

Special Publication



Biodiversity Monitoring Protocol for REDD+



REDD Implementation Centre
Ministry of Forests and Environment
Government of Nepal

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Biodiversity Monitoring Protocol for REDD+

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Ministry of Forests and Environment

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Foreword

Nepal has made significant progress in biodiversity conservation through conservation friendly policies and enormous efforts in the management of its natural resources. Conservation of these resources is vital to maintain ecosystem health, as well as to ensure continuous provisioning of services and goods. Nepal has extended its priorities to cope with climate change effects and capture the benefits available in the global arena through REDD+ implementation. While the monetary benefits that could be realized from REDD+ projects could be substantial, the effect on biodiversity is dubious, with the possibility of negative impacts when the focus is on maximization of carbon sequestration. Additionally, maintenance and enhancement of biodiversity for REDD+ projects as co-benefits have the potential to make a value addition to the carbon that could be traded.

The importance of biodiversity conservation has been realized by the government of Nepal, which has made significant progress in species and ecosystem conservation in and outside protected areas. While robust and diverse monitoring methods have been used by researchers and related stakeholders in biodiversity conservation in Nepal, such methods and processes might be too vague and complex for REDD+ project proponents. Thus, there is a need for a document that guides REDD+ project proponents to ensure that REDD+ project activities have positive impacts on biodiversity and that they do not compromise the rights of the communities to continuously receive service and goods available from the use of such resources.

This "Biodiversity Monitoring Protocol for REDD+" will help to fill that gap in the REDD+ project implementation in Nepal. It will guide REDD+ project proponents to choose appropriate methods, criteria, and indicators for carrying out biodiversity monitoring. I would like to thank the DNPWC, NTNC, and ICIMOD for their efforts to produce this valuable book. We are proud to have this opportunity to authorize this protocol for biodiversity monitoring in REDD+ projects in Nepal.

Bishwa Nath Oli, PhD

Secretary

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Acknowledgements

Nepal has made significant progress in REDD+ readiness phase and is soon going to implement the Emissions Reduction Program in thirteen districts of Terai Arc Landscape in Terai region. While implementing the program, there is an immediate need to ensure that the REDD+ program will not have detrimental impacts to the biodiversity and the local people. In this regard, the Biodiversity Monitoring Protocol (BMP) for REDD+ will be instrumental for guiding the project proponent to choose appropriate methodology, as well as formulating criteria's and indicators while preparing the baseline of the biodiversity of the project area. In addition, it will help in reassessing the changes in the biodiversity after the implementation of REDD+ activities.

REDD Implementation Centre (RIC) and Department of National Parks and Wildlife Conservation (DNPWC) took the initiative to prepare the BMP for REDD+ in Nepal. I would like to thank National Trust for Nature Conservation (NTNC) and International Center for Integrated Mountain Development (ICIMOD) for providing technical and financial support in preparing BMP for REDD+. The steering committee members and advisory committee members who were involved in preparation of this protocol also deserve special recognition for their efforts.

I would like to extend a special thanks to Sindhu Dhungana, Yam Pokharel, Mohan Poudel, Amir Maharjan, Ajay Manandhar, Hari Laudari, and Kalpana Dhakal from the Ministry of Forests and Environment for their valuable contribution. I would also like to express my gratitude to Bhaskar Singh Karki, Nabin Bhattarai, Pradyumna JB Rana and Trilochana Basnett from ICIMOD and Rajan Poudel, Megh Dhoj Adhikari and Shyam Thapa from NTNC for overall support and shaping this document in good form. A special thanks goes to Santosh Bhattarai, Ashish Gurung, Shashank Poudel, Purna Lama, Binod Darai, Ramesh Darai and Kiran Thakuri of NTNC for their kind support in the field.

The completion of this protocol would not have been possible without the support from DNPWC, NTNC, and Biodiversity Conservation Center, Chitwan and Parsa Conservation Programme. Similarly, the contribution from Forest Research and Training Centre, Department of Forests and Soil Conservation, and Department of Plant Resources to finalize this document is also highly appreciated.

Finally, all the reviewers and experts are valued for shaping the document in this form with their technical inputs.



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Acronyms and Abbreviations

ANSAB	Asian Network for Sustainable Agriculture and Bio-resources
CBD	Convention on Biological Diversity
CC	Climate Change
CCB	Climate, Community, and Biodiversity
CCSP	Concentric Circular Sample Plots
CER	Certified Emission Reduction
CF	Community Forest
CITES	Convention on International Trade in Endangered Species
CO ₂	Carbon Dioxide
CWD	Coarse Woody Debris
DFRS	Department of Forest Research and Survey
DGPS	Differential Global Positioning System
DNPWC	Department of National Parks and Wildlife Conservation
DoF	Department of Forests
DoFSC	Department of Forests and Soil Conservation
DPR	Department of Plant Resources
ES	Ecosystem Services
FRTC	Forest Research and Training Centre
FUGs	Forest User Groups
GHG	Greenhouse Gas
GPS	Global Positioning System
HCVF	High Conservation Value Forest
ICIMOD	International Centre for Integrated Mountain Development
MEA	Multilateral Environment Agreement
MRV	Monitoring, Reporting, and Verification
NHPL	National Herbarium and Plant Laboratories
NTNC	National Trust for Nature Conservation
PA _s	Protected Areas
QA/QC	Quality Assurance/Quality Control
REDD	Reducing Emissions from Deforestation and Forest Degradation
RIC	REDD+ Implementation Center
SDG	Sustainable Development Goals
SIR	Scale, Intensity, and Risk
Spp.	Species
TAL	Tarai Arc Landscape
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework for Climate Change Convention
VHF	Very High Frequency

Executive Summary

Biodiversity monitoring protocol for REDD+ has been developed to help project proponents, policy makers, and those responsible for the design and implementation of biodiversity monitoring and land-based carbon projects implement cost-effective biodiversity assessments. The biodiversity monitoring protocol for REDD+ can help to achieve the targets and standards, and compliance with international conventions, donor agencies, investors, and other stakeholders in REDD+. In addition, implementation of this protocol will contribute to the avoidance of negative impacts on biodiversity conservation, as recognized in the Cancun Safeguards at the 2010 UNFCCC meeting, to meet the multiple-benefit standards as suggested by the Climate, Community & Biodiversity (CCB) Standards. Additionally, this will also promote and strengthen coordination between UNFCCC and CBD, which will ultimately lead to the implementation of the Multi-lateral Environmental Agreement (MEA), including Rio Conventions, on the ground.

A strategic aim of REDD+ activities is to reduce the risk of biodiversity depletion through prioritization of sites with both high carbon value and high biodiversity benefit. To assess priority sites for conservation, one would ideally obtain biodiversity measures assessing the species richness (total number of species), species diversity (type of species), and population sizes of all species present at the site. In order to help attain this information, this document provides a variety of methods, tools, and assessment at multiple points.

This protocol has been prepared in the simplest of formats to cater to all kinds of stakeholders, and it contains all the tools necessary for biodiversity monitoring, covering all taxonomic groups and the selection of sampling sites. This protocol will help to generate temporal and spatial data/information on the patterns, processes, and trends of biological resources, which can be used to inform resource managers, policy and decision makers, community members, and other stakeholders.

Chapter 1: Introduction

Background

REDD+ is a policy aimed at reversing the historic trends of increasing deforestation and greenhouse gas emissions from forested landscapes. It is one instrument under the UNFCCC as a climate change mitigation mechanism in which developing countries can participate voluntarily. This instrument is based on an incentive mechanism where developing countries receive financial payments for undertaking any one or as combination of the following activities (1/CP.16, paragraph 70):

- Reducing emissions from deforestation;
- Reducing emissions from forest degradation;
- Conservation of forest carbon stocks;
- Sustainable management of forests;
- Enhancement of forest carbon stocks.

Due to the nature of the REDD activities, there is a need to harmonize the three multi-lateral environment agreements of the Rio Convention, namely UNFCCC, CBD, and UNCCD. All land-based activities must contribute to fulfilling the goals set out by these global conventions. REDD+ offers expectations for biodiversity conservation, as a co-benefit of protecting forests to reduce carbon emissions (Strassburg et al. 2010; Venter et al. 2009). Nepal, in its submission to UNFCCC in March 2013, recognized the following non-carbon benefits when REDD+ activities are implemented with safeguards:

- Enhancement of local livelihoods;
- Increase in the value of biodiversity;
- Better ecosystem services to people and the environment;
- More resilient ecosystems for climate change adaptation;
- Improved governance, institutional setup, and policies for natural resource management at local and national levels;
- Contributions to MEAs.

