveal high importance laid on the concepts of sustainable management of forest and conservation of resources. However, there is also a need to incorporate the sustainable extraction limit for various forest resources in the working plans so as to regulate a practice of protection and conservation amongst the villagers. Capacity building programmes for the community should be carried out by the forest department, encouraging them to learn concepts of carbon assessment, GIS techniques and biomass assessment. For this the forest department will have to lend technical support to the existing Van Panchayat.

At present, the pilot site shows a small decrease in the carbon stock stored. However, with improved practices of sustainable harvest, introduction of alternative livelihood opportunities in the region, mobilized community efforts to conserve and protect the forests, the site has great potential to show increased carbon stock storage. The community needs to be made self-sustainable in order to reap the benefits of any international mechanism like the REDD Plus. The emergence of a market to trade the carbon sequestration services will also incentivise the local communities.

Chapter 7 REDD Plus Assessment in Renukoot

Description of the Selected Site

The pilot site selected in the state of Uttar Pradesh is Gardarwa Forest Block is located in the Duddhi Forest Range of Renukoot Forest Division. Renukoot Forest Division is located in Sonbhadra district, in Duddhi range. It is surrounded by Obra forest division in Theorth, Vindhyachal in the east, Chhattisgarh in the south and Madhya Pradesh in the west. It is located at the latitude of 23 degree 52′ 15″ and longitude of 24 degree 21′ 27″ north and longitude of 82 degree 40′ and 83 degree 24′42″east. The Gardarwa village forest is dependent mainly on Gardarwa Forest Block which encompasses 77 ha area. The Gardarwa village forest constitutes 89 households which are the Forest User Groups (FUGs). The Gardarwa forest type is dry deciduous forest which is a moderately dense forest.

The forest is the main source of livelihood in the area. . Agriculture in the village is completely rain-fed. People around the forests are mostly tribals and forest dwellers. The people are mostly wage labourers, MFP collectors and subsistence farmers. They are heavily dependent on forest resources. In Gardarwa, demand of fuelwood, small timber and MFPs is very high compared to sustainable supply from forests, fuelwood demand is high owing to weak agriculture that includes rainfed cropping only (maize, bajra). Demand of small timber is high for house roofing and fencing as pucca houses are completely absent around the forests. Sources of GHG emissions in the village forest are fuelwood burning, heavy cutting of small timbers for roofing, fencing and household use, shrinking forest cover owing to demand being more than sustainable supply, and decrease in growth of forest carbon due to pole stage cutting, forest cover shrinkage due to encroachment and forest fires.

Renukoot has some opportunities for REDD plus projects such as low opportunity cost of farmland (as agricultural practices are limited),and possibility of reduction in pole stage cutting of forest trees that may result in a high rate of carbon sequestrationTradition of forest-based livelihood practices exist eg. Tasar and lac culture, potential of agro forestry and farm forestry practices exists, fossil fuel emissions are absent, and encroachments can be minimized by adopting livelihood based forestry in vulnerable areas. Besides, there are a few REDD plus challenges in Renukoot such as conflict between conservation and sustenance needs, growing population in village around forests, reduction of fuelwood cutting and burning, stopping deforestation and degradation, checking decrease in growth of forest carbon due to pole stage cutting, reducing forest cover shrinkage due to encroachments, ensuring sustainability of emission reductions, costs of emission reduction, poverty, forest rights, and reducing forest fire incidents

Demography

The total population is 292, of which 48.11% is constituted of women, while 52.23% is constituted of men. The gender wise population distribution is given in table 7.1 and figure 7.1 below.

Table 7.1 Gender wise population distribution

	Number
Males	152
Females	140
Total	292

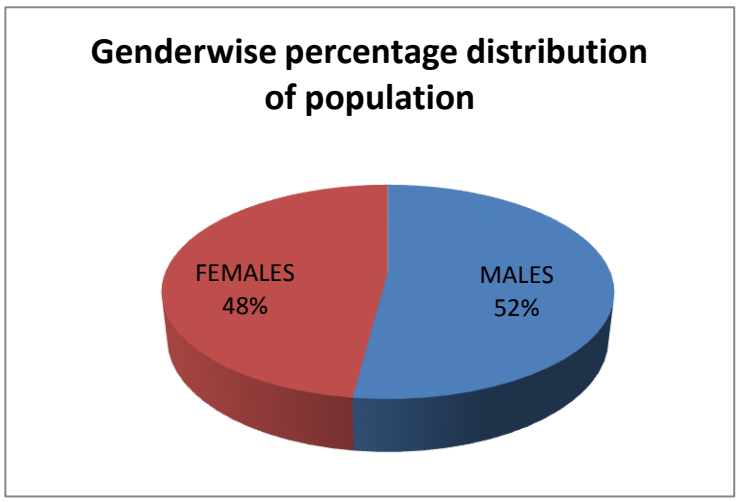


Figure 7.1 Percentage distribution of male and female

The average household size (number of members in each household) is 3, with the maximum being reported as 6, and a minimum of 1. Table 7.2 gives the village-wise average household size.

Table 7.2 Household size

Village	HH size (Average)	Max	Min
Gardarwa	3	6	1

The literacy rate noted among the men is about 25.6% and among women is about18.4 (figure 7.2) as given in table 7.3 below. The total literacy in Gardarwa village is about 44% and illiteracy is about 56%.

Table 7.3 Gender wise percentage of literacy

Village	Literacy (%)	
	Male	Female
Total	25.6	18.4

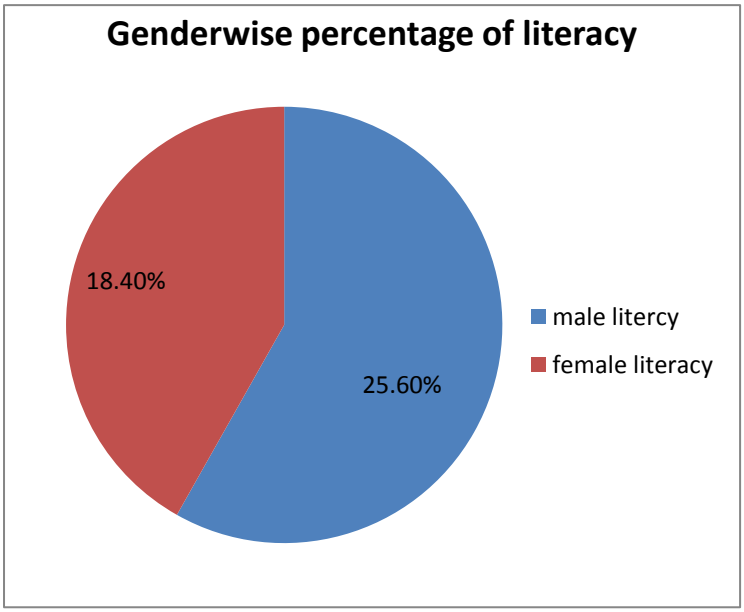


Figure 7.2 Gender wise percentage of literacy

Caste distribution

The caste composition of the population shows dominance of Scheduled tribe category, with 48.31% of the total 89 households falling under Scheduled Tribe, 47.19% falling under Other Backward Class, 2.25% falling under Scheduled Caste and 2.25% falling under General caste (figure 7.3). The village wise break-up of caste distribution is given in the table 7.4 below. Gardarwa Forest Block is basically a tribal village forest.

Table 7.4 Caste-wise household distribution

Category	General Caste-1	Other Backward Class-2	Scheduled Caste-3	Scheduled Tribe-4
percentage	2.25	47.19	2.25	48.31

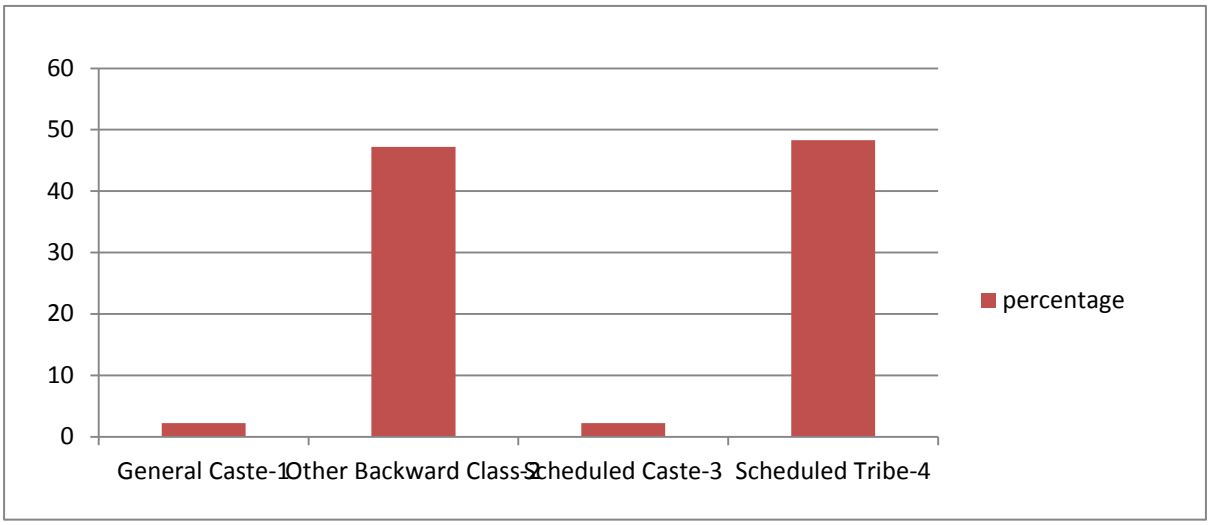


Figure 7.3 Percentage distribution of households caste-wise

Below Poverty Line

A total 89 households (100%) fall under BPL category. The number of households with the category of BPL card is shown in table 7.5 below.

Table 7.5 Number of BPL households

Type of BPL Card	Number of Households
Red	8
Yellow	31
White	50
Total	**89**

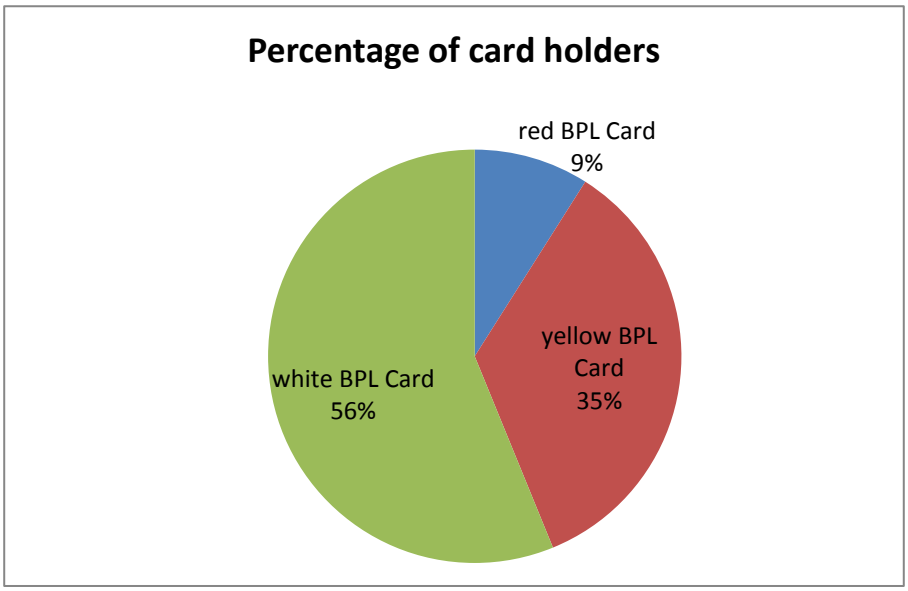


Figure 7.4 Number of BPL households

Occupational Structure

Unskilled labour is the main occupation for 31% of the population; 9% of the population is constituted of students. In terms of secondary occupation, agriculture involves 44% of the population. Table 7.6 below shows the overall population distribution in various occupations, while table 7.7 shows the gender wise distribution.