In reality, biodiversity conservation and forest resource management are core activities, and benefits generated from reduced CO₂ emission have come up as co-benefits. Although the anticipated impact of REDD+ on biodiversity conservation in most forests is positive, such an impact cannot be guaranteed. Poorly designed REDD+ efforts. For example, projects focusing solely on carbon for obtaining Certified Emission Reduction (CER) credits could damage forest biodiversity, and in the process threaten the continued provision of ecosystem services for human well-being (CBD 2011). Indeed, the impact of REDD+ on biodiversity conservation could potentially be negative if low-carbon, high-biodiversity forests are replaced with high-carbon, low-biodiversity forests, or if the protection of high-carbon forests in one area leads to

the displacement of threats to other, more bio-diverse, forests (Miles and Kapos 2008; Paoli et al. 2010; Strassburg et al. 2010). Similarly, REDD can also produce other disparities in equitable benefit sharing and restrictions in the rights of local communities. Thus, biodiversity monitoring programs are clearly needed to constitute an essential component of REDD+ and ensure that the impacts of emission reduction activities on biodiversity are positive, rather than negative (CCBA 2013; Gardner et al. 2011). The Paris Agreement also acknowledges under article 5/6 that integrating biodiversity monitoring into REDD+ facilitates compliance with the “Cancún Safeguards” stipulated by the UNFCCC to exclude environmental risks (Schmitt, 2014) and provides an opportunity to further enhance the Aichi targets stipulated by CBD (Panfil, S.N. and Harvey 2014).

Similarly, implementing REDD+ also fulfills the indicators outlined under Goals 13 and 15 of the 2030 SDG. Additionally, under the UNCCD, five Strategic Objectives relate to the interventions in REDD+.

Table 1: Linkage between Multi-Lateral Environment Agreements and REDD+

Multilateral Environment Agreements	Targets/Description related to REDD+
United Nations Framework Convention Climate Change: Cancun Safeguards	<p>Parties to the UNFCCC agreed at the 2010 climate talks in Cancún to promote and support seven REDD+ social and environmental safeguards (UNFCCC (2011) FCCC/CP/2010/7/Add.1: 1–31). These so-called “Cancún Safeguards” are a set of basic principles to help guide REDD+ implementation and ensure that REDD+ “does no harm to people and the environment” (Latham et al. 2014).</p> <p><i>Cancun safeguards (UNFCCC Decision 1/CP.16) relevant to biodiversity</i></p> <ul style="list-style-type: none"> • Consistency with objectives of national forest programmes and relevant international conventions and agreements; • Conservation of natural forests and biological diversity and enhancement of other social and environmental benefits; • Actions to address the risks of reversals; • Actions to reduce the displacement of emissions.
United Nations Convention on Biological Diversity: Aichi Biodiversity Targets	<p>CBD also sees the direct linkages with REDD+ in several ways, as shown below with specific reference to Aichi Biodiversity Targets (Panfil, S.N. and Harvey 2014)</p> <p><i>Aichi Biodiversity Targets relevant to REDD+</i></p> <p>Target 5: rate of forest loss is at least halved and where feasible brought close to zero degradation, and fragmentation significantly reduced</p> <p>Target 7: areas under agriculture, aquaculture, and forestry are managed sustainably, ensuring conservation of biodiversity</p> <p>Target 11: at least 17 percent of terrestrial...areas..., especially areas of particular importance for biodiversity and ecosystem services, are conserved through... systems of protected areas and other effective area-based conservation measures</p> <p>Target 14: ecosystems that provide essential services...are restored and safeguarded, taking into account the needs of women, indigenous, and local communities...</p> <p>Target 15: ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced through conservation and restoration, including restoration of at least 15 percent of degraded ecosystems.</p>

Multilateral Environment Agreements	Targets/Description related to REDD+
United Nations Convention to Combat Desertification	<p>Under the UNCCD, the future strategic framework of the Convention, there are five Strategic Objectives related to the interventions in REDD+.</p> <p>Strategic Objective 1: To improve the condition of affected ecosystems, combat desertification/land degradation, promote sustainable land management and contribute to land degradation neutrality</p> <p>Strategic Objective 2: To improve the living conditions of affected populations</p> <p>Strategic Objective 3: To mitigate, adapt to, and manage the effects of drought in order to enhance resilience of vulnerable populations and ecosystems</p> <p>Strategic Objective 4: To generate global environmental benefits through effective implementation of the UNCCD</p> <p>Strategic Objective 5: To mobilize substantial and additional financial and non-financial resources to support the implementation of the Convention by building effective partnerships at global and national level</p>
2030 Sustainable Development Goals	<p>There are two 2030 SDG directly related to forests and REDD+.</p> <p>Goal 13: Take urgent action to combat climate change and its impacts</p> <p>Goal 15: Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.</p>

Scope of Biodiversity Monitoring Protocol for REDD+

Cancun Safeguard principles recognize the need to address biodiversity conservation; however, none of the standards currently proposed includes significant guidance on biodiversity monitoring. There is a need for a rigorous framework and protocol to ensure that the biodiversity concerns are incorporated into national REDD+ programmes. It is imperative that the goals of biodiversity conservation be met with appropriate regard to well-established ecological principles and experiences (Gardner et al., 2011; Waldon et al., 2011) based on the national circumstances.

REDD+ has the potential to benefit biodiversity, but there are also several potential risks (see Box 1). Monitoring the change in biodiversity due to implementation of REDD+ can help ensure that risks are mitigated and benefits achieved (RIC 2016). Additionally, the results of monitoring may help in demonstrating compliance with international conventions and agreements.

Though a few biodiversity monitoring manuals and protocols (e.g., NTNC 2005) and some species-specific protocols, action plans, and protocols are available in Nepal, the protocol for biodiversity monitoring in relation to REDD+ has not been developed yet. In addition, existing documents do not provide clear methodological guidance for REDD+ projects proponents to meet CCB standards or other multiple benefit standards. Lack of this kind of protocol is a key factor constraining the adoption of good practices, especially given that many REDD+ project proponents are not specialists in biodiversity assessment. As most REDD+ projects are

Box 1: Potential benefits and risks to biodiversity from implementing REDD+ activities

Benefits	Risks
Reducing deforestation, forest degradation, and conservation of forest carbon stocks	
Retain the existing biodiversity and ecosystem services of the remaining forest and reduce pressures on biodiversity that are associated with fragmentation and loss of forest area. Decreasing degradation can reduce pressures on forest resources so that forest biodiversity and ecosystem services may recover.	Displace conversion and extractive use pressures on lower carbon forests and non-forest ecosystems due to continuing need for the production of food crops, pasture, or biofuel, negatively impacting the biodiversity and ecosystem services these areas provide. Management activities could have unintended impacts (e.g., fire control could impede natural disturbance processes).
Sustainable management of forests	
Contribute to ensuring the long-term maintenance of forest resources that are already in use; e.g., by controlling where timber can be extracted and in what quantity.	Depends on the definition of sustainable use, which is not yet characterized in detail by the parties to the UNFCCC. REDD+ revenues rewarding this activity could promote harvesting in unlogged areas.
Enhancement of forest carbon stocks (afforestation, reforestation, and forest restoration)	
Great potential, e.g., by increasing the connectivity between areas of intact forest or by reducing pressure on existing forest by providing alternative sources of wood products.	Could result in low biodiversity and impact ecosystem functioning, and promote the spread of invasive species if monoculture plantations, non-native species, and unsustainable high inputs (e.g., water, fertilizer, etc.) are used; can harm important non-forest biodiversity and ecosystem services if implemented in places not previously forested.

Source: SCBD 2011

implemented at the landscape level, the focus of this protocol has been more on the Tarai Arc Landscape (TAL) of Nepal, which has the potential to secure funding from REDD+ projects. TAL has one of the most productive forests, along with high biodiversity, within Nepal. This landscape has been the focus of the government for the REDD program, and an Emission Reduction Program Document is being prepared for this landscape. Accordingly, this protocol has been prepared with a focus on this landscape; however, this protocol can be customized for other landscapes.

Thus, monitoring biodiversity as such becomes a very vague and complex process that is further restricted by limited resources, including finances, human resources, and time. Prioritization of what to monitor using which method in any landscape is essential. The following section provides general ideas on the process of prioritization and setting criteria and indicators for biodiversity monitoring.

Prioritizing the Levels of Biodiversity Monitoring

The term biodiversity includes all the biological forms and thus monitoring of biodiversity can become a challenging task unless areas of interest are identified. Identification and classification of forests according to their conservation value can be a first step for prioritization of the biodiversity monitoring activities. The conservation value of the forest can be accessed using secondary sources, literature, and survey data, particularly the

environmental and socioeconomic baseline survey, and can then be classified into six specific forest values as adopted by the Forest Stewardship Council (Annex 4). Identification and categorization of the sites as HCVF (High Conservation Value Forest) should be done with adequate expert and field consultation as needed. The following table (Gaines et al., 1999) shows the area of interest and key priorities at different levels of biodiversity that should be kept in mind during biodiversity monitoring for REDD+.

Table 2: Priorities for Biodiversity monitoring at different levels

Biodiversity Level	Area of Interest	Key Priorities
Landscape Level	<ul style="list-style-type: none"> • Identity, distribution, and proportions of each type • of habitat; trends and distribution of species within those habitats • Landscape diversity, connectivity, and fragmentation • Disturbance, energy flow, geomorphic, hydrologic process and land-use changes 	<ul style="list-style-type: none"> • Biodiversity hotspots, corridors, and connectivity • Rare or threatened habitats (globally, regionally, nationally) • Features of high socioeconomic and cultural importance (e.g., grazing lands, touristic landscapes, sacred areas) • Climate refugia (macro-refugia and micro-refugia)
Ecosystem level	<ul style="list-style-type: none"> • Richness, evenness, and diversity of communities' species, and guilds • Distribution of key physical and biological features • Response to disturbance 	<ul style="list-style-type: none"> • Rare, threatened, and critical habitats (regionally, nationally, locally) • Habitats of specific importance (e.g., large, highly natural forest) • Specific species community • Forest cover dynamics • Biomass productivity
Species level	<ul style="list-style-type: none"> • Abundance, density, and biomass of each population • Population dynamics • Dispersion/Migration • Regeneration and Growth 	<ul style="list-style-type: none"> • Globally threatened species (i.e., on IUCN Red Lists) • Significant populations of rare, endemic, or otherwise nationally or regionally threatened species • Faunal species, specific plants
Genetic Level	<ul style="list-style-type: none"> • Genetic diversity of individual organisms within a population • Genes of special importance 	<ul style="list-style-type: none"> • Endemic species • Rare and threatened species • Species with low populations • Characteristic Species

Source: adopted from: Gaines et al., 1999

Chapter 2: Biodiversity Monitoring Approach

Remote Sensing and Geographic Information Systems

Recent years have seen an increased use of remote sensing and geographic information systems for planning and executing projects in natural resource management. This tool can be used to gather preliminary information about the study area and layout of the study plots. Supervised classification of the images that involves a mixture of remotely sensed data and field data is one of the widely used methods to lay out permanent study plots and classify the land use. RS and GIS can be deployed to demarcate ecological zones, forest types, and species distribution.

Images captured over different times can be used to detect land use changes such as the increase or decrease in forest area over time. Information on vegetation change, wildlife population, their habitats and movements, combined with the remotely sensed data, can provide useful information for long-term research. Additionally, use of tracking collars for wildlife has also proven to be a very effective tool for monitoring their movements and behaviors. It provides clues to their home range sizes, daily movements, behavior, and diet. In particular, Very High Frequency (VHF) collars and Global Positioning System (GPS) collars have been used in Nepal. Conservation drones -- miniature unmanned aircraft -- can also be used to remotely capture real time images and videos for monitoring species and habitat.

Participatory Biodiversity Monitoring

Rapid assessment of biodiversity can be made using tools like Participatory Mapping, transect walk, focus group discussion, key informant surveys, enterprise and forest user groups' records, photo monitoring, and documentation of traditional knowledge. This is an effective method that engages stakeholders at various levels and which can provide local knowledge on the status of biodiversity and their distribution in the area. A checklist of species and maps of their possible distribution can be prepared to establish the knowledge on existing species, and photographs and local names of species can be printed and shown to the local people for quick study. As the local communities are the real stewards of the biodiversity, they must be engaged and familiarized with the need and importance of biodiversity and its research objectives. This method can be used in the preliminary stages of biodiversity monitoring before planning and executing detailed scientific surveys. Ethnobiological information collected through interviews with local people, participatory resource mapping, focus group discussions, and field visits is widely recognized and can also provide useful scientific insights. An appropriate form and checklist has to be developed before conducting a participatory biodiversity assessment, depending on the objective of the study (ANSAB 2010).

Biodiversity Monitoring Using Permanent Plots

This approach is useful for REDD+ programmes that have long-term implementation models and that last over a longer period (>10 years). Monitoring the flora, fauna, and other variables using permanent plots, taking seasonal variation into consideration, can be the best way for long-term biodiversity monitoring. Permanent plots can be located in different areas of interest such as areas with significance for biodiversity, areas sensitive or resistant to changes in climate, and land use (De Groot et al. 2010). The number and size of plots can vary according to the ecological and logistical concerns. Within the plots, information on all flora, fauna, disturbances, and seasonal changes should be recorded. Using the baseline data, changes in the biodiversity within the plots can be easily monitored (Chettri et al., 2015).

Periodic Biodiversity Monitoring

As every biodiversity assessment requires adequate time and resources, regular monitoring may be resource intensive. In such cases, periodic monitoring might be the best approach (Ticker et al., 2005). Biodiversity monitoring can be done seasonally, in alternate years, or at a fixed interval, such as every four or five years depending on resources and relevance. While doing monitoring, seasonal variation can be taken into consideration. Conducting such periodic monitoring in a systematic manner contributes to long-term biodiversity monitoring. Periodic monitoring also provides valuable information on the trends and changes in the status of biodiversity over time and space.

Chapter 3: Setting Criteria and Indicators

Setting Criteria for Biodiversity Monitoring

Development of criteria and indicators is essential prior to monitoring biodiversity for REDD+ programmes. These criteria and indicators must provide information on three major aspects of biodiversity – pressure, state, and response (Spangenberg et al., 2009). (See Table 3).

Table 3: Simple template for assessment of status of biodiversity monitoring criteria

S.N.	Biodiversity Monitoring Criteria	Status				
		Very Good	Good	Normal	Bad	Very Bad
1	Ecosystem Health and Vitality					
2	Monitoring Threats to Biodiversity					
3	Monitoring Biodiversity Enhancing Factors					

Criteria 1: Ecosystem Health and Vitality

The conservation of biodiversity is possible in a healthy ecosystem that can retain its structure, has a built-in capacity to cope with threats, and performs its functions effectively. The group of indicators, such as species richness, number of rare and endangered species, keystone species, flagship species, vegetation types, crown cover, old growth trees, coarse woody debris (CWD), regeneration and growing stock, growth and yield, and human disturbances, can be used to assess the health and vitality of an ecosystem. Information on the rare, endangered, and endemic plant species, species associated with wildlife (e.g., preferred food-plant of wildlife, dead standing trees with tree holes), and number of pollinator species can also be used as indicators, as illustrated in Table 4.

Table 4: Quantification of Biodiversity

Area	<ul style="list-style-type: none">Vegetation types: e.g., grasslands, rangelands, forests, and other woody landsForest types: Sal forest, sisoo-khair forest. Forest under different management modalities: e.g., protected areas, religious forest, leasehold forest, community forest, collaborative forest, and private forestHabitat range: Occupied habitat and potential habitat of wildlife species, e.g., tiger, rhino, red panda
Number	<ul style="list-style-type: none">Total number of floral and faunal speciesNumber of endemic endangered species; number of pollinators; scavenger species; number of ecosystems and vegetation types; number of community forests; protected areasNumber of invasive species and seed treesNumber of seedlings and saplings
Percentage	<ul style="list-style-type: none">Canopy cover; litter cover; invasive species and dead trees

Criteria 2: Threats to Biodiversity

Many species of flora and fauna are seriously threatened, primarily due to human-induced pressures such as hunting, grazing, encroachment, uncontrolled fire, and removal of vegetation. The Scale, Intensity, and Risk (SIR) of threats may be different depending on the management regime and location. Major threats are listed and prioritized based on their SIR. The number and extent of distribution of the invasive species, trends in changes in the forest area, species composition, and management regime/ownership pattern can be considered while monitoring threats.

Criteria 3: Biodiversity-Enhancing Factors

Biodiversity-enhancing factors are influenced by the organizational and individual behavior of forest-related stakeholders. Law enforcement and management interventions like silvicultural operations, harvesting resources, forest tenures, protection of wildlife, and practices and actions related to promotion of regeneration are important enhancing factors. Changes in the conservation practices of local stakeholders are important factors for monitoring biodiversity enhancing factors.