Table 7. 6 Percentage of population engaged in various occupations

Occupation	Main occupation	Secondary occupation
Agriculture	13	44
Regular business	-	-
Unskilled labour	31	16
Skilled labour	6	2
Temporary service	1	-
Permanent service	0.4	-
Domestic work	21	24
Student	9	-
Infant/elderly	20	-

Table 7.7 Gender-wise engagement of population in various occupations

Occupation	Main Occupation			Secondary Occupation		
	Males	Females	Total	Males	Females	Total
Agriculture	25	10	35	32	19	51
Regular Business	-	-	-	-	-	-
Seasonal Business	-	-	-	-	-	-
Skilled Labour	15	-	15	2	-	2
Unskilled Labour	52	31	83	11	7	18
Temporary service	2	-	2	-	-	-
Permanent Service	1	-	1	-	-	-
Domestic Work	2	56	58	2	26	28
Student	17	6	23	-	-	-
Infant/Elderly	30	24	54	3	13	16
Total	**144**	**127**	**271**	**50**	**65**	**115**

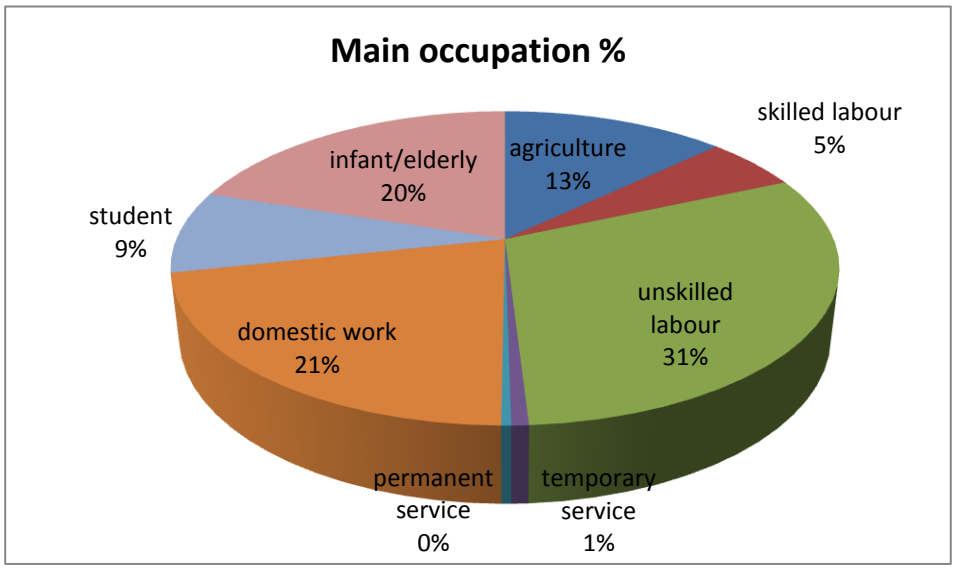


Figure 7.5 Occupational pattern

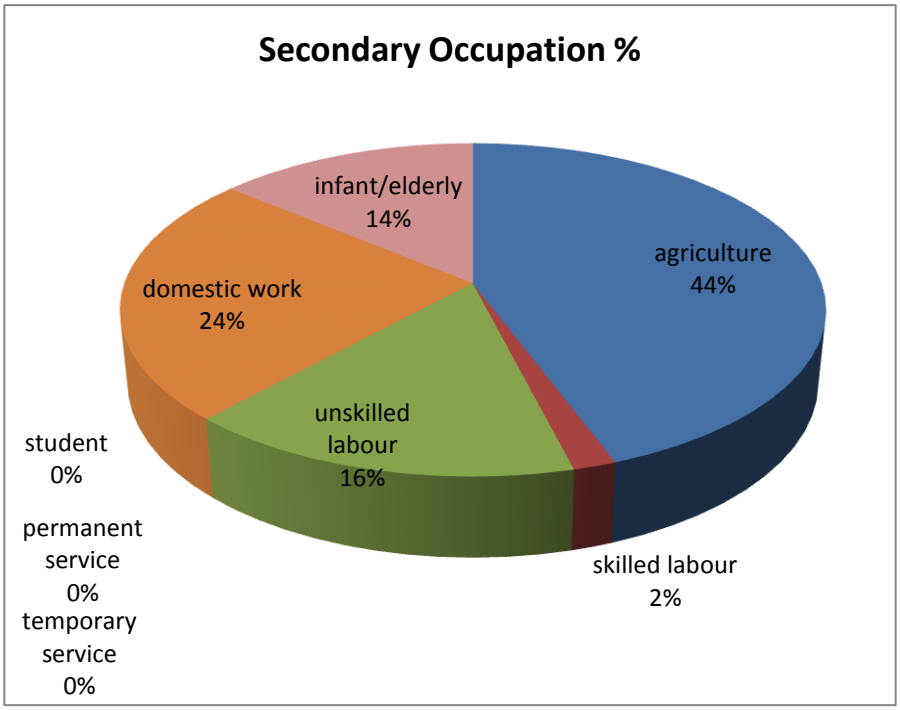


Figure 7.6 Occupational pattern (secondary)

Work related migration is not a significant phenomenon in the area. None of the family members migrate out for work. Therefore the rate of migration is nil in the Gardarwa village forest.

Forest Composition

The Renukoot Forest is a Tropical Dry Deciduous forest. Since the forest is a miscellaneous forest, the different forest types are:

1. Dry Peninsular Sal Forest – In this forest type sal is present in small patches of pure stands. Mixed stands of sal are also present with other tree species such as *Terminalia Tomentosa, Lagerstromia parviflora, Diospyros melanoxylon, Buchanania lanzan, Emblica officinalis, Anogeissus latifolia* and *Boswellia serrata*. Apart from these other tall tree species also exist in small number such as *Miliusa tomentosa, Elaeodendron glaucum, Adina cordifolia, Pterocarpus marsupium, Madhuca indica, Butea monosperma*, etc. The most popular shrub is *Woodfordia fruticosa*, the grasses such as *Chyrysopogon fulvus* and *Heteropogon contortus* are also found in these forests.
2. Northern Dry Mixed Deciduous forest – It is the predominant forest type of the Renukoot Forest Division. *Boswellia serrata* is mostly found at hill tops and *Acacia catechu* is mostly found at slopes. *Anogeissus latifolia, Diospyros melanoxylon, Lagerstromia parviflora, Buchanania lanzan, Emblica officinalis, Cassia fistula, Adina cordifolia, Hardwickia binata* and *Lannea coromandelica* are found in different numbers in the forest. *Holarrhena antidysenterica* occurs as an understorey species and *Woodfordia fruticosa,* Van tulsi occurs as shrubs in the forest.

3. Southern Dry Mixed Deciduous forest – These are situated in the southern most part of the forest. The forest constitutes *Anogeissus latifolia, Diospyros melanoxylon, Terminalia Tomentosa, Shorea robusta, Buchanania lanzan, Chloroxylon swietenia, Lagerstromia parviflora, Hardwickia binata, Boswellia serrata, Acacia catechu, Bridelia squamosa, etc.*
4. Riparian Fringing Forest – Main tree species is *Terminalia arjuna*.
5. *Hardwickia binata* Forest

Sustainable harvest of Forest Produce from Gardarwa Forest Compartment

Techniques for sustainable harvest of Fodder grass as prescribed in the Working Plan:

1. Avoidance of harm or injury to the plantations, while harvesting or cutting the fodder grass.
2. Grazing for the cattle of the village forest is allowed in areas of *Eulaliopsis binata* grass, but grazing is prohibited in plantation and regeneration areas.
3. Harvest of the fodder grass is done from August or September till the end of February or March every year.

Rules for Lopping to overcome unsustainable harvest of fuel wood as prescribed in the Working Plan:

1. Lopping will not be done in plantation and regeneration areas.
2. Lopping is strictly prohibited in Mulberry, Haldu and sal trees.
3. Lopping is strictly prohibited above two-third height of the tree.
4. The branch with diameter more than 5 cm will not be lopped in any case.
5. The trees having circumference less than 40cm will not be lopped.
6. In all the trees lopping is strictly prohibited from base upto 183cm height.

Techniques for sustainable harvest of Tendu leaves as prescribed in the Working Plan:

1. Tendu leaves will not be collected from trees with DBH more than 75cm.
2. Collection period for Tendu leaves is from last week of April to first week of June.
3. Harvesting period for Tendu leaves is best while turning from crimson colour to green parrot colour.
4. Tendu leaves should be harvested from the centre of the coppice stock because the leaves below the coppice stock are over mature and the leaves above are immature.
5. Tendu leaves should be harvested by plucking and use of axe for lopping or logging is strictly prohibited.
6. Harvesting of Tendu leaves should be complete before the rains or by the end of June.

Techniques to increase production of Tendu leaves as prescribed in the Working Plan:

1. Coppice –If the original shoot of 15cm diameter is injured just above the ground or if the advanced growth of the tree is cut back and freed from the crown in the month of February to March, it shoots up strongly and gives rise to good quality Tendu leaves within 40-45 days.
2. Pollarding– True pollarding consists in topping a pole tree at some height above the ground so that it produces a crown of new shoots from buds below the cut. *Diospyros* trees with 15 cm diameter are cut at 60cm height above the ground. Trenches made round standing trees or green stumps of half diameter of about 120-240 cm.
3. Pruning – For pruning sharp saw is used to avoid harm to the cambium. Branches of approximate diameter 2-8 inches are pruned. In pruning living or dead branches are cut in order to get fresh new bunch of leaves which are obtained within 45 days of pruning.
4. Root suckers and Trenching – Reproduction by root suckers occurs to some extent naturally (example in *Diospyros*) but is usually induced by felling the parent tree or by injury to the roots; in the former case shoots are developed from adventitious buds formed on any part of the root system, and in latter mostly at or near the cut ends.

Techniques for sustainable harvest of Mahua flowers as prescribed in the Working Plan:

1. During harvest of mahua flowers, fire is kindled to clear the area, so permission will be granted in this case only in the presence of a fire management system.
2. Lopping of tree branches, felling of trees or any other injury to the trees should be strictly prohibited while collecting mahua flowers.

Techniques for sustainable harvest of Mahua seeds as prescribed in the Working Plan:

1. Mahua seeds are collected from February to April.
2. Mahua seeds can be obtained upto age of 200 years of the tree.
3. Mahua seeds are sold in the market due to their richness in oil content which is used for various household purposes.

Techniques for sustainable extraction of Gum from *Boswellia serrata* as prescribed in the Working Plan:

The following rules are followed while extracting gum from trees:

1. For extracting gum, trees with DBH less than 30cm should not be injured. Only self oozing out gum will be extracted from such trees.
2. Use of sharp objects will be made for making cuts on the tree for extracting gum.
3. For every fresh cut, minimum 1.5mm to maximum 3mm cut is to be made on the tree bark.

4. Make sure that, very thin layer of wood is cut under the thick bark, which is cut for extracting gum.
5. The cut made on the tree bark should not be more than 45 cm long in either direction.

Dependence on Forest

The main forest products that are extracted from Gardarwa Forest Compartment are grass, tree fodder, fuel wood and Minor Forest Produce. The product wise dependence on the Forest and the amount of extraction is discussed below.

Fodder Grass

Grass is harvested for a period of 9 months in a year. Of the total 89 households, 67% (60) extract grass from the forest. The dependence on Gardarwa Forest compartment is shown in table 7.8 below.

Table 7.8 Number and percentage of households dependent on forest for grass

Number of HHs depending on grass	60
% of HH that use grass from forest	67

Extraction

The grass extracted is used for self-consumption as fodder to feed livestock. The total amount extracted from Gardarwa Forest Compartment is 35820 kgs (358.2 Quintals) in a year, an average 587.2Kgs (6 Quintals) is extracted for self-consumption annually. The quantity of grass used for self consumption is given in tables 7.9 and 7.10 below.

Table 7. 9 Quantity of grass extracted from Forest (Total) annually

Quantity of Grass used for Self Consumption			
Kgs		**Quintals**	
Sum	Average	Sum	Average
35820	587.2	358.2	6

Table 7.10 Quantity of grass extracted from Forest (Average) annually

	Kgs	Quintals
Total	35820	358.2
Min	108	1.1
Max	1620	16.2
Average	587.2	6

Tree fodder

Of the total 89 households, 6.7% extract tree fodder from the forest. The dependence on Gardarwa Forest compartment is shown in table 7.11 below.

Table 7.11 Number and percentage of households dependent on forest for tree fodder

Number of HHs depending on tree fodder	**6**
% of HH that use tree fodder from forest	6.74

Extraction

The tree fodder extracted is used for self-consumption as fodder to feed livestock. The total amount extracted from Gardarwa Forest Compartment is 1820 kgs (18.2 Quintals) in a year, an average 303.2Kgs (3 Quintals) is extracted for self-consumption annually. The quantity of tree fodder used for self-consumption is given in tables 7.12 and 7.13 below.

Table 7.12 Quantity of tree fodder extracted from Forest (Total) annually

Quantity of tree fodder used for Self Consumption			
Kgs		**Quintals**	
Sum	Average	Sum	Average
1820	303.2	18.2	3

Table 7.13 Quantity of tree fodder extracted from Forest (Average) annually

	Kgs	**Quintals**
Total	1820	18.2
Min	168	1.7
Max	504	5
Average	303.2	3

Sustainable or unsustainable use

The sustainable limit of grass and tree fodder is derived using the following method:

- 1 cow unit = 1 standard cattle unit
- 1 cow wt. = 250 kgs
- Convert into cow unit = 400/250 = 1.6
- 5 goat or sheep = 1 cow

- Dry fodder = 2.5% of body weight = 2.5% of 250 = 6.25 kg
- Wet fodder = dry fodder * 4 =6.25*4 = 25 kg
- For Gardarwa Forest Block allowed harvest = 1 cattle unit/ha (after discussion with DFO Renukoot)
- For 77 ha = 77 cattle unit
- Sustainable Limit = cattle unit*wt of wet fodder*No. of days in a yr
- Unsustainable harvest = Actual harvest - Sustainable harvest
- Sustainable Limit for fodder and Unsustainable harvest of fodder is calculated using the above method.

Table 7.14 Livestock population

Livestock	Cattle units
Cows	31
Bull	120
Calves	4.68
Goat	128
total cattle units	283.7
actual cattle units	284
Half of the cattle go for grazing	142
wt of dry fodder	6.25kg
wt of wet fodder	25kg
Allowed	1 cattle unit/ha
Allowed for 1/3rd of 77ha	26 cattle units
Duration	180 days
actual harvest (kgs)	639000kg/yr
actual harvest (ton)	639 tons/yr
For half day length	320 tons/yr
sustainable (tons)	117 tons/yr
unsustainable (tons)	203 tons/yr

Fuel wood

Fuel wood, mainly, dead and fallen, is harvested over a period of 10 months in a year and used for household needs. As seen in table 7.15 below, of the total 88 households that collect fuel wood, almost all depend on Gardarwa Forest Compartment.

Table 7.15 Number and percentage of households dependent on forest for fuel wood

	Household need	Sale
Number of HHs depending on fuelwood	88	36
% of HH that use fuelwood from forest	99%	41

Extraction

About 88 households fuelwood for self-consumption i.e. household needs, out of 88 households, 36 households extract fuelwood from Gardarwa Forest Compartment for sale in Duddhi market.