Selecting Biodiversity Monitoring Indicators

Each of the criteria has a set of indicators and verifiers. Biodiversity indicators are measurable surrogates of biological or other features of the environment that reflect to some degree the state of an ecosystem, habitat, or other component of biodiversity. Such indicators aim to fulfill three basic functions – Simplification, Quantification, and Communication. The indicators must provide simplified numerical measurements of complex biodiversity features (See Table 5) so that they enable understanding of the current status and trends of biodiversity in the area. Depending on the complexity, relevance, and costs, these indicators could be measured at different levels of precision and frequency. It is preferable to use a limited number of indicators, so that key conclusions are apparent.

The selection process of indicators should include a test to verify that it clearly reflects the changes in the ecosystem for which it was chosen as an indicator. While selecting biodiversity indicators, attention must be paid to ensure that they are closely related to REDD+ activities. Selection of indicators must encompass the geographical scale of REDD+ programmes and

Table 5: Properties of Indicator Species Selected for Monitoring

Properties of Indicator Species Selected for Monitoring

- Easy to identify, observe census or sample
- Well understood with respect to its ecology and interactions with land uses
- Representative of the habitat requirements and ecology of a large number of species
- Able to respond rapidly to environmental changes, so that they can provide early warning of detrimental impacts
- High intrinsic or popular appeal so that they can help motivate action (e.g., “flagship” species)
- Keystone species; endemic, rare, and endangered species
- Economically important or tradable species

select an appropriate indicator that reflects and represents the biodiversity in the area. The presence of a particular species may be used as an indicator of habitat quality or species richness. In particular, amphibians, butterflies, fishes, habitat-specific mammals, and sensitive plants are suitable indicators to monitor changes (Thapa et al., 2015). Properties of indicator species for monitoring are explained in Table 5.

Indicators of Healthy Forest

A healthy forest is one in which the ecosystem functions, such as water retention, nutrient cycling, and photosynthesis, are being maintained. They include water, forest carbon, recreational opportunities, and habitat for animals, wood for housing and cooking, and others.

Key Indicators of Forest Health

The presence of tree regeneration

The first and foremost indicator of forest sustainability is regeneration. If there are no seedlings or saplings present, then in the long term, the forest will not be sustainable. The only exception to this is if the canopy is closed, allowing little light to reach the forest floor. If the species growing on that site are “shade intolerant”, meaning they need nearly full sunlight for their seedlings to grow, there will not be any regeneration under the mature trees. These conditions will be obvious, in that no sign of tree cutting will be seen and the tree crowns will be touching, allowing little light to reach the dark forest floor.

Species of regeneration

A second sign of forest degradation is if the species of regeneration is of an inferior type. Then a new forest will be growing, but it will not be as good as the forest that is being cut. Noting the species of the young seedlings and saplings is a good way to check for this type of degradation.

Richness and abundance of wildlife species

The presence of wildlife is one good indicator of undisturbed and intact forest. A forest rich in different species of mammals, birds, herpeto-fauna, aquatic animals, and insects indicates a healthy forest.

Richness and abundance of plant species

Abundance and diversity of plants are good indicators of a healthy forest ecosystem.

Signs of cutting and lopping

Cutting and lopping indicate whether the forest is being used.

Occurrence of forest fires

High frequency and intensity of forest fires poses a threat to floral and faunal diversity and therefore forest health.

Density of grazing

In many areas, the problem with regenerating forests is domestic animals browsing the seedlings and samplings. The livestock grazing leads to trampling, which inhibits regeneration.

Prevalence of invasive species and vines

When the canopy is opened, allowing light to reach the forest floor, woody lianas (vines) often grow profusely. They will grow up and cover existing trees, often carpeting an area, adversely affecting native tree species and preventing regeneration (Cierjacks et al., 2008).

Diameter/height ratio

A good indicator of forest health is the basal diameter-to-height ratio of the saplings. Trees that are being cut often and are re-sprouting will develop large diameter stumps for the given height of the sprout. The higher the height-to-diameter ratio of the forest, the healthier it is.

Chapter 4: Methods for Floral Diversity Assessment

The chapter provides a detailed methodology for conducting floral assessment. Various tools, such as a resource inventory transect walk and photo monitoring, can be used to monitor changes in vegetation diversity of the area. These vegetation assessments can be carried out in both rectangular and circular plots.

At the national level, widely-used methods of forest inventory are outlined by DFRS for Forest Resource Assessment (DFRS 2015), which can be deployed for floral diversity assessment.

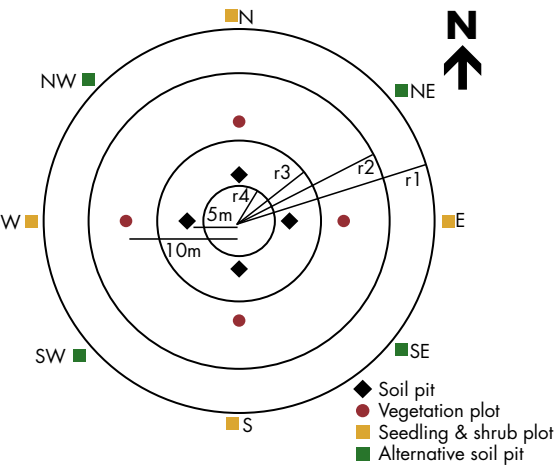
Sample Plot Design

Each sample plot consisted of four concentric circular sample plots (CCSP) of different radii, four vegetation sub-plots, four shrubs and seedlings sub-plots, and four soil pits. The plot design for tree measurement is given in Table 6 and Figure 1.

Figure 1: Layout of concentric circular permanent sample plots and sub-plots

Table 6: Size and area of CCSP of different radii with DBH limits

S.N.	Plot radius (m)	DBH limit (cm)	Area (m ²)
1	20	>30.0	1,256.63
2	15	20.0-29.9	706.86
3	8	10.0-19.9	201.06
4	4	5.0-9.9	50.27



Other sub-plots were established to assess the status of seedlings, saplings, shrubs, and herbs. Seedlings, saplings, and shrubs were measured in four circular sub-plots, each with a radius of 2 m, located 10 m away from the centre of the plot in each of the four cardinal directions (north, east, south and west). Species-wise, stem counting, and mean height estimations were carried out for tree and shrub species having a DBH less than 5 cm. Information on non-woody vascular

plants was collected from four 1 m² plots, each located 5 m away from the centre in the four cardinal directions. Dead wood was assessed in a circular plot with a radius of 10 m from the plot centre.

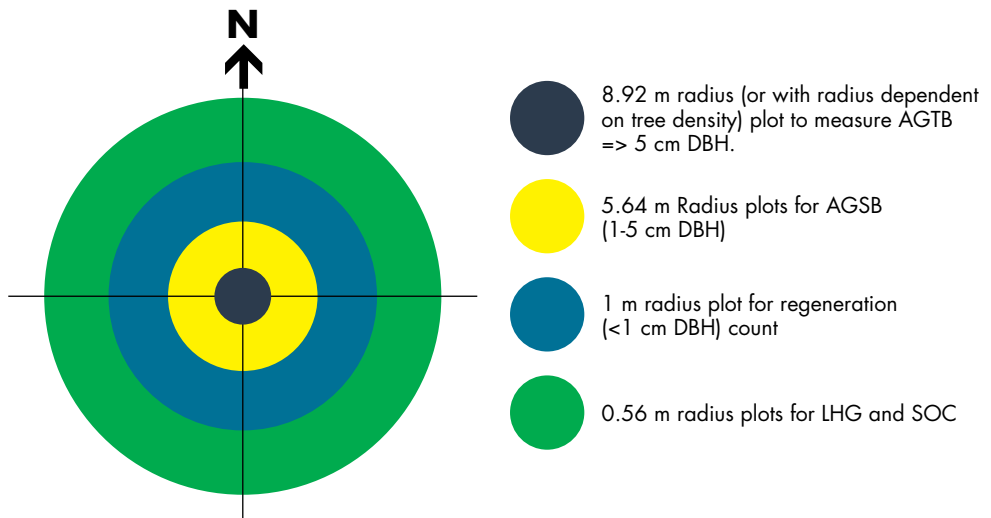
Fourteen categories of natural and anthropogenic forest disturbances were assessed through field observations of both their occurrence and intensity (severe, moderate, minor) in the 20

m radius plot. Four soil pits per forest stand were prepared in order to identify soil texture and to determine soil stoniness. Soil, litter, and debris were collected as composite samples by combining the materials collected at all soil pits. The sample plots were navigated in the field by using hand-held GPS and located with a differential GPS (DGPS). Height of the sample tree was measured by using Vertex IV and Transponder T3. Crown cover was estimated by using spherical densitometer. Calipers and D-tapes were used to measure diameter (refer to Annex 6 for data sheets).

It is important to note that this assessment must be compatible with the Monitoring, Reporting, and Verification (MRV) Framework such that the data generated compliments MRV information.

At the community level, there is also the Community Forest Inventory Guidelines 2004 (DOF 2004) and Guidelines for Measuring Carbon Stocks in Community-Managed Forest (ANSAB 2010), as shown below in Figure 2, which can also be used as outlined in Monitoring, Measuring, and Reporting (MMR) Guideline (RIC and ICIMOD 2016).

**Figure 2: Sampling design of circular plot (default size)
for measuring carbon stocks in community-managed forest**



Adopted from: ANSAB, 2010

While conducting floral diversity assessment, it is important to consider, where appropriate, species that are threatened, protected, and endangered. The methodology will depend on the specific threatened, protected, and endangered species, and the assessment must be tailored accordingly.

Indicators for biodiversity richness, abundance, diversity, and number counts are recorded in the data sheet from these sampling plots (Refer to Annex 10 for data sheets).

Collection of plot information

Detailed information needs to be collected in an orderly manner, such as plot number, plot location (GPS X and Y), date and time of field measurement, district, altitude, aspect, slope, signs of forest fire, grazing, fodder collection, fire wood collection, timber collection, encroachment, signs of wild life, signs of landslide and soil erosion, soil type, forest type, ground cover by tree, herbs and grasses, and shrubs.

Collection of data and information on shrubs

Data and information on the shrubs should be collected from the circular plot as prescribed by DFRS methodology (DFRS 2015). The forest technician/supervisor should collect the data and information on the name of the species, number of seedlings and young individuals of the shrubs, and average crown and height of each shrub.

Herb and grasses measurement

Herbs and shrubs should be measured as prescribed by DFRS methodology (DFRS 2015).

Seedling measurement

The main objective of counting the seedlings is to study the status of regeneration and forest health in the particular forest and contribute to developing the measures for protecting and managing the forest in a sustainable manner. The circular plot is laid out and regeneration should be counted within that plot, according to the DFRS guidelines (2015).

Sapling and pole measurement

Sapling and pole measurement follows the DFRS guideline (2015).

NTFPs measurement

Based on the different types of formal and informal group discussion and participatory resource mapping, the NTFPs available in the forest area will be listed and prioritized. The top five to ten prioritized NTFPs species can be inventoried following the toolkit "NTFP inventory guideline" (DOF 2012). Priority species for inventory can vary according to the bio-climatic zone where the inventory is being conducted. The Government of Nepal has prioritized 33 species for research and development and 13 species for agro technology development.

Sampling rare and endangered species

Rare and endangered plant species present special problems for conservation since they reflect characteristic differences from common plants in their biology, pattern of threat, and resources available for conservation management (Acharya et al. 2000). Assessing rare and endangered plant species with conventional sampling techniques might not be feasible to obtain the information on occurrence and spatial distribution (Cochran, 1977), resulting in

a small probability of occurrence. As suggested by Thompson and Seber (1996), adaptive cluster sampling is the best method for conducting inventory/research for rare and endemic plant species. Adaptive cluster sampling design consists of two steps. In the first step, systematic sampling is applied, yielding an initial set of M sampling units (plots). In each plot, the presence of at least one tree (dbh 12 cm) of the rare species concerned is determined. If at least one such tree is present, the second step adds neighboring plots to this plot (and thus to the sample). The presence of at least one rare tree of the species in each one of these added plots is determined. If positive, further neighboring plots are added. Plots are added repeatedly until no additional plots contain the rare tree species anymore (Acharya et al. 2000).

The area in which systematic adaptive cluster sampling is to be applied consists of a set of contiguous square blocks of the same size. Each block is divided into an equal number of non-overlapping square plots. To select the initial systematic sample, a plot is selected randomly in the first block. Its location in the block defines the systematically arranged plots in all other blocks. This set of plots forms a primary unit, whereas the plots themselves are the secondary units. More than one primary unit may be randomly selected. A primary unit is a projection of a possible collection of initial sampling units to such a block, for example, the first block. Secondary units (plots) are the sampling units included in the sampling after selection of a primary unit. Detailed methods with figures are given in Annex 2, which is adopted from Bhattarai (1997).

Herbarium collection

Botanical collections are essential to our understanding of flora and plant communities. A good-quality herbarium reference collection provides the following:

- a tool for plant identification;
- a data source for research on the taxonomy and distribution of plant groups and for writing handbooks and floras;
- an historical record of plant locations and of a collector's contribution to the science of botany;
- a repository for voucher specimens related to published scientific reports;
- an educational resource for learning to recognize the plant species of an area; and
- accurate and permanent documentation of botanical information that adds credibility to data collected in vegetation surveys.

Detailed techniques and procedures for collection, preserving, and processing the botanical specimens are contained in Annex 7.

Calculating biodiversity richness

The structure and diversity of a plant community in a forest can be studied by taking into consideration a number of characteristics, namely:

- density abundance and dominance;
- frequency;
- importance value index;
- comparison of two communities or stands; and
- species diversity.

All above-provided characteristics are calculated from the field data based on the formula from Zobel et al. (1982), as shown in Annex 1.

Equipment for floral assessment

Vertex, diameter tape, densiometer, GPS, compass, measuring tape, Vernier caliper, rope, laser range finder, distometer, field guide for plant identification, aluminium foil, blotting paper, newspaper, herbarium press, colours, and plant cutter.

Chapter 5: Methods for Faunal Biodiversity Monitoring

A comprehensive monitoring would entail general fauna survey methods, such as those used regularly in environmental impact assessments (Hyder et al. 2010). A range of methods is available (see Annex 3) for monitoring different taxa and species within those taxa. Since monitoring all the species is complex and time consuming, it is best to identify the key indicator or keystone species and monitor the species. Monitoring of the faunal biodiversity is particularly important in high conservation value forests, including protected areas (PAs). This assessment, in combination with the floral assessment, supplements the assessment of forest health.

Large Mammals

Survey methods for large mammals are relatively well documented for many species, both carnivores and ungulates.

Reconnaissance (Recce) Transects method can be used quickly and easily to cover large areas. This method might be biased towards high density and/or non-elusive species.

Transect Survey is suitable for surveying a wide range of mammal species. Conspicuous species can be surveyed using direct observations, whereas indirect observations can be used to survey elusive or nocturnal species. This method can be used to estimate absolute density and is an efficient way of monitoring changes in the population of a target species over time. Inactive, small, or timid species are often missed, and a high sampling effort is required to accurately estimate the encounter rates.

Fecal counts can be used to provide population estimates if animals can be assumed to be defecating at random within certain strata. Pellet counts can be used for assessing the abundance of deer populations. However, fecal counts for carnivores and insectivores can only be used to provide information on presence-absence and distribution, but not for estimation of population abundance.

Camera trapping is the most widely used method for capturing large mammals, mostly cat species like tiger and leopards. One-two km camera spacing is recommended for a mammal survey. For medium-large carnivores and herbivores, 1km spacing is recommended. For small carnivores and herbivores, 500m to 1km spacing should be used and the height should be below 1m. Species showing unique patterns, as in cats, can be identified at individual levels using this method.

Preferred Season: All seasons except hazard (fire, erosions) prone seasons

Time: 100 camera trap days is usually recommended

Human Resource: one researcher, two technicians, one data collector, one helper

Equipment needed: Camera traps, baits/lures, ropes, sickle/knife, binoculars, field guidebook, camera, GPS, flashlight, tape, data sheets, camping gear, utensils, clipboard, and pencil.

Example 1: ID-based Rhino monitoring

The Rhino count is conducted every five years in Nepal to determine the status of the endangered greater one-horned rhino (*Rhinoceros unicornis*). Total count of the rhino is done in blocks where each rhinoceros is located and counted by well-trained wildlife biologists and wildlife technicians riding on 25-30 domestic elephants along the transects. Each individual rhino is identified using shape and horn size, folds present in the neck and rump, special body marking (cuts, scars, and skin lobes), and any other special characteristics present on both flanks of the body. To avoid double counting, careful observations are being made to record both sides of each rhino observed. Special attention is being given to differentiate the sex among each rhino in order to estimate the population's sex ratio. This method has proven most effective, practical, and reliable to estimate population size of mega herbivores like rhinoceros. Further, GPS collars have been used to monitor individual rhinos.