Table 7.16 Quantity of fuel wood extracted from Forest (Total) annually for self-consumption

Quantity of fuel wood used for Self Consumption			
Quintals		Tons	
Sum	Average	Sum	Average
1362.4	15.6	136.24	1.6

Table 7.17 Quantity of fuel wood extracted from Forest (Total) annually for self-consumption

Quantity of fuel wood used for Sale to generate additional Income			
Quintals		tons	
Sum	Average	Sum	Average
98.5	2.7	9.9	0.27

Hence the quantity of total extraction of fuel wood by 88 households from Gardarwa Forest Compartment is 1461.4 Quintals/yr or 146 tons annually.

Income generated by sale of fuel wood is given in table 7.18 below

Table 7.18 Income from fuel wood sale

Sale of fuelwood	Price	Total Income	Average income per HH
Period of sale	Rs/head load	Rs/yr	Rs/yr
12 months	150	73,875	2,052

Sustainable or unsustainable use of Fuel wood

Gardarwa Forest Compartment is a dry deciduous forest. According to the primary data of the aboveground biomass assessment of Gardarwa Forest Compartment, the total growing stock is calculated as 150 cubic meter per hectare.

The annual productivity for the Dry Deciduous forest is 3% of the total growing stock.

Hence, Annual Productivity= 2%*150 = 3 cubic meter/ha

Volume of Growing stock=3 cubic meter/ha

Now density of wood is 0.67

Since, Mass of fuel wood= density*volume of growing stock= 0.67*3= 2.01 tons/ha

Hence, Mass of fuel wood for 77ha= 154.77 tons.

Since the forest composition shows that it is a miscellaneous forest, 50% is used as fuel wood and 50% is used as timber. Therefore,

Sustainable Limit for fuel wood harvest is 77 tons/yr

Actual harvest is calculated as 146 tons/yr

Unsustainable harvest = actual harvest – sustainable limit

Unsustainable harvest = 69 tons/yr

Minor Forest Produce

Tendu patta (Diospyros melanoxylon)

Tendu patta is harvested for a period of 15 days in a year. Of the total 89 households, 29% harvest Tendu patta from the forest. The dependence on Gardarwa Forest compartment is shown in table 7.19 below.

Table 7.19 Number and percentage of households dependent on forest for Tendu patta

Number of HHs depending on tendu patta	26
% of HH that use tendu patta from forest	29

Extraction

The tendu patta extracted is sold to the Forest Corporation. The quantity of tendu patta sold and the income generated by sale is given in table 7.20.

Table 7.20 Quantity of tendu patta extracted from Forest (Total) annually for sale

	Sale (gaddi/yr)	Price (Rs/gaddi)	Income (Rs/yr)
Total	17916	50	852000
Average	664		37043

Sustainable Limit for harvest of Tendu patta is 2/3 of the available quantity and 1/3rd should be left for growing as tree.

Van Tulsi

Van tulsi is harvested for a period of 15 days in a year. Of the total 89 households, 25% harvest van tulsi from the forest. The dependence on Gardarwa Forest compartment is shown in table 20 below.

Table 7.21 Number and percentage of households dependent on forest for Van Tulsi

Number of HHs depending on Van tulsi	22
Percentage of HH that use Van tulsi from forest	25

Extraction

The quantity of Van tulsi sold and the income generated is given in table 7.22.

Table 7.22 Quantity of Van tulsi extracted from Forest (Total) annually for sale

	Sale kg/yr	Price Rs/kg	Income (Rs/yr)
Total	381	12	4698
Average per HH	17.32		214

Sustainable Limit for harvest of Van tulsi is 2/3 of the available quantity and 1/3rd should be left for natural regeneration.

Seeds of Van tulsi should also be planted with minimum distance of 45x30cm and the plants should be watered at least once a week.

Mahua

Mahua is harvested for a period of 14 days in a year. Of the total 89 households, 25% harvest Mahua from the forest. The dependence on Gardarwa Forest compartment is shown in table 7.23 below.

Table 7.23 Number and percentage of households dependent on forest for mahua

Number of HHs depending on mahua	22
Percentage of HH that use mahua from forest	25

Extraction

The Mahua extracted is consumed at home and also sold to the Forest Corporation and in the Duddhi market to local dealers. The quantity of mahua consumed, sold and the income generated is given in table 7.24.

Table 7.24 Quantity of Mahua extracted from Forest (Total) annually both for consumption and sale.

	Cons kgs/yr	Sale kg/yr	Price Rs/kg	Income (Rs/yr)
Total	460	950	12	12265
Average per HH	46	73.1		943

Sustainable Limit for Mahua is limited to fallen flowers only. The picking of Mahua flowers should be with sustainable techniques also to avoid damage to young crop of Mahua and other trees.

Among the various MFP harvested from Gardarwa Forest Compartment, the maximum dependence is on Tendu patta. (Figure 7.7 below).

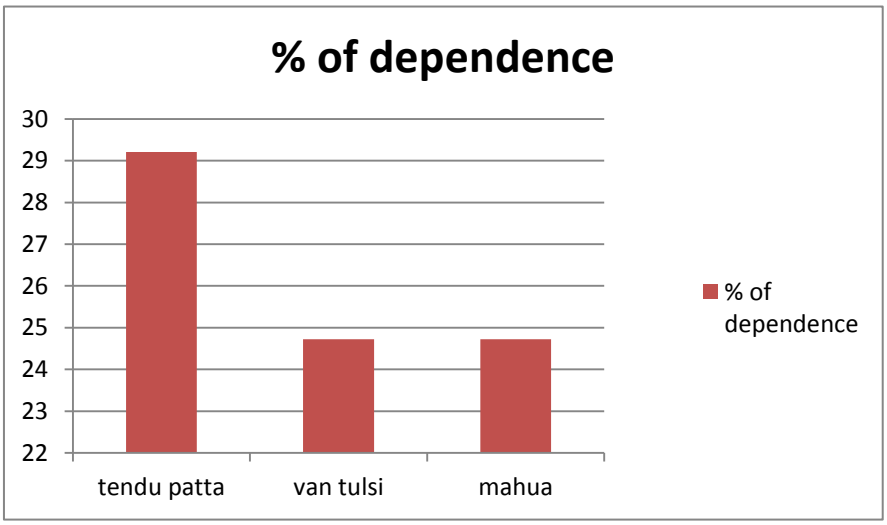


Figure 7.7 Dependence on MFP

Among the various forest products harvested from Gardarwa Forest Compartment, the maximum dependence is on fuel wood as shown in Figure 7.7 above.

Livelihood Sources

Unskilled labour is the main occupation; besides there is dependence on rain fed agriculture. A large number of households also rely on labour and service for livelihoods.

Agriculture

A total of 1491 32 acre of land is under un-irrigated agriculture; which is completely rain fed. Details of agricultural land ownership are given in table 7.25 below.

Table 7.25 Ownership of agricultural land

Land Type	Owned (acre)		Leased in		Leased out	
	Total	Average	Total	Average	Total	Average
Irrigated	0	0.0	0	0	0	0.0
Unirrigated	32	0.5	0.6	0.3	10.5	1.2
Barren	0	0.0	0	0	0	0
Total	32	0.5	0.6	0.3	10.5	1.2
Percentage	74		1.5		24.6	

The major crops grown are rice and maize. The detailed annual production and consumption from agriculture is given in table 7.26 below.

Table 7.26 Annual production and consumption of major crops grown

Crop	Annual Production (kg/year)				Self-Consumption (kg/year)			
	Total		Per HH		Total		Per HH	
	Kgs	Quintals	Kgs	Quintals	Kgs	Quintals	Kgs	Quintals
Rice	8550	85.5	203.6	2.04	8550	85.5	203.6	2.04
Maize	12050	120.5	211.4	2.11	12050	120.5	211.4	2.11

Livestock

A total number of 243 livestock is owned, at an average of 3 per household. Table 7.27 below shows that category wise livestock owned.

Table 7.27 Livestock owned

Cows			Buffaloes			Calf		Bull	Mule	Sheep	Goat	Total
Milk	Non-milk	Total	Milk	Non-milk	Total	Cow	Buffalo					
31	-	31	-	-	-	9	-	75	-	-	128	243

Sale of livestock products is nil in Gardarwa village forest.

Income generating activities (IGA)

Among other income sources, 41% of the total 89 households reap the benefits of MNREGA activities; there is also reliance on income from JICA and Forest watchery, 29% and 5% respectively while 7% households depend on teaching as shown in figure below (figure 7.8). Table 7.28 gives the details of income from other sources.

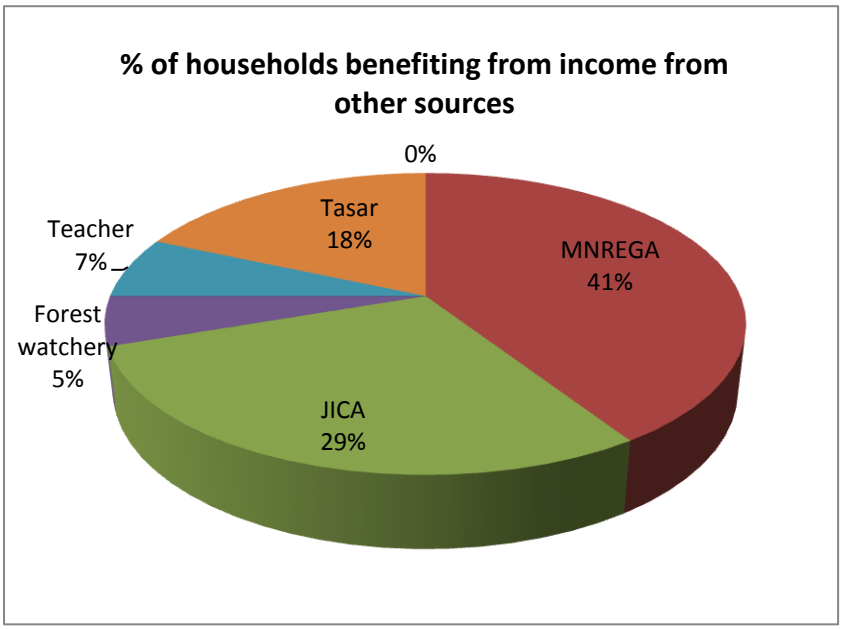


Figure 7.8 Income from other sources

Table 7.28 Income from other sources

Source	No. of HH dependent	Average Income per month/per day (Rs)	No of months	Annual Income (Rs)
MNREGA	31	100 /Day	2	6000
JICA	22	120 /Day	2	7200

Source	No. of HH dependent	Average Income per month/per day (Rs)	No of months	Annual Income (Rs)
Forest watchery	4	2400 /Month	5	12000
Teacher	5	2200 /Month	7	15400
Tasar	14	1200 /Month	6	7200

Apart from these, the village forest has Self Help Groups (SHG), whose composition is as follows:

1. SHG – 17 members (13 male and 4 female) - Tasar farming
2. SHG – 15members (15 female) – poultry farming
3. SHG – 14 members (11 male and 3 female) – poultry farming

The formation of these SHGs aims to alleviate poverty among the forest dependent communities on one hand and to deviate the pressure from forests to other sectors of employment, on the other hand.

The Public Distribution System (PDS) is very weak. The whole population of the Gardarwa village forest is below the poverty line, only 9%the households have red BPL card, 35% have yellow BPL card and rest 56% have white BPL card. The white and yellow card holders get almost no food on their cards to meet their household day to day needs; and agriculture is completely rain fed in the area, therefore the village forest communities are dependent on wood and other NTFPs from the forest to survive throughout the year.

Gender Assessment

The following section discusses specific gender dimensions viz. a) Gendered division of labour in extraction of the site specific forest products viz. harvesting, sale, collection and maintenance, b) role of men and women in decision making over shortage of forest products, c) involvement of men and women in existing forest management and institutional arrangements, and d) gendered division of labour in other sources of livelihood.

Forest Products

There is no sale of any of the forest products such as grass and fodder, whereas fuel wood which in addition to self-consumption is also sold in the market at a good price, as mentioned in the previous sections. Apart from fuel wood, the MFPs such as Tendu patta, Van tulsi and mahua are sold in the market and to Forest Corporation. Mahua is also used for self-consumption. It is observed that the harvesting of each product is done particularly by womenfolk. Where men are involved, it is in addition to the involvement of women of the household. Table 7.29 shows the number of households where men and women are involved in extraction of forest products.

Table 7.29 Household wise gendered division of labour in extraction of forest products.

Product	Harvesting role	
	Male	Female
Grass	-	52
Tree Fodder	-	5
Fuelwood	4	88
MFP		
Tendu patta	17	21
Van tulsi	14	19
Mahua	14	44

Fodder collection and maintenance

In the collection and maintenance of fodder from various sources the division of labour, is shown in the following table (table 7.30).

Table 7.30 Number of households where women and men are involved in collection and maintenance of fodder from various sources

Source	Collection		Maintenance	
	Male	Female	Male	Female
Forest	14	45	2	57
Agriculture	1	14	6	12
Market	-	-	-	-
Open grazing (from forest)	12	-	8	-

Although women are the ones who are involved in collection of fodder, when it came to taking decisions on the use of alternatives at times of shortage of fodder, it was largely the male members of the household who dominated the decision making (table 7.31).