Example 2: Tiger and its prey base monitoring

Base monitoring guidelines for tiger and its prey have been published by the Department of National Parks and Wildlife Conservation (DNPWC). Tiger monitoring has been carried out in the PAs of Nepal since the 1970s, initially through pugmark censuses. Camera trapping has recently been introduced as an unbiased and practical method of monitoring tiger abundance. Karanth and Nichols (1998) and Karanth et. al. (2004) describe in detail the camera trapping of tigers for estimating their abundance.

Tiger Monitoring: The area can be divided into blocks based upon logistic concerns, human resources available, and the number of camera traps at your disposal. Within these blocks, camera traps are set at approximately fixed distance, usually no more than 2 km (Wegge et. al. 2004) to cover all potential areas without leaving any potential gaps. The exact location of cameras within the 2 km grids can be varied by identifying sites frequently used by tigers, such as along the forest roads, river and stream beds, ridge lines, and trails. Camera traps are usually placed in the study areas for 90 days. Tigers are identified at the individual level after a rigorous examination of the unique stripe patterns on the flanks, limbs, and forequarters in each tiger photograph (Chauhan et. al., 2006; Jhala et. al., 2011). For this, various software like CAPTURE (Otis et. al., 1978; White 1982), SPACECAP package Version 1 (Gopalaswamy et. al., 2012), and Program DENSITY (Efford et. al., 2009) can be used.



Photo 1: Fresh pugmarks of tiger and an adult tiger captured in a camera trap.

Prey Base Monitoring: The prey base of tigers is monitored using the line transect survey, which is the preferred population abundance estimation method for visual detection of animals. (Burnham et. al., 1980; Buckland and Elston 1993; Peres 1999). Length of transects could vary from 1.0 to 2.0 km (DNPWC, 2017). Two trained observers walk along the line counting prey animals observed on either side of the line. The sample counts should be done between 06:30 and 09:30 hours, when prey animal species are most active. For each observation, the species, number of animals, radial sighting distance to the animal, the included angle (sighting angle) between the transect line and the center of the animal cluster, and animal behavior upon and after the detection (to assess flight response bias in calculating the effective strip width) are recorded. During analysis, these counts and the associated distance data are used to generate sighting probabilities to estimate the animal abundance (N) in the sampled area from the counts (C) obtained in the survey.

Small Mammals

Small to medium-sized mammals, such as Viverridae, Mustelidae, and the smaller cats, can be captured using camera traps. Very small mammals, such as shrews, voles, and field mice can be surveyed using Sherman traps and pitfall traps. Both kinds of traps should be placed in such a way that all major representative habitats are sampled. Trap positions can be selected based on microhabitat suitability; i.e., along obvious trails used by very small mammals, tunnels at the base of vegetation (in thick grass, this may mean right down at root level) close to logs, boulders, or other cover, paths across leaf litter, moss, or soil, etc. When trapping a steep bank, you can balance the trap on a couple of sticks rammed firmly into the substrate. If you are trapping with box-like live traps on slopes, angle the trap so that the bedding will be kept dry if it rains and water runs down the slope – otherwise, your catch is liable to die of hypothermia.

There are two main ways of arranging traps, by grid and by line. With the first, the trapping is done from the exact point given by the predetermined spacing; in the second, this point is used as a center point or guideline and traps are placed in suitable spots nearby. The number of traps placed can vary according to the habitat suitability in the fields; however, a minimum of one trap per transect/per plot/per grid must be fixed. Drift nets can be erected, using



Photo 2: Collapsible and Elliot trap

strips of plastic sheet (~ 9-12 inches in height) to direct animals toward pitfall traps. These traps can be constructed from plastic buckets, which are then buried, with the top flush with the ground. Holes should be drilled into the bottom of the bucket to prevent rain water from collecting at the bottom. Locally available foods, fruits, and meat can be used as baits to attract the animal.

Mist nets can be used to survey small bats. The mist nets should be taken down during the day to prevent birds from getting trapped. Traps and nets must be checked in the early morning of each day. All animals captured must be identified and released immediately. All animals captured (including non-mammal fauna) should be photographed and the names recorded, along with date, time, weather, transect name and segment number, and GPS location on pre-designed data sheets.

Preferred Season: Summer

Length of Survey: Depends on species

Time: On good sunny mornings and afternoons

Human Resources Required: Researcher, field biologist, assistant, local guide, and helpers

Equipment: Sherman traps, buckets, plastics, shovels for digging, Bait, foam, mist net, small mammal identification book, GPS, notebooks, camera, sample collection tubes, and silica preservative

Additional Useful Resources: <http://www.small-mammals.org/>

Avian Species

Birds can be surveyed using the point count or transect count method. However, a combination of both can also be applied in most of the biodiversity monitoring programs for better results. The points and transects must be placed so that they represent different types of habitats. For most birds, surveys should be conducted during the morning between 0600 and 1100 hrs and at dusk from 1600 to 1800 hrs.



Photo 3: Black-crested bulbul and Jungle owllet

Transect Method: In this method, observers walk in the transect and identify and count the number of birds seen on either side of the transect. Distance and angle of the birds is noted, along with other environmental and climatic parameters. A rangefinder can be used to verify the distance. Same transects can be walked again to increase the replication and number of sightings.

Point Count Method: In this method, point count locations are established at different locations in each habitat type. The spacing between points is so maintained as to minimize double counting (usually $>250\text{m}$) and cover the area of concern. Observers stop at these points and remain quiet for about five minutes to allow birds to settle down, and then they record all birds seen and heard at the location for at least 10 minutes.

When both point count and transect count methods are combined, these point count stations can be fixed as the starting and end points of each transect segment. In both methods, observers must note the location, habitat types, weather, disturbance level, and other essential ecological and biophysical parameters. Besides direct counting, nest counting along transects can also be done for nest birds. Further, for wetland birds, the survey double observer method can be applied, in which different individuals count the number of birds on the same day at the same sites but at slightly different times. For birds that are elusive and hard to detect, call count methods should be applied. Observers should listen to the sound/call made by birds to identify them; playing back of bird sounds can also be done. A mist net can be used to trap and study birds and bats.

Preferred Season: Summer

Length of Survey: According to the area of concern, at least one week

Time: Dawn and dusk

Human Resources Required: Bird expert, assistant, helper

Equipment needed: Binoculars, range finder, sound recorder and playback instrument, bird book, GPS, notebooks, and pencils

Additional Useful Resources: <http://www.ebcc.info/wpimages/other/birdsurvey.pdf>
<http://www.birdlife.org/>

Reptile and Amphibian

Visual Encounter Survey is the most feasible method for reptile and amphibian survey. This method is inexpensive, easy to implement, and efficient over diverse habitats (Manley, Schlesinger, Roth, & Van Horne, 2005). Surveys can be done in systematically or randomly placed plots or transects. The ecology and physiology of reptiles and amphibians are closely tied to environmental conditions and they are therefore good indicator species of environmental changes like climate change and disturbance. However, members of both taxonomic groups are cryptic, and little information is available on their distributions and other ecological information. Thus, careful and thorough monitoring of this taxa is required. Preliminary information sites with possible habitats must be acquired before actual survey.

Searches should focus on suitable microhabitats by turning over rocks and logs, searching among leaf litter, in crevices, tree trunks and tree holes, and other possible refuges. The sampling effort applied, i.e., the time taken and the distance searched, should be recorded for each plot or transect.

Surveys for reptiles should be conducted during the daytime, between 1000 and 1600 hrs, when reptiles are likely basking or otherwise active and can be seen. To obtain complete and comprehensive amphibian surveys, nocturnal surveys should be carried out, especially along streams and wetlands. Audio recordings and analyses of calls should be done to identify the species. Cover boards and minnow traps can also be used.

All reptiles and amphibians collected or seen should be photographed and identified, and the following information should be recorded: name, date, time, plot number or transect number and segment, weather, ambient temperature, microhabitat temperature (i.e., temperature at location where animal was found), and other relevant information.