Table 7.31 Number of households seeking options to deal with fodder shortage and role of men/women in its decision making

Options willing	Yes	No	Household member/s involved in decision	
			Male	Female
a) Increase no. of fodder trees in farm land	10	1	17	2
b) Go long distance to collect forest products	11	-	4	15
c) Reduce livestock herd size	1	7	8	12
d) Sell farmland	-	8	19	2
e) Increase use of chemical fertilizer for soil fertility	-	8	18	3
f) Purchase commercial feed from nearest market	2	7	10	11
g) Shift from large livestock to small livestock	2	8	16	4
h) Start poultry farming for manure and HH income	-	8	20	2
i) Plant other leguminous grasses in riser and bunds	-	8	21	1
j) Other	-	7	18	1

Fuel wood collection and maintenance

As in the case of fodder, even in the case of fuelwood women are largely involved in collection and maintenance of fuel from various sources (table 7.32). However, when it came to taking decisions on the use of alternatives to deal with shortage , the results show that male members of the household dominated the decision making (table 7.33).

Table 7.32 Number of households where women and men are involved in collection of fuelwood from various sources

Source of fuel	Collection		Maintenance	
	Male	Female	Male	Female
Forest	2	88	-	88
Agriculture waste	-	1	-	1

Table 7.33 Number of households seeking options for fuel shortage and role of men/women in its decision making

	Options willing	Yes	No	Household member/s involved in decision	
				Male	Female
a)	Plant more trees in private land	58	30	60	25
b)	Began use of livestock dung	17	67	55	31
c)	Shift from fuelwood to kerosene (lighting, cooking, heating)	1	81	39	42
d)	Shift from fuelwood to electricity (lighting, cooking, heating)	-	82	78	2
e)	Introduced bio gas plant (lighting cooking heating)	-	82	45	36
f)	Increase improved stoves to save fuel wood consumption	-	82	39	41
g)	Introduce fuel saving utensils (pressure cooker etc.)	-	82	29	51
h)	Reduce cooking time	44	40	32	52
i)	Other (LPG)	16	66	43	39

Other Income Generating sources

In terms of earning from other sources of income, the engagement of men is higher than that of women. In all the other sources of income, namely, labour, service, business, drawing of animal labour men are the bread winners; while among the pension holders the number of women is higher than that of men. Table 7.34 shows this distribution.

Table 7.34 Number of households with gender wise distribution of household members earning from other sources of income

Source	HH members involved	
	Male	Female
MNREGA	25	14
JICA	15	15

Source	HH members involved	
	Male	Female
Forest watchery	4	-
Tasar	13	2
Teacher	5	-

Existing Forest Management and Institutional Mechanism

An independent Joint Forest Management Committee (JFMC) had been formed in Gardarwa village forest in 2010. The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 is implemented in Sonbhadra district of Uttar Pradesh. Also, individual forest rights and Community forest rights have been distributed to the tribal people in Gardarwa village forest under The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006.

There is a need to strengthen the Joint Forest Management Committee at the community level, so that both Forest Department and the community can work in partnership . In the Renukoot site, formation of the JFMCs under Uttar Pradesh Participatory Forest Management and Poverty Project funded by JICA in the region helped the existing forests to rejuvenate. The project aims to restore the degraded areas and enhance forest cover through afforestation and reforestation activities in order to improve the livelihood and empower local people. The proposed project activities focus on promoting Sustainable Forest Management (SFM) through the involvement of local communities, thereby improving environment and alleviating poverty. In the division, forest department is also promoting forest based livelihood activities for the local communities. The forest department is actively involved in cultivation of minor forest produces, lac cultivation, honey production, tussar cultivation, and sericulture production etc.

Carbon Assessment

RS/ GIS based methodology helped in estimating carbon stock of the benchmark year as well as in estimating future stock at periodic intervals. The methodology is presented in Chapter 3 and is not being repeated here.

Results

Change in Above Ground Tree Biomass

An increase of 75.68% in Above Ground Tree Biomass is recorded.

Table 7.35 Change in AGTB from baseline to present year.

Project Area (in ha)	AGTB (ton ha^{-1})			Total AGTB (ton)		
	1990	2012	Change	1990	2012	Change*
77	70.41	123.70	53.29	5421.72	9524.97	4103.25 (75.68)

*Values in parenthesis refers to the change in percent from the baseline year to the present year

Change in Carbon from Above Ground Tree Biomass

Table 7.36 Change in AGTB Carbon from baseline to project year

	Carbon (ton ha^{-1})			Total Carbon (ton)		
Project site	1990	2012	Change	1990	2012	Change
Renukoot	31.69	55.67	23.98	2439.78	4286.24	1846.46

Change in Below Ground Tree Biomass

Table 7.37 Below Ground Tree Biomass

BGTB (ton ha^{-1})			Total BGTB (ton)		
1990	2012	Change	1990	2012	Change
19.01	33.39	14.38	1463.86	2571.74	1107.87

Change in carbon from BGTB

Table 7. 38 Change in carbon from BGTB.

	Carbon (ton ha^{-1})			Total Carbon (ton)		
Project site	1990	2012	Change	1990	2012	Change
Renukoot	8.55	15.025	6.47	658.73	1157.28	498.54

Dead wood carbon stock

The dry weight of deadwood in Renukoot site was estimated at 204 tons. Carbon from the deadwood was estimated at 91.82 tons.

Table 7.39 Deadwood

DW (tdm)		Carbon (ton)	
ha^{-1}	Total	ha^{-1}	Total
2.65	204.05	1.19	91.82

Leaf litter carbon stocks

The dry weight of leaf litter in is 197.89 tons. Carbon from the leaf litter in Renukoot is 1.16 tons per ha. The total carbon from leaf litter varies from Renukoot is (89.05 tons).

Table 7.40 Leaf litter

LL (tdm)		Carbon (ton)	
ha^{-1}	total	ha^{-1}	Total
2.57	197.89	1.16	89.05

Estimation of soil organic carbon

Table 7.41 Soil organic carbon

Depths	0-15 cm	16 – 30 cm	31 - 45 cm
Soil Weight (t ha^{-1})	1800	3600	5400
Average Soil Carbon Percentage (%)	1.73	1.63	1.26
Soil Organic Carbon (tC ha^{-1})	31.19	27.62	9.48
Total Soil Organic Carbon (tC)	2401.63	2126.74	729.96

Net increment in carbon

The total net increment is around 2345 tons of Carbon, which is around 75.68% from the baseline year.

Table 7.42 Net increment

Total Carbon (ton) from AGTB and BGTB		
1990	2012	Change
3098.51	5443.52	2345.01 (75.68%)

***Values in parenthesis refers to the change in per cent from the baseline year to the present year**

Action Research to overcome the unsustainable harvest

In Gardarwa Village forest, 88 households collect fuelwood for self-consumption i.e. household needs, and36 households extract additional fuelwood from Gardarwa Forest Compartment for sale in Duddhi market. The quantity of total extraction of fuel wood by 88 households from Gardarwa Forest Compartment is 1461.4 Quintals/yr or 146 tons annually. The sustainable limit is 77 tons per year. Total income generated by sale of fuel wood is approximately Rs 73, 875 per year. There is need to reduce the excessive unsustainable extraction of fuel wood (69 tons per year) from Gardarwa Forest Compartment, by substituting fuel wood and by providing alternative employment opportunities in other sectors to deviate pressure from the forestry sector.

Strategies that can be adopted in Renukoot are decreasing fuel wood cutting and burning by providing improved stoves, initiating and enhancing of use of solar energy for lighting & pumping, decreasing fuel wood & pole stage cutting in natural forests by initiating agro forestry, enhancing/strengthening forestry based livelihood practices such as tasar and lac culture particularly in forest areas vulnerable to encroachments, and creating alternative livelihood opportunities through poverty alleviation programmes. Fast growing energy plantations may be raised on farmlands to reduce emissions from the natural forests, Agro forestry in cultivated farmlands and farm forestry in fallow farmlands can be developed,

Harvest must be accompanied by regeneration, Harvesting and regeneration is to be planned when CAI is either stagnant or no longer enough to provide the sufficient mitigation benefits, Species to suit the demand of fuelwood and small timber in minimal time- Gamhar (Gmelina arboria) in bunds for small timber and Akashmuni (Acacia auriculiformis) in fallow farmlands may be selected

Energy plantations of indigenous species in degraded lands, particularly around settlements and in the periphery of the village forest may provide one of the means to enhance productivity. In the village forest, fuelwood is burnt in a highly inefficient manner in open spaces or old-fashioned mud-chulhas (stoves). There is ample scope for introduction of improved stoves. One way of reducing the gap between demand and supply is to harness maximum energy potential of the wood through efficient burning devices . Normal chullas having energy efficiency of 8-10% should be replaced with improved chullas developed by TERI, which have energy efficiency of 40-42%. Another alternative is to provide energy efficient pressure cookers.

Use of renewable and non-conventional energy sources must be promoted.. Fuel wood collection and consumption are intricately linked to natural resource management. Alternative sources of rural domestic energy crop residues, animal dung, wood from trees on the farm, biogas, kerosene and sun and wind power do not cause forest degradation. Substitution from fuel wood to these alternatives resources can reduce pressure on natural forests. In addition, more wide-spread use of improved stoves, biogas, and other improved end-use technologies through reduced energy input requirements also has the potential to reduce pressure on forest resources. The same can be said about improved functioning of local natural resource management institutions and efforts at promoting "participatory" and "joint" forest management. Fuel wood has a potentially large opportunity cost in terms of collection labour time, which varies according to the density, distance, and accessibility of local forest resources. Since improved cooking technologies and renewable energy sources carry substantial overhead costs so these should be provided at subsidized rates. Crop residues and by-products, sometimes used as fuel, can provide micro-nutrients when ploughed back into the soil and are useful for animal fodder. Policies and projects that target

to protect the remaining forest stock (e.g., reforestation, plantation works, stricter rules of access to commons and state forests) might be more effective if implemented in conjunction with policies influencing domestic fuel substitution and energy conversion technology (e.g., promotion of trees on private land, subsidization of non-forest fuels, and dissemination of improved stoves. Another fuel source is biogas which is produced through the decomposition of organic materials like cattle dung and human waste in the absence of air. It is a clean and efficient fuel used for cooking and lighting. In Gardarwa the fodder grass extracted is used to feed livestock. The total amount extracted from Gardarwa Forest Compartment is 35820 kg (358.2 Quintals) in a year. The tree fodder extracted is used for self-consumption as fodder to feed livestock. The total amount extracted from Gardarwa Forest Compartment is 1820 kg (18.2 Quintals) in a year.

The total cattle units in Gardarwa Forest Compartment are 284, whereas 1 cattle unit per hectare is . The carrying capacity of Gradarwa forest compartment is calculated to be 117 tons per year whereas the actual harvest came out to be 320 tons per year. Therefore the there is a need to overcome the extra 203 tons per year by substitution of fodder for livestock to reduce grazing pressure on forests and with the application of sustainable harvest techniques as given in the Working Plan of Renukoot Forest Division, Sonbhadra.

Azolla is a sustainable feed substitute for livestock. Azolla can be easily digested by livestock, owing to its high protein and Low lignin content.. Among the forage crops, napier grass holds its importance as it is a vigorous, hardy, high-yielding perennial grass and is now widely recognized as a valuable fodder grass. It is also considered as a soil-restoring crop as grass leaves the soil richer in organic matter. Napier grass or elephant grass is a well known perennial grass which gives fodder all the year round i.e. during summer as well as winter. Napier grass is a native of Rhodesia in South Africa and is cultivated in Asia, Africa, southern Europe, America, Pakistan, Sri Lanka and India. The major states in which Napier grass is grown in India are Assam, Gujarat, Madhya Pradesh, Uttar Pradesh, Punjab, West Bengal, Orissa, Bihar and Haryana.

The Forest Department, in collaboration with Panchayati Raj Institutions, Joint Forest Management Committees, and research institutes should be responsible for rehabilitating the degraded grazing lands through promotion of fodder species – grasses, legumes and trees - and creating fodder banks in the Forest Fringe Villages. Formulation of a national policy on grazing-cum-fodder and pasture development should be done in consultation with civil society organizations and domain experts. There is a need to rehabilitate and enhance productivity of degraded forests through silvi-pastoral practices of integrating grasses and fodder trees under the instruments of Joint Forest Management. There is also a need to develop fodder blocks in Forest Fringe Villages through revival and development of pastures on CPRs in collaboration with Panchayati Raj Institutions. There should be promotion of incorporation of fodder trees with agricultural practices towards agro-forestry initiatives.

Minor Forest Produce forms a major source income for the inhabitants of Gardarwa Village Forest. One of them is Tendu leaves. It is harvested for a period of 15 days in a year. Of the total 89 households, 29% harvest Tendu patta from the forest. The tendu patta extracted is sold to the Forest Corporation. The quantity of tendu leaves sold and the income generated by sale is Rs 8,52,00 per year by the sale of 17916 Gaddis per year. Some of the prescribed techniques for sustainable harvest of tendu leaves include the prescription that tendu leaves will not be collected from trees with DBH more than 75cm, Collection period for Tendu leaves is from last week of April to first week of June, Harvesting period for Tendu leaves is best while turning from crimson colour to green parrot colour, Tendu leaves should be

harvested from the centre of the coppice stock because the leaves below the coppice stock are over mature and the leaves above are immature, Tendu leaves should be harvested by plucking and use of axe for lopping or logging is strictly prohibited and last but not least harvesting of Tendu leaves should be complete before the rains or by the end of June.

Van tulsi which is harvested for a period of 15 days in a year. Of the total 89 households, 25% harvest Van tulsi from the forest. The Van tulsi extracted is sold to the Forest Corporation. The quantity of Van tulsi sold is 381kgs per year and the income generated is 4698 Rs per year. Sustainable Limit for harvest for regeneration of Van tulsi is 1/3rd. Seeds of Van tulsi should be planted with minimum distance of 45x30cm and the plants should be watered at least once a week.

Another MFP, Mahua is harvested for a period of 14 days in a year. Of the total 89 households, 25% harvest Mahua from the forest. The Mahua extracted is consumed at home and also sold to the Forest Corporation and in the Duddhi market to local dealers. The quantity of mahua consumed is 460 kgs per year, sold is 950 kgs per year and the income generated is 12265 Rs per year.

Other livelihood opportunities to deviate pressure from the forestry sector include Lac culture practice which saves the butea trees- a representative of degraded forests, raising tasar plantations on land vulnerable to encroachment has saved the land. Apart from the forest based activities, total income generated from other income generating activities is approximately Rs 47,800 annually by 76 households in Gardarwa Village Forest. These IGAs include plantation and construction work under MNREGA, JICA, Tasar factory, Tasar Farming, Teaching and Forest Watchery. Another activities that have recently started is poultry farming under the Self-Help Groups.

There is a need to construct artificial water harvesting systems to promote agriculture in the village and to reduce dependency on the forest.

Action research projects may be formulated by the Forest Department and implemented through JFMCs. Funds may be augmented through schemes such as MNREGA and through support from overseas donors.

Discussion and Conclusion

Garhdarwa Village Forest had a stock of 3099 tonnes of carbon in 1990 and 5444 tonnes in 2012 with an increase of 2345 tonnes in 22 years in spite of providing fuel wood, fodder and MFP for self-consumption as well as for their substantial livelihood based on largely unsustainable harvest. There is a need to substitute unsustainable harvest by alternative natural resource and agriculture based livelihoods to keep harvest of forest produce within the sustainable limit, as detailed earlier in this chapter. The carbon stock could increase substantially if harvest of forest produce, particularly fuel-wood, is managed within sustainable limit. The community is putting efforts in the management and conservation of village forests but unable to restrict harvest of forest produce within sustainable limit due to failure of the implementation of other rural development schemes which could have otherwise substituted the unsustainable harvest. The Gardarwa Village forests have the potential of trading of enhanced carbon while maintaining availability of forest produce within sustainable limit for both for self-consumption as well as for livelihoods. Willingness of the community to take steps in this direction is also high. The site therefore has a good potential for implementation of a REDD+ project.

Chapter 8 REDD Plus Assessment in Sundarban Area

Introduction

Sundarban has been in the national and international limelight on account of several unique features. Sundarban hosts the only mangrove forest in the world that has a tiger population. It consists of the largest single block of halophytic mangrove forest across the globe. It shares its territory with India and Bangladesh and lies in the delta formed by the super-confluence of Ganga, Padma, Brahmaputra and Meghna rivers.

The region is known for its rich biodiversity, comprising more than 65 mangrove species and harbouring a large number of endangered animal species such as Royal Bengal Tiger, Estuarine Crocodile and Gangetic Dolphin. The dominant mangrove species is *Heritera fomes* (sundari) and though the derivation of the name 'Sundarban' remains obscure, it is probable that the region was named after this species. From a socio-economic point of view, this is a backward region with a high level of poverty. The region is vulnerable from an ecological point of view, being subjected to cyclonic storms and intrusion of saltwater. Agriculture is completely rainfed and primarily a subsistence activity. High levels of urban or peri-urban migration is a common feature.

Sundarban represents an area of global significance in terms of its unique biodiversity but also a region where livelihood needs of people are compromised. In the context of the REDD Plus assessment, the choice of Sundarban is dictated by the following criteria:

- The area is important for critical ecosystem services, and represents a case to demonstrate the co-benefits of carbon stock enhancement
- The area is inhabited by poor and vulnerable people with compromised livelihood options and harsh natural conditions
- The introduction of participatory forms of management is relatively recent, especially in the study site, where an FPC (Forest Protection Committee) was formed in 2004.

Profile of the area

The mangrove forests of the Sundarban are located in the Khulna District of Bangladesh and the 24 Parganas (South) district of West Bengal.

The total area of the mangrove forests of the Sundarban within the Indian territory is approximately 2118 sq km (FSI 2011) of which 1014 sq km (48%) and 873 sq km (41%) are classified as Very Dense and Moderately Dense respectively. There is an increase of mangrove cover of 2 ha over the last assessment (2009). The Indian Sundarban fall within the 24 Parganas (South) Forest Division of West Bengal, headquartered at Alipore (Kolkata), demarcated by Vidya and Matla river in the east, Bay of Bengal in the south, Muriganga river in the west and the urban conglomerate of Kakdwip in the north. Sundarban Biosphere Reserve covers the entire Indian Sundarban region and was constituted in 1989 under the Man and Biosphere (MAB) programme in 1989; subsequently it was recognized as Global Biosphere Reserve by UNESCO in 2001. A part of the Reserve Forest (RF) area (on the eastern side of the Matla river) was constituted as a Tiger Reserve in 1973 under Project Tiger. The RF area has one National Park (the core area of the Tiger Reserve) and three

wildlife sanctuaries – Haliday Island WLS, Lothian WLS and Chintamani Kar Bird Sanctuary. The NP area was declared a World Heritage Site in 1987 by UNESCO. Sundarban area fall between 21-31 to 22-31 N latitude and 88-10 to 89-51 E longitude.

The forests occupy a deltaic swamp, most of which is under water during the high spring tides. The region is interspersed by a network of rivers, channels and creeks.

The site within Sundarban selected for the assessment is the area protected by Jharkhali FPC. The site was selected in consultation with the Director, Sundarban Biosphere Reserve. The key features of the site are the following:

- Relatively backward region with high incidence of poverty (60% of households below the poverty line)
- Important for the protective services of mangrove forest, especially storm protection services and high vulnerability (located on the fringes of the Sundarban Tiger Reserve)
- Limited direct dependence on forests and a strong institutional set-up (an active FPC)

The specific selection of Jharkhali – III for socio-economic assessment was based on consultations with officials at the Range level. Four FPCs have been formed in the Herobhanga beat – Jharkhali (I to IV). The registration number of Jharkhali – III is 33 dated 1-3-04.

The area protected by Jharkhali – III FPC (the site selected for REDD Plus assessment) is located in Herobhanga Beat in Matla Range of 24 Parganas (South) Forest Division. The forest area covered by this FPC is 638 ha. Herobhanga is flanked by Matla river on the west and south, Vidya river on the west, and the Namkhana Forest Range on the north. It is located in the fridges of the Tiger Reserve area. Administratively, it lies in the Basanti Block of 24 Parganas South district. The area for carbon assessment comprises Herobhanga Compartments 4,5,6,7 and 8 with an approx. area of 4420 ha.

The average annual rainfall is 78.81 mm, the average maximum temperature 97 degree F and the average minimum temperature 53 F. The average humidity is 70% and stays more or less uniform throughout the year.

Administrative and forest maps of 24 Parganas (South) are provided as Figures 8.1 and 8.2.

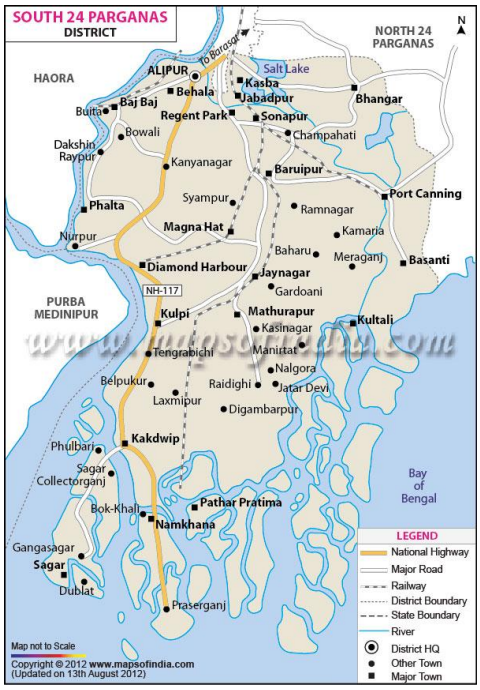


Figure 8.1 Administrative Map of 24 Parganas South District

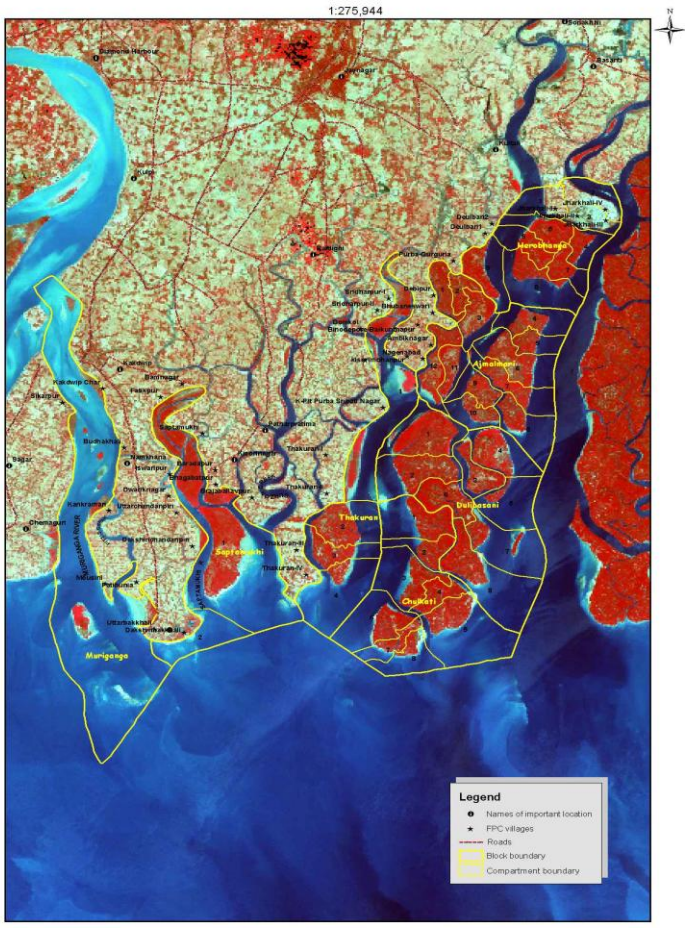


Figure 8.2 Forest Map of 24 Parganas South District

Socio-economic profile of the study area

The extent of forest dependence has been captured through a socio-economic survey [5]among members of Jharkhali – III FPC. The corresponding Beat is Herobhanga and the corresponding Revenue Village is Tridipnagar with approximately 350 households of whom about 31% belong to the BPL category. The nearest primary school is 2 km away, the nearest primary health centre is 7 km away and the distance to the nearest motorable road is about 3 km.

The socio-economic profile of the area and the nature of forest dependence is captured through a household-level questionnaire survey. The bilingual (English-Bangla) survey questionnaire is appended to this report.

The sample for the household level survey was 50, that is, about 14% of the total number of households. 84% of the households surveyed belonged to the SC/ST category; this was in line with the overall socio-economic profile of the area (>90% SC/ST population). All households surveyed stayed in kutcha houses, and only 8% of them had electricity connections. The average family size was 5.

The main primary occupations of the respondents were agriculture (62%) and labour (30%) (Figure 8.3) (Primary occupation has been defined as that occupation that accounts for the largest share of the regular household income, including non-cash income). 28% of the households earn an income from fisheries; however this constitutes the primary occupation of only 6%. The average landholding per household is 3.5 bigha (or about 0.5 ha). All agricultural land is rain-fed; in a majority of cases, rain water is directly used and in a few cases, rain water is stored in ponds and used later. The major crops are paddy, chilli, lentils and pumpkin in the kharif season, and paddy and sunflower in the rabi season. The livestock ownership is as follows: 0.6 cows/hh, 1.2 goats/hh and 1.6 ducks/hh (average values). Almost all milk and livestock products are consumed locally.

The main source of cash income is wage labour and the average income per households from this source is Rs 23024 / year.

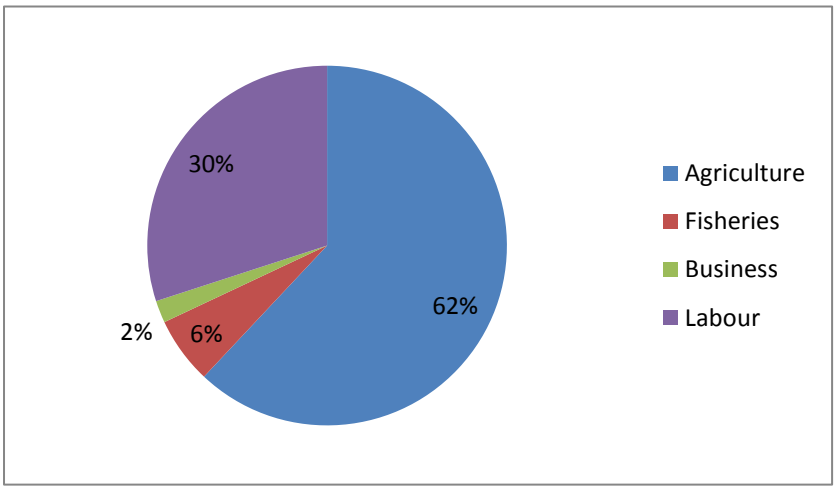


Figure 8.3 Primary occupation of sampled households

[5] Conducted in association with SHER, a Kolkata-based NGO headed by Mr Joydeep Kundu.