Preferred Season: Spring for reptiles, monsoon for amphibians

Time: Good sunny afternoons for reptiles, nocturnal survey for amphibians

Human Resources: Reptile and amphibian expert, two technicians, assistant, helper

Equipment: Leather gloves, GPS, hand lens, stopwatch, binoculars, snake stick, camera, field guidebook, recorder with playback

Additional Useful Resources: http://www.nri.org/projects/publications/ecological_methods/m_chapter11_en.pdf



Photo 4: Red necked keelback, Bronze grass skink and Indian burrowing frog

Example 1: Crocodile Survey

The total count method is usually applied for a crocodile survey. The survey is done in the afternoon, coinciding with the basking time of the animals and with an assumption that all animals will come out of the water bodies for basking during the survey period (Khadka et al. 2008). The survey area is divided into different blocks, and rivers are divided into segments. The entire segment of rivers are surveyed in a single day using a canoe with two observers accompanied by a boatman, and each segment is consecutively surveyed for three days. For lakes and ponds, the survey should be conducted on foot, walking along the bank of the water bodies. On detection of the animal, the sex is identified in case of adult gharial, as they are sexually dimorphic; size class should be estimated for both gharials and muggers, following standard protocols (Salisbury & Frey, 2004) "type": "paper-conference"}, "uris": ["http://www.mendeley.com/documents/?uuid=b508f1fb-fd1d-4f70-8d44-64c0e90c6472"]}], "mendeley": {"formattedCitation": "(Salisbury & Frey, 2004. Anthropogenic and habitat covariates should be recorded at each 500 m in river systems for both species. However, for lakes and ponds, a separate data sheet for each lake must be prepared to collect data such as the nature of the lakes, habitat types, and other faunal species.

Butterflies, Moths, and Other Insects

Butterflies make good indicator species of environmental change because of their short generation times and specialized habitats and host plants.

The Pollard Walk method can be used for a butterfly survey, which is designed to record species composition and relative abundances (Pollard 1991). In this method, observers walk at a slow and steady pace in transects, identifying and counting all the butterflies seen on either side of the transect. Ideally, transects should be walked between 1000 and 1500 hrs on sunny, relatively calm days. Butterflies can be netted for identification and photography, if needed. Take pictures of butterflies that cannot be identified in the field for later identification. Record name, time, weather, air temperature, and transect location and segment. Air temperature should be measured in each habitat along the transects to detect changes in microclimate within the plots.

Light Traps are the most widely used methods for monitoring moths. This survey should be conducted on warm, calm, and overcast nights using light bulbs and a normal white cloth/net. Pitfall traps can be used to monitor insects like beetles and other ground creepers. As the number of insects is large and little is known about their life histories, that might be highly variable, so devising an exact monitoring protocol is complex and time-consuming. The Canopy spraying method can also be used to study small insects that mostly live in the canopy by spraying insecticides.

Preferred Season: Spring, March-June

Time: Warm, calm, and sunny days

Human Resources: Butterfly expert, two technicians, helper

Equipment: Swift net, gloves, GPS, hand lens, stopwatch, binoculars, camera, field guidebook



Photo 5: Spot swordtail

Aquatic Diversity

Monitoring of aquatic fauna is limited to a few species like the Gangetic river dolphin, and the majority of other aquatic fauna, particularly fishes, remain ignored. The distribution of successfully reproducing fish is a valuable measure of the ecological condition of a given river system. Fisheries surveys can produce important insights into the health of the overall aquatic environment. The following methods can be applied during aquatic biodiversity surveys.

Direct visual count of aquatic fauna is the most practical and commonly used method of aquatic fauna survey in Nepal. Bankside counts can be made where observers move along the river banks or wetland banks, observe the aquatic species, and record their numbers and behaviors. This can also be done by using boats, where two observers sit on a boat, with one observer counting aquatic animals seen on the right side, and the other recording animals seen on the left side. This method can be used for surveying dolphins and crocodiles.

Catch returns methods can also be used. In this method, the details of catch information from the fisherman can be collected to calculate the catch per unit effort.

Traps and nets can also be used to catch the fish and monitor them.

Hydroacoustic counts can produce better results, but are often expensive.

Besides fish and large aquatic biodiversity, monitoring of macro-invertebrates can also be a good indicator of environmental changes.

Preferred Season: Summer

Length of Survey: Depending on species

Time: On good sunny mornings and afternoons

Human Resources Required: Researcher, field biologist, assistant, local fisherman, and helpers

Equipment: Fish nets, buckets, plastics, bait, identification book, GPS, notebooks, camera, sample collection tubes, silica preservative

Monitoring Dragonflies and Damselflies

Dragonflies and Damselflies are one of the most fascinating yet least studied organisms. The Dragonfly (*Odonata*) could serve as an indicator of ecosystem health. They prefer to be around swampy habitats and near lakes and ponds. Dragonflies were monitored during the piloting of this protocol in Parsa Wildlife Reserve. They were counted in the predefined transects along the waterside within a strip of 5 m left and right. The transect should be at least 100 m and care should be taken to avoid double-counting. A length of 100 m is in most cases long enough to count a reasonable number of Damselflies (*Zygoptera*). For other Dragonflies (*Anisoptera*), one may need to walk more than 100 m to get a useful count. At larger water bodies, extra sections of 100 m can be added to the transect, up to a maximum of 500 m. Observers should walk slowly, stopping occasionally to scan with binoculars.



Photo 6: *Crocothemis servilia* and *Ceriagrion coromandelianum*

Counting of the dragonflies can also be done using the point count method. Observers need to be stationed in the potential habitats of dragonflies near lakes and swampy areas. These vantage points should be at least 10 m apart. Each count should last not more than five minutes. Dragonflies can be photographed or captured and released for identification.

Chapter 6: Institutional Arrangement for Biodiversity Monitoring

The institutional arrangement for biodiversity monitoring for the REDD+ programme needs to be established.

Faunal diversity within the protected areas is assessed and monitored by DNPWC, while those outside the protected areas are assessed and monitored by the Department of Forest and Soil Conservation (DoFSC), with support from DNPWC.

Floral diversity inside and outside the forest in a landscape or at country level is assessed and monitored by the Forest Research and Training Center (FRTC), which is also responsible for conducting monitoring and reporting for REDD+. The Department of Plant Resources (DPR) will support FRTC in identification of the species. In addition, biodiversity within community-based forests is assessed and monitored by the respective community-based forest-managed (CBFM) groups.

The overall monitoring protocol will be implemented in line with MRV and the Safeguards framework and coordinated by the REDD+ Implementation Centre (RIC).

Chapter 7: Quality Assurance and Quality Control

Quality Assurance

Provisions for quality assurance (QA) and quality control (QC) must be implemented to ensure that the biodiversity status reported are reliable and meet minimum measurement standards. The QA/QC provisions are an integral part of standard operation procedures and include procedures for: (1) collecting reliable data from field measurements; (2) verifying data entry and analysis techniques; (3) checking data completeness and consistency; and (4) maintaining and archiving data.

Field Measurements

Rigorous standard operating procedures (protocols) must be developed to detail all steps taken in the field. Protocols ensure that measurements executed by different teams or at different times are consistent and comparable. Once the protocols are developed, those responsible for biodiversity monitoring must be trained so as to be fully cognizant of all procedures and the importance of collecting accurate data.

Forms and formats for data collection should be developed and updated. All equipment's and instruments should be collected, checked, and calibrated in advance and ensured that they are functioning well. Similarly, a complete checklist should be prepared for ensuring that no instrument is left behind.

The technicians/supervisor can use and modify the formats as per need of the inventory design and objectives of the assessment. A monitoring program for field measurement and sampling should be established to ensure that the data collection process and collected data are as per the set standards. When field work is completed, about 10% of the plots should be checked independently. Field data collected at this stage can be compared with the original data, and errors should be corrected and recorded. To provide an estimate of the measurement errors, errors can be expressed as a percentage of all plots that have been rechecked.

Data Entry

Data entry can be done immediately in the field using laptop computers. In most cases, however, measurements are written down in the field and must be entered manually on to spreadsheets and/or data sheets. Data entry on to spreadsheets and/or a database is often a significant source of error. Ongoing communication between all personnel involved in measuring and analyzing data is critical for resolving apparent anomalies before final analysis. Special attention must be paid to units used in the field. All measurements contained

in spreadsheets and/or data sheets must have their unit clearly indicated. If there are anomalies that cannot be resolved, the plot should not be used in the analysis.

Data Completeness and Consistency Check

To assist field inventory personnel, data analysts, and individuals and institutions involved in evaluating the quality of analytical data, QA procedures are developed. The QA/QC procedures include specific criteria to evaluate the quality of the analytical data that have been gathered. These QA/QC procedures will promote the acceptance of the analytical data and reduce the need for additional sampling and analysis to support and/or confirm the analytical data and the professional decisions. The QA/QC procedures are therefore an absolutely essential part of any sampling operation. These QA/QC procedures evaluate (a) data completeness and (b) data consistency.