Table 8.1 Social and economic categories of households

	Whether BPL		
	Yes	**No**	**Total**
GEN	4	4	8
SC/ST	25	17	42
Total	**29**	**21**	**50**

As Table 8.1 shows, the village is inhabited predominantly by SC/ST households. Of the SC/ST households, about 60% belong to the BPL category, whereas among the General households, 50% belong to the BPL category.

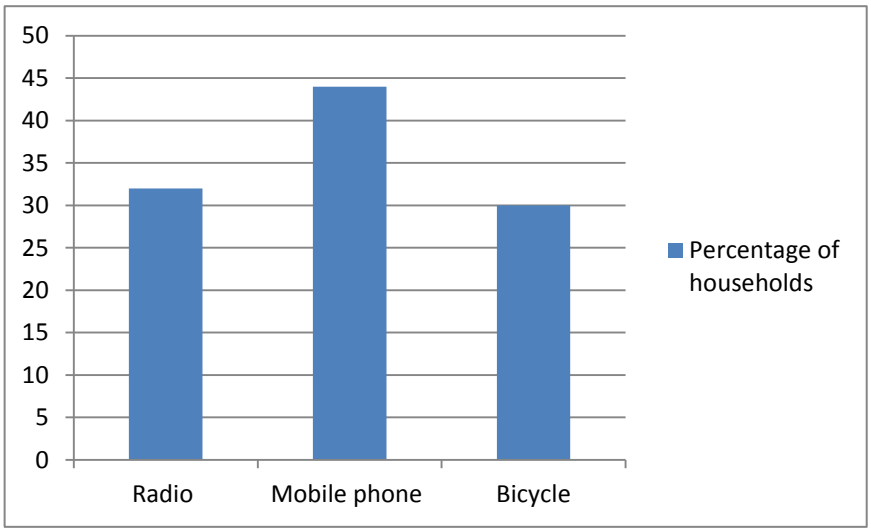


Figure 8.4 Holding of assets

The ownership of assets is shown in the Figure 8.4. Less than 10% of the respondents had electricity connections at home, and the ownership of electrical appliances such as fan, TV and refrigerator was not reported.

Migration is a common feature of the area. 62% of the respondent households had at least one member living outside the village on a regular basis – either for the entire year or for part of the year. Lack of tertiary occupation opportunities within the village is the key factor. The following is a break-up of migrants by number of months stayed outside the village. If a member has stayed outside for more than nine months, s/he is assumed to have migrated for the whole year.

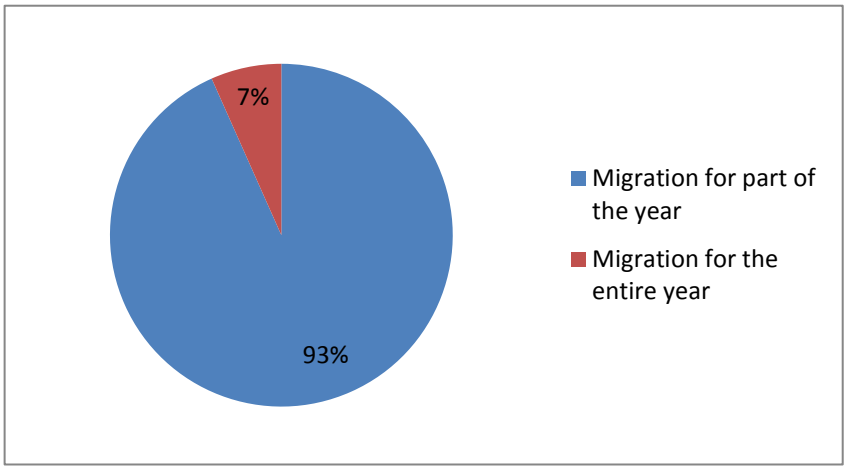


Figure 8.5 Migration pattern

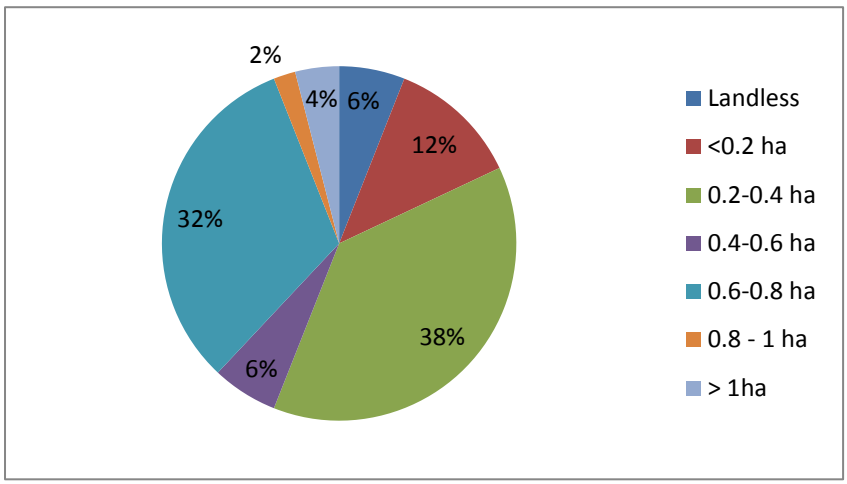


Figure 8. 6 Land holding pattern

The land holding pattern of the sampled households is shown in Figure 8.6. It is evident that almost all households possess some land. The land distribution is quite uniform with only a few farmers possessing more that > 0.8 ha of land. Only 6% of households are landless. 96% of households are marginal farmers, that is, their individual landholding is less than 1 ha (1 *bigha* = 0.13 ha).

The livestock holding pattern is shown in Table 8.2 below. The sampled households own a total of 26 units of livestock. Projecting to all FPC households, the estimated total livestock holding is 186 livestock units.

Table 8.2 Livestock holding

Type of livestock	Number	CF	Livestock Unit
Cow	29	0.5	14.5
Calf	13	0.25	3.25
Buffalo	2	0.5	1
Sheep	2	0.1	0.2
Goat	62	0.1	6.2
Duck	83	0.01	0.83
Total			**25.98**

CF: Conversion factor

(FAO conversion factors used)

http://www.fao.org/ag/againfo/resources/en/publications/sector_briefs/lsb_IND.pdf

Direct dependence on forests

The direct dependence on forests is relatively low in this area. Forests are important primarily for their protective functions; more specifically for their storm protection services.

Fuel needs are principally met through kerosene. There is no or very limited use of LPG, biogas or solar cookers in this village. Fuel needs are also partially met through fuelwood collected from own farmlands and forests. As many as 60% of households report fuelwood collection from own farmlands and 52% report fuelwood collection from forests. The average fuelwood consumption from forests is 29 kg/ week/hh, and the average fuelwood consumption from own farmlands is 32 kg/week/hh. Approximately 2 hours are spent per day in collecting fuelwood.

The collection of fuelwood is primarily a women's activity. In 78% of households, women take up primary responsibility for collection of fuelwood.

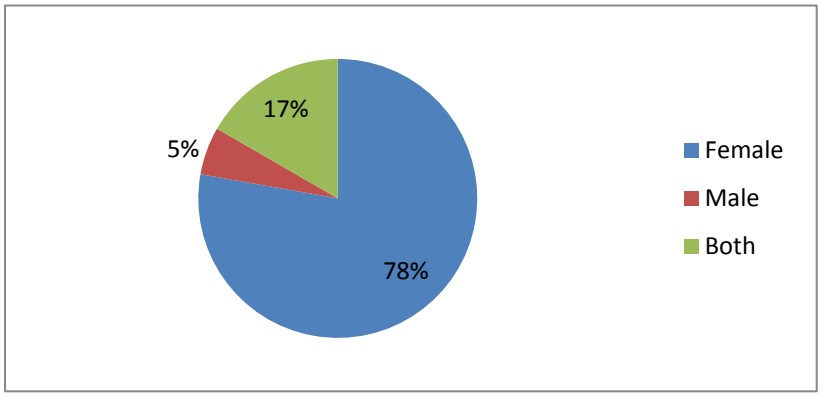


Figure 8.7 Collection of fuelwood (by gender)

An assessment of sustainability of fuelwood consumption from forests can be made based on the above ground biomass (AGB) estimated from our vegetation survey. The estimated AGB is 326.05 t/ha or 208020 t for the entire area under Jharkhali –III FPC (i.e. 638 ha). Assuming productivity of 3% p.a, the sustainable extractable biomass works out to 6241 t p.a. Assuming that 10% of this amount is the sustainable limit for fuelwood extraction, the sustainable limit works out to 624 t p.a. For a total 350 households, the annual fuelwood consumption is 29 kg/wk/hh * 350 hh * 52 wks = 528700 kg or 529 t (approx.). The current extraction pattern is therefore well within the sustainable limit.

There is no dependence on forests for fodder. 18% of households use agri-waste as fodder and the average consumption is 36 kg/week/hh. 22% of households take their livestock for open grazing in agricultural fields. Grazing is not permitted on forest land.

A few households report the collection of honey from the forest. However the quantity is negligible and no sale of honey on a regular basis is reported among the sampled households.

Indirect dependence on forests

The following section describes differential monetary losses on account of (avoided) damage to houses and property and (avoided) loss of agricultural production in the aftermath of Cyclone Aila that struck the region on May 27, 2009, causing extensive damage in the coastal region of India and Bangladesh. The reference period is 1999 when a super cyclonic storm struck the eastern coast of India.

Cyclone Aila was classified by the Indian Meteorological Department (IMD) as a Severe Cyclonic Storm (SCS) with an associated pressure deficit of 8.5 to 15.5 hectopascal and windspeed of 90-119 kmph. In the state of West Bengal, an estimated 1 million people were rendered homeless and at least 100 river embankments were breached by storm surge. However, significant damage was avoided in several parts of the Sundarban region where participatory approaches were used to protect the mangrove forest in the presence of active FPCs.

The indirect dependence on forests is captured through 'damage cost avoided' approach. The average distance of homestead land of respondents from the coast is 1.3 km and the average distance of agricultural land of respondents from the coastline is 1 km. The average distance of homestead land from the nearest mangrove forest is 0.8 km and the average distance of agricultural land from the nearest mangrove forest is 0.6 km.

The average monetary loss on account of damage to houses and property was Rs 54,545 per household or Rs 19090750 for all 350 households. There was total loss of agricultural production for up to three years for many households. Agricultural land remained submerged for 153 days on an average and homestead land remained submerged for 21 days on an average. However the degree of damage and associated monetary loss varied with distance from the mangrove forest.

A linear plot of distance from mangrove forest against the monetary value of house and property loss shows a positive relation between the two variables. The regression equation may be interpreted to mean that (other things being equal), households staying nearer to the mangrove forest suffered relatively less damage on this account. For each kilometre of reduced distance, the extent of damage went down by approximately Rs 14856 (27% of the average value). (See Figure 8.8)

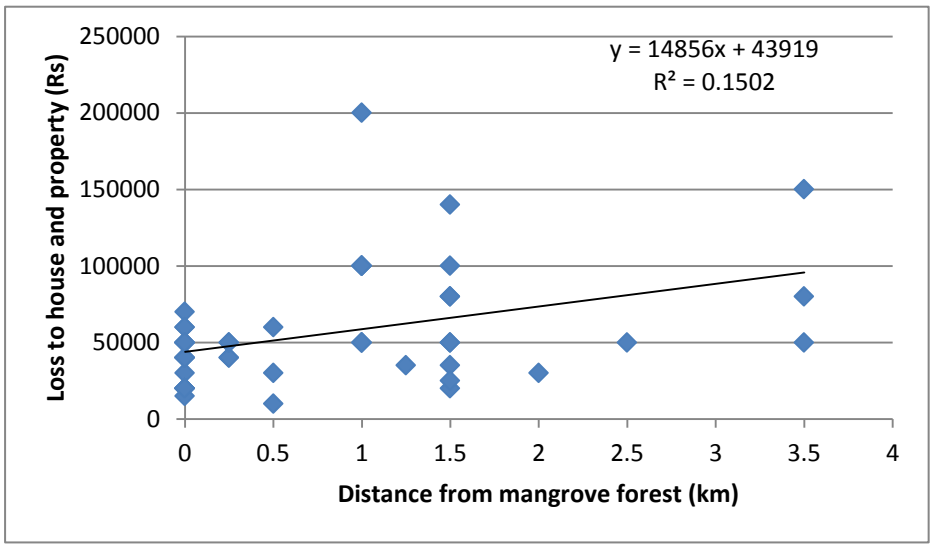


Figure 8.8 Loss to house/property against distance from mangrove forest

Institutional arrangements

The Forest Protection Committee (FPC) of Jharkhali –III was formed in 2004. The process of formation of FPCs in this Division started in 1997, and by 2004, FPCs were formed in almost all the Ranges. The FPCs have been named *"Ban-O-Bhumi Sanskar Sthhayee Samiti".*

As per the Resolution of the state government, the FPC members would need to protect the forest / plantation for at least five years to be eligible for the sharing of usufructory benefits when the crop attains the age of 15 years. 25% of the net sale proceeds at every final harvest would be paid to eligible members The members are also entitled to royalty-free collection of fallen twigs, grass, fruits, flowers and seeds without causing damage to forests/ plantations. One-fourth of the intermediate yield from coppicing, multiple shoot-cutting and thinning would also be shared with the FPC members. The entire collection of honey and bee-wax would be deposited with the Forest Department and the members would receive payments against their individual collections based on the approved tariff.

The members of the FPCs are normally economically backward people living in the vicinity of the forests concerned. However, every family living in the vicinity of the forests

concerned has the option of becoming a member of the FPC, provided the family members contribute to forest protection activities.

In case of Reserve Forests/ Protected Forests, there are no rights of any kind, though there is no restriction on fishing in the rivers and creeks interlacing the forests. All households surveyed were members of the FPC and 44% of them were also members of at least one Self-Help Group.

Net income from agriculture and fisheries

The principal crop of the region is paddy, and other important crops are dal, betel-leaf, sunflower and chilli. Vegetable cultivation is limited and restricted to a few households. The average annual production of paddy for farm households is 548 kg/year. The average landholding is 0.5 ha/ household and approximately 70% of the agricultural land is used for paddy so that on an average 0.35 ha of land is used for paddy cultivation by the average household. The productivity thus works out to about 1566 kg/ha which is slightly lower than the reported average productivity of the region under rainfed conditions - approximately 2000 kg/ha. The average expenditure is Rs 8803/yr/ha; this includes expenditure on fertilizer, hired labour and pesticides. Since agriculture is entirely rainfed, there is no expenditure on irrigation. Farmgate price of paddy is Rs 10, and the net return per year is estimated at Rs 6607/yr/ha.

The net return from agriculture is used to compute the value of the storm protection services of the mangrove forests. The loss of agricultural production and the corresponding monetary loss will be the indicator.

The agricultural production dropped to zero after the salt water inflow caused by the cyclone, and returned to near-normal values after three years. The loss of production over three years leads to a monetary loss of Rs 3210606.

About one-third of the households (approx. 120 households) are involved in fisheries. The annual average net income from fisheries is Rs 10,600 per household. The loss of income from fisheries is estimated as Rs 10,600 * 120 * 3 = Rs 3816000.

By the estimate in the previous section, 27% of the average value of the loss is reduced for each kilometer of reduced distance from the mangrove forest (or 13% for each 500 m of reduced distance). The following is the distribution of households in terms of distance of agricultural land from the mangrove forest:

Table 8.3 Distance of forest from agricultural land

Dist. from forest of agricultural field (km)	No of HH (Sample)	Total land holding (ha)
0 to 0.5	29	82.81
0.5 to 1	3	10.01
1 to 1.5	8	27.3
1.5 to 2	9	40.95
2 to 2.5	0	0

Dist. from forest of agricultural field (km)	No of HH (Sample)	Total land holding (ha)
2.5 above	1	0.91
Total	**50**	**161.98**

The total assumed loss for 161.98 ha of land is Rs 3210606, assuming total loss of agricultural production, and the estimated loss is Rs 494217, so that damage worth Rs 2716389 is avoided. This translates to avoided damage of Rs 4258 per hectare of forest.

The estimated total loss is presented below:

Table 8.4 Estimated loss on account of cyclone

Nature of loss	Amount (Rs)
House and property	19090750*
Agriculture	2716389**
Fisheries	3816000*
Total	25623139

***Represents total loss ** Represents differential loss (difference between assumed total loss and actual estimated loss) over three years**

Perceptions of environmental services

There is generally a high level of awareness on environmental services of mangrove forests. The following services received a relatively high ranking in terms of perceived benefits: Storm protection, recreation (bringing in more tourists), micro-climate (local improvement in air quality, mainly).

The process of FPC formation started relatively late in the region, and the FPCs in the Herobhanga Beat were formed as recently as 2004 (less than 10 years back). The formation of FPCs in the Division started in 1993 with Ramganga, Bhagatpur and Namkhana Ranges. The relatively late initiation of JFM in Herobhanga area is at least in part responsible for the limited awareness of the broader environmental benefits of mangrove forests. The primary dependence being on agriculture and fisheries, the mangrove forests of the region are valued for protective functions, especially in terms of loss avoided due to extreme events such as cyclonic storms. The Aila disaster of 2009 was relatively fresh in the memory of the respondents, and the significantly reduced damage as compared to previous storms was commonly perceived as a benefit of the forest. Interestingly, the reduced impact on households staying near the forest area was noted by several FPC members as an incentive for the strengthening of protection effort.

Carbon stock assessment

The methodology for estimation of carbon stocks (present i.e. 2012 and baseline i.e. 1990) is presented in the accompanying report "Carbon stock assessment for REDD plus pilot project sites in India", and is not being repeated here.

For the Sundarban (Herobhanga) site, 40 sample plots were laid each of size 20 m * 25 m. The location of the plots is shown below:

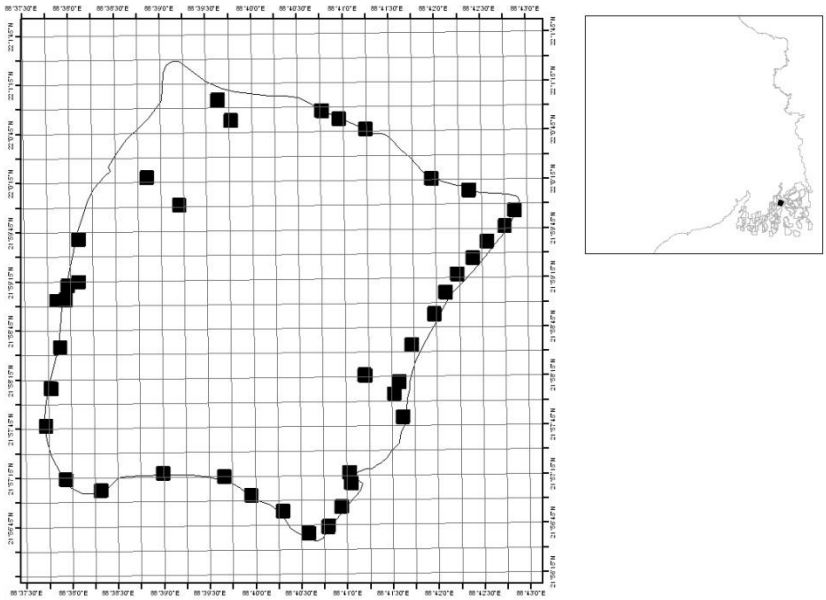


Figure 8.9 Location of sample points

Satellite imageries of the project area (1990 and 2012) are shown in the Figure 10 below:

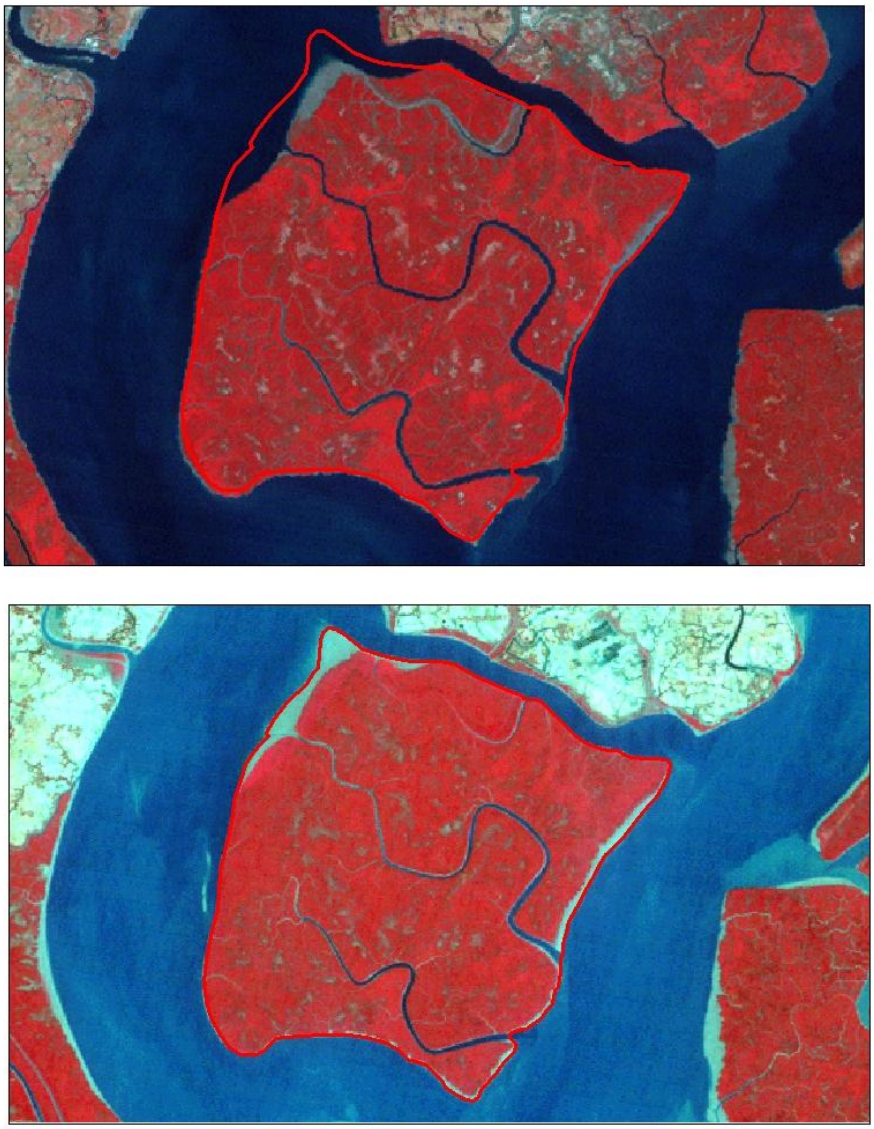


Figure 8.10 Satellite imageries of the project area (1990 (top) and 2012 (below))

The eligible carbon pools in the present context are Above Ground Tree Biomass (AGTB), Below Ground Tree Biomass (BGTB), Deadwood (DW), Leaf litter (LL) and Soil Organic Carbon (SOC).

The following table shows changes in AGTB and BGTB between the baseline and current period.

Table 8.5 Above and Below Ground Tree Biomass

	Baseline (1990) (t/ha)	Baseline (1990) Total (t)	Present (2012) (t/ha)	Present (2012) Total (t)	Change (t/ha)
AGTB	256.74	1134790.80	344.21	1521408.80	87.47
BGTB	69.31	306393.51	92.93	410780.21	23.61
Total	326.05	1441184	437.14	1932189	111.08

There is an increment of 87.47 t/ha in AGTB and an increment of 23.61 t/ha in BGTB, or a total increment of 111.08 t/ha, which is an increase of 34% over the baseline.

The table below shows the change in carbon values. There is an increment of about 50 t/ha over the baseline.

Deadwood biomass and leaf litter have not been considered in the area. As this is a swampy area, the quantity of such biomass is negligible.

Table 8.6 Carbon from Above and Below Ground Biomass

	Baseline (1990) (t/ha) Average (t/ha)	Baseline (1990) Total (t)	Present (2012) Average (t/ha)	Present (2012) Total (t)	Change of av. value (t/ha)
Carbon from AGTB	115.53	510655.86	154.89	684633.96	39.36
Carbon from BGTB	31.19	137877.08	41.82	184851.09	10.62
Total	146.72	648532.94	196.71	869485.05	49.99

Soil Organic Carbon (SOC) estimates for the project site (present period) are provided below:

Table 8.7 Soil Organic Carbon estimates

Depth (cm)	0-15	16-30	31-45
Soil Weight (t ha^{-1})	1800	3600	5400
Average Soil Carbon Percentage (%)	0.69	0.67	0.8
Soil Organic Carbon (tC ha^{-1})	12.36	11.68	19.28
Total Soil Organic Carbon (tC)	54631.2	51625.6	85217.6

Conclusions

It is evident that the Jharkhali FPC site (Herobhanga Beat) represents a situation where the direct dependence on forests is limited. There is some dependence for fuelwood but the consumption is well within the limits of sustainability, as computed based on existing standing biomass. The primary dependence on forests is on account of the storm protection functions, and the prevention / moderation of salt water inflow into agricultural fields and fishery ponds in the aftermath of extreme events. The Jharkhali – III FPC is protecting 638 ha of forests with a ban on grazing on forestland and substitution of fuelwood from forests by other sources including collection of fuelwood from own farmlands.

It may be noted that the benefits of such protective action flows outside the habitation zone of the FPC members. The storm protection function of the mangrove forests protects habitation and agriculture over several kilometers into the mainland.

In this scenario, the incentives for protecting mangrove forests in the vicinity by restricting fuelwood collection and regulation of benefits needs to be built around providing enhanced livelihood opportunities and the promotion of alternative sources of energy. Migration is a key feature of the area, and subsistence agriculture under rainfed conditions is clearly unable to provide a regular source of cash income. The cash income is approx. Rs 23000 per annum for the average household or less than Rs 5000 per capita per annum. The region is economically backward and subject to harsh natural conditions. With low cash incomes, temporary loss of agricultural production and loss of property causes further hardship to the members of the community as poor and vulnerable people typically have low coping capacities to external shocks.

The total damage avoided (on account of agricultural production alone) is estimated at Rs 2716389 over three years, or Rs 7761 per household (which is about a third of the annual cash income). It is therefore important that appropriate incentives be provided at the community level for the conservation effort that includes restriction of fuelwood collection and complete avoidance of grazing on forest land. As already mentioned the extraction of forest products is maintained within sustainable limits. Incentives for enhancing the conservation could take the following forms:

- Promotion of biogas and solar cookers as alternative sources of energy. At this point the primary dependence is on kerosene with average consumption of 4 l / month for a family, apart from fuelwood collection from own farmlands.
- Arrangements for adequate insurance against crop damage due to unforeseen events, especially for the poorer households. The average landholding being low (96% of farmers are marginal) and agricultural being a subsistence activity, such arrangements will enhance the coping capacities of FPC members.
- Promotion of organized honey collection. In the study area, honey is collected at the individual level, and there exists a possibility of organizing group-level activities at a small scale.

In summary, the Sundarban example illustrates a case where the protective functions of forests is dominant, and recognized notionally by the members of the FPC. However there is a global/ regional benefit of this effort in terms of carbon stock enhancement as well as moderation of the impact of cyclonic storms.

As the data above shows, there is an increment of carbon stock (in 2012) of 50 t/ha over the baseline (1990). This is clearly a global benefit on account of local conservation effort.

Likewise, there is clearly a global / regional benefit in terms of enhanced protective functions of forests. There is a reduction of loss to house/property of Rs 15000 (approx.)/ hh for each km of reduced distance from the forest; there is also avoided damage of Rs 7761 / hh on account of agricultural production. There are tangible benefits of local conservation effort, which are (also) enjoyed over a larger geographical scale; that is by people who are not members of the Jharkhali –III FPC. There is therefore a strong case for using the existing institutional mechanism to route incentives as suggested to sustain and enhance the conservation effort.

Chapter 9 Conclusion

Reducing Emissions from Deforestation and Forest Degradation (REDD) is a global endeavour to incentivize developing countries to protect, sustainably manage, conserve and develop their forests resource and thereby, contribute to the global fight against climate change. REDD+ goes beyond checking deforestation and forest degradation, and includes incentives for ecosystem services, biodiversity conservation, sustainable forest management, and enhancement of carbon stocks. It has specifically opened up the possibilities for countries like India to expect compensation for its pro-conservation approach and sustainable forest management. However, at this stage, there is no strategy formulated by the Government of India to formalize the concept of REDD+. The formulation of national strategy is in process at the level of Ministry of Environment and Forests. After the decisions taken at COP-19 with respect to REDD+, the developing countries can obtain result based financed through REDD+ mechanism , and also obtain finance for readiness for REDD+ provided drivers of deforestation and forest degradation are addressed and appropriate national monitoring system is in place as per the guidelines agreed at UNFCCC level. . However, the REDD+ concept has to be implemented in India keeping national policies and constitutional provisions into consideration. Importantly, India has to take many safeguards such as recognition of forest rights, strengthening community based-forest governance, maintenance of livelihoods of the people living in and around forests and maintenance of ecosystem services while implementing REDD+.

The present study has attempted to develop a broad methodology for REDD+ implementation potentially at the sub-national level by carrying out comprehensive assessment at five pilot sites. The five sites were selected to represent varying geographical and socio-economic contexts. Assessments in these sites were meant to provide concrete guidance towards development of a REDD+ methodology that is suited or can be adapted to different contexts.

The five pilot sites, namely Gardarwa Forest Block (Renukoot Forest Division, UP), Delakhari Forest Block (West Chhindwara Forest Division, MP) Jarapada Beat (Angul Forest Division, Odisha), Magra Forest Block -5 (Mussourie Forest Division, Uttarakhand) and Herobhanga Beat (24 Parganas South Forest Division WB) were selected for the assessment. Carbon stock assessment and an analysis of forest dependence were conducted in the sites. In addition, estimates of the degree of (un)sustainable extraction of forest resources was also generated.

In Renukoot, the forest has been degraded due to unsustainable harvest of fuel wood, fodder and minor forest produce. There are many constraints for the villagers such as poor agricultural production, no other source of livelihood except forests, poor public distribution system, and illiteracy resulting in large dependence on fuel wood extraction for sale which is highly unsustainable and a cause of forest degradation. There is a need to restrict the harvest of forest produce within a sustainable limit which, in this case, is 203 tonnes of fodder and 69 tonnes of fuel wood annually from 77 hectare of forest. The forest degradation could be checked if livelihood is substituted by involving the community in tusser cultivation, value addition of MFPs, providing livelihood through MNREGA, construction of a small dam for the collection of rain water and also improving the public distribution system of food grains.

In Mussooriee Forest Division, two villages namely Raton ki Beli (122 households) and Jhalki (14 households) are dependent on the selected forest compartment for fodder leaves,

grass and fuelwood. The harvest of fuel wood and fodder is unsustainable. The sustainable limit for fodder leaves is 59.4 tonnes per year while extraction is 284.5 tonnes; this amounts to unsustainable harvest of 225.1 tonnes of oak leaves per year. This adversely impacts the productivity and causes degradation. The extraction of fuelwood is 156 tonnes while the sustainable limit to extract fuel wood is only 54 tonnes per year. There is unsustainable harvest of 102 tonnes of fuel wood which leads to forest degradation and adversely impacts the productivity. The grazing and harvest of grasses is well within the sustainable limit of 131 tonnes per year. To check the over extraction of fuelwood from the forests, 28 households (other than the present 41 households) have been suggested to completely shift to LPG consumption. Also, green cook stoves can be distributed amongst the villagers in collaboration with the Uttarakhand Forest Department. The use of alternative sources of energy such as solar energy and biogas may further help villagers to limit the harvest of fuelwood. The unsustainable harvest of Oak leaves is due to the livelihood dependence through milk production. Enhancing awareness amongst the villagers and also providing other sources of income would help in reducing the unsustainable harvest of Oak leaves. Better public distribution of food grains and improvement in agricultural practices would further enhance the possibility of other sources of income which would help villagers to keep harvest of Oak leaves under sustainable limit. Grazing and harvest of grasses are under sustainable limit.

In Angul Forest Division(Odisha) , a pilot site in Jerang Budhi Pahad village has been taken which has dependence of 116 households on fuel wood (100%), fodder(52%) , bamboo (84%) and minor forest produce (93%). The sustainable limit from the pilot site has been estimated at 626 tonnes per year for fuel-wood and 168 tonnes for fodder. The harvest of fuel wood and fodder is 157 tonnes and 159 tonnes respectively which are well within sustainable limit. The harvest of bamboo and other minor forest produce is also well within sustainable limit. Villagers harvest the forest produce largely for their consumption, rarely for sale, particularly minor forest produce.

A pilot site in Compartment No. 164 (162.33 ha) and Compartment No.165 (341.84 ha) in Delakhari Forest Beat from the Delakhari Forest Range of West Chhindwara Forest Division (MP) was taken up for assessment . The site is associated with Anjandhana and Khatuadhana villages. The villagers have dependence on forests for fuel wood, fodder and minor forest produce such as Achar *(*Buchanania lanzan), Mahua (Madhuca indica), Sal seeds (Shorea robusta), tendu patta (Diospyros melanoxylon). The quantities of collection of MFPs are 5838 kg of Mahua flowers, 837 kg of Achar seeds and 33906 bundles of Tendu patta; these are been harvested from the 504 hectare of forests . The sustainable limit are as follows: Achar seed 586 kgs, Mahua flower 5838 kgs and tendu patta 23734 bundles. The villagers are harvesting minor forest produce unsustainably, and also with unsustainable techniques. The sustainable limit for fuel-wood is 31 tonnes while harvest by villagers is 175 tonnes. There is unsustainable harvest of 144 tonnes of fuel-wood which is largely due to inefficient use of fuel wood for their energy requirement. The fodder harvest and grazing are well within sustainable limit. The villagers largely depend for their income on agriculture and minor forest produce. The efficient use of fuel wood and harvest of minor forest produce within sustainable limit along with use of sustainable techniques will definitely improve the quality of forests and enhance the carbon stock. Notably, individual and community forest rights under Forest Rights Act, 2006 have been recognized at this site..

A pilot site, Herobhanga 4-8, having area of 4420 hectare in Sundarbans (24 Parganas South Forest Division) was taken up to assess REDD Plus issues in the context of coastal mangrove

forests. The socioeconomic survey indicates that the people are depending on mangrove forests largely for protective services and to some extent for fuel wood to some extent. There is no dependence for fodder and grasses. The mode of forest governance is through Joint forest Management. The Forest Protection Committees in Herobhanga were established in 2004. Jharkhali – III FPC was chosen for socio-economic assessment as the dependence of FPC members were found to be representative of the overall dependence pattern in Herobhanga. The sustainable limit for fuel wood is 624.1 t p.a. and total extraction of fuel wood is 528.7 t p.a. which is well within sustainable limit. Some of the households collect honey from the forests. The most important contribution is towards protective service (storm protection) which is estimated at Rs.7761 per annum (which is about 1/3 of the average total income of the household). The value for the protective service has been estimated with the help of Damaged Cost Avoided methodology. Since there is enhancement of 50 t p.a. per hectare carbon stock (in 2012) over the baseline (1990), this is a potential site for implementing REDD+ as well as for trading carbon in the voluntary market.

Five pools of carbon have been taken as parameters for the assessment of carbon stock and changes therein . The year 1990 has been taken as base year and above ground biomass for this year has been estimated on the basis of satellite imageries. A major reason for choice of this base year is the fact that broadly speaking, SFM started getting implemented from 1990 as mandated in the National Forest Policy, 1988. Overall net increase in the Carbon from AGTB and BGTB from all the five pilot project sites is 29582.97 tons of Carbon which is equivalent to 108569.50 tons CERs. The net increment from the baseline year to the present project year is around 44%. In Angul, there is a total 1619 ton of carbon increase, which is around 9.8% from the baseline year. In Chhindwara total net increment is 25765 tons of Carbon, which is around 85.3% from the baseline year. Similarly, in Renukoot total net increment is around 2345 tons of Carbon, which is around 75.68% from the baseline year. In Sundarbans, there is net gain of 491005 tons of carbon which is a 34% increase over the baseline. . In case of Mussoorie the change is in negative and there is total net decrease of 146 tons of Carbon from the baseline year, which is around 1% from the baseline year. For the purpose of estimating carbon stock in 2012 over baseline of 1990, only AGB and BGB have been considered. The soil carbon , leaf litter and dead-wood carbon cannot be estimated with retrospective effect, and moreover, the amounts are relatively less as compared to AGB and BGB. The details of the net change of Carbon in all the five pilot sites are provided in following table.

Table 9.1 Carbon Stock changes

Project site	Area (ha)	1990 (t/ha)	2012 (t/ha)	Change (t/ha)	Change (%)
Angul	200	83	91	8	10
Chhindwara	504	60	111	51	85
Mussourie	95	175	173	-2	-1
Renukoot	77	40	71	31	76
Sunderban	4420	147	197	50	34

The most important outcome of the study is that carbon stocks in Renukoot, Chhindwara , Angul and Sundarbans have been enhanced substantially while there is a slight decrease in Mussoorie. This decrease is due to unsustainable lopping of Oak trees for fodder requirement.

The following are some major observations based on the study:

1. The rights of the community on forests must be respected as the rights under FRA have been assigned in Renukoot, Chhindwara and Angul while in Mussoorie, rights have been assigned through Van Panchayat.
2. The forest dependent communities are heavily dependent on forests for their livelihood and subsistence needs and are causing degradation due to unsustainable harvest of fuel wood, fodder and MFP in a majority of situations.
3. Forests cannot bear the load of livelihood of all members of the forest- dependent community. There is a need to provide alternative livelihood options through convergence of other schemes of rural development to maintain the harvest of forest produce within sustainable limit.
4. Since there is no documentation regarding quantification of sustainable limit of forest produce, there is need to quantify the sustainable limit of MFPs in the working plans /micro plans.
5. The capacity of the community is to be built with respect of methodology and techniques of biomass assessment. The GIS and remote-sensing support must be provided by the State forest Department.
6. The forest governance model is to be synchronized with the provisions of the Forest Rights Act, 2006. The Forest Department should provide technical and legal support to the JFMC/CFMC while implementation and benefit-sharing should be done solely by the community.
7. Since four out of five sites have shown a positive trend with respect to enhancement in the carbon stock, there is potential of trading of enhanced carbon. The carbon may be traded through voluntary market mechanism. Development of Project Design Documents under REDD+ methodology of VCS may be explored for the trading of additional carbon.
8. The existing institutional mechanism should be strengthened with respect to Monitoring, Reporting and Verification (MRV) and wherever possible, capacities should be built at the community level.

Some key recommendations for the furtherance of the REDD+ concept are as follows:

1. The Government of India should go for a national level decision to reduce the carbon emissions by the corporate sector. There is need to establish authority at national level for achieving emission reduction targets. It could be achieved to some extent through REDD+.
2. The CSR funding could be explored under the umbrella of emission reduction to support livelihood opportunities of forest dependent communities and ecosystem services.

3. The biomass assessment, estimation of actual harvest of forest produce and quantification of sustainable limit of the forest produce should be part of Working Plan preparation exercise so that updated information will be available at ten year intervals.

India has diverse forest ecosystems across the country ranging from temperate in the Himalayas, tropical in the central India, desert in western part of the country and mangrove forests in the coastal areas of the country. Due to resource constraints, only five pilots have been taken which represent temperate, tropical and mangrove forest ecosystems. The quantification of sustainable harvest is not available in the secondary literature. Not much research has been done to quantify the sustainable quantity of minor forest produce in particular. More research is needed on this aspect. The quantification of sustainable harvest of minor forest produce has been done on the basis of primary data, discussion with the community and front line staff and available information in the respective Working Plans. There is also a need to consider carbon sequestered by phytoplanktons in mangrove forests but this could not be done due to financial and time constraints.

In the post COP-19 regime, developing countries can obtain result based finance through the REDD+ mechanism provided drivers of deforestation and forest degradation are addressed, safeguards such as rights of the forest dependent communities are taken care of, and national monitoring systems as per UNFCCC guidelines is in place. These five pilots deal with several of these issues. The outcomes of the pilots also indicate that Indian forests have potential of obtaining finance from REDD+ provided some gaps are addressed and efforts are made to build the capacity of the Forest Department and communities. Indian forests also have a potential in India for obtaining finance from voluntary markets, and projects could be designed by using under approved methodology under VCS (Voluntary Carbon Standard) so that finance could be obtained thorough sale of CERs.