Data Archiving

Because of the relatively long-term nature of forestry activities, data archiving and storage are important. Original copies of the field measurement (data sheets and electronic files) and laboratory data should be maintained, entered in electronic media, and stored in a secure location. Copies of all data analyses, models, GIS products, final estimates of the amount of carbon sequestered, as well as a copy of the measuring and monitoring reports, should all be stored in a secure location (preferably offsite). DNPWC will be a center for faunal biodiversity data archiving while the RFTC and National Herbarium and Plant Laboratories (NHPL), DPR, can be a center for floral data archiving.

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Annex 1: Floral Diversity Assessment

Density Abundance and Dominance

Density represents the number of individuals per unit area. The terms abundance and density represent the numerical strength of species in a community. The former, if considered along with frequency, gives an idea of the distribution pattern of species. The density and frequency taken together are of immense importance in determining community structure. (Details discussed below.)

Density and abundance are calculated by the following formulae:

$$\text{Abundance} = \frac{\text{Total number of individuals of species}}{\text{Total number of quadrats of occurrence}}$$

$$\text{Density} = \frac{\text{Total number of individual of species}}{\text{Total number of quadrats studied}}$$

Index of Dominance

Communities, at least major ones, have producers, macro consumers, and micro consumers. Within these group, species or species groups, which largely control the energy flow and strongly affect the environment of all other species, are known as ecological dominants. The degree to which dominance is concentrated is one, several, or many species and can be expressed by an appropriate index of dominance that sums up each species' importance in relation to the community as a whole. Simpson (1949) has suggested the following formula to estimate the index of dominance:

$$C_d \sum_{i=1}^s (p_i)^2$$

Where p_i is the proportion of i^{th} species and s is the number of individuals of all the species.

In a mixed crop, where almost all the constituent species share almost the same number of individuals or biomass almost equally, the dominance value will be very low. Whereas in an almost pure crop, dominated by one or two species, dominance will be high, showing values of more than 0.5.

Frequency

Frequency, as described by Raunkiaer (1934), indicates the number of sampling units in which a given species occurs. It expresses the distribution or dispersion of various species in a community, and from this the percentage frequency is calculated as follows. (Details discussed below.)

$$\% \text{ Frequency} = \frac{\text{Number of quadrats of occurrence of a species}}{\text{Total number of quadrats studied}} \times 100$$

Importance Value Index

In order to express the dominance and ecological success of any species with a single value, the concept of *importance value index* has been developed. This index utilizes three characteristics: relative frequency, relative density, and relative dominance. (Details discussed below.)

The dominance of the plant species is determined by the Importance Value Index (IVI) of the species. The value of IVI was computed by a summation of the value of the relative frequency, relative density, and relative dominance. Basal cover is considered as the portion of ground surface occupied by a species. Basal area is calculated by using the following formula; basal area = πr^2 , where "r" is the radius of the species.

$$\text{Importance Value Index (IVI)} = \text{Rel. Freq.} + \text{Rel. Den.} + \text{Rel. Dom.}$$

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{Frequency of all the species}} \times 100$$

$$\text{Relative Density} = \frac{\text{Density of a species}}{\text{Density of all the species}} \times 100$$

$$\text{Relative Dominance} = \frac{\text{Basal area of a species}}{\text{Basal area of all the species}} \times 100$$

Species Diversity

Biodiversity is a precious resource which should be conserved for our future generations. Conservation of biodiversity holds the key to the survival and progress of humankind, as well as civilization. Today, biodiversity resources are under tremendous pressure because of the uncontrolled increase in the human and livestock populations, changing lifestyle patterns, and environment-degrading trade practices. In the context of rapid social and economic transformation in society, the conservation and sustainable utilization of biological resources have assumed paramount importance.

While the common species or dominant species largely accounts for the energy flow in each tropic group, it is the large number of rare species that primarily determines the species diversity of whole communities. Species diversity tends to be low in a physically controlled ecosystem and high in a biologically controlled ecosystem. It is directly related to stability. Higher diversity means longer food chains and more cases of symbiosis (mutualism, parasitism, commensalism, and so forth) and greater possibilities for negative feedback control, which reduces oscillations and hence increases stability.

Two broad approaches are used to analyze species diversity in different situations. These are as follows:

- Comparisons based on the shapes, patterns, or equations of species abundance curves.
- Comparisons based on diversity indices, which are ratios or other mathematical expressions of species-importance relationships.

The methods relating to the second approach are taken up for illustration. The different bio-diversity indices used under the second approach are as follows:

Species Diversity Index

Different kinds of indices for species diversity have been suggested by a number of ecologists.

Odum, Cantlon, and Kornicker (1960) have taken diversity (d) as the number of species (S) for one thousand individuals.

$$d = \frac{S}{1000}$$

Margalef (1958) has suggested the following formula:

$$d = \frac{S - 1}{\log N}$$

Menhinick (1964) has given following formula:

$$d = S/\sqrt{N}$$

Where

d = Diversity index

S = Number of species

N = Number of individuals

Shannon's index of general diversity (H) (Shannon and Wiener 1963):

$$H = -\sum (p_i) \log (p_i)$$

Where p_i = is the importance probability of each species, p_i

The evenness or equitability index shows the distribution of individuals among the species. For example, two systems or habitats containing 10 species and 100 individuals have the same S/N index. But these could have widely different evenness indices depending on the apportionment of the 100 individuals among the 10 species. The evenness index is an example of convenient expression for this component. The widely used Shannon's or "H" index combines the variety or evenness components as one overall index of diversity.

Evenness index (Pielou 1966):

$$e = \frac{H}{\log(S)}$$

Where H = Shannon Index of Diversity:

S = Number of species

Similarity Index

Sorensen (1948) has given a simple formula to determine the index of similarity (S) between two sample vegetation.

$$S = \frac{2C}{A+B} \times 100$$

Where

A = Number of species in Sample A

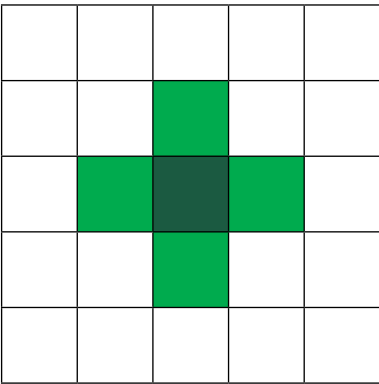
B = Number of species in Sample B

C = Number of species common to both samples.

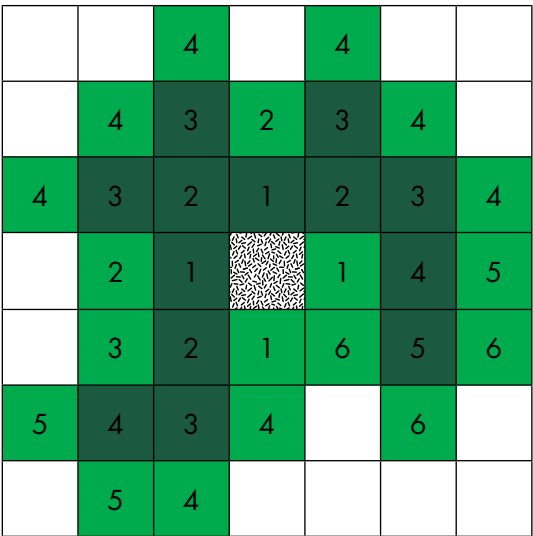
Such indices can be used to compare one community or group of population with another, provided it is first determined that the S is a linear function of the similarity or square root of N .

Annex 2: Sampling for Rare and Endangered Plant Species

In adaptive procedure, when an individual of the concerned tree species intersects the initial sampling unit u_{ij} , the search areas are extended adaptively. So, neighbouring units to the left, right, top, and bottom u'_{ij} (s) are added to the sample in a cross shape, including to initial unit u_{ij} .



The adaptive procedure is repeated until all or at least one of the added unit(s) satisfy the condition (contains at least one or more individuals of the concerned tree species).



In the above figure, the central dark grid square is the initial sampling unit that satisfies the required condition (at least one or more individual trees of concerned species). The adjacent

neighbouring units (which are numbered 1) are added adaptively. Among those four, two squares satisfy the required condition. So, in the third step, squares numbered 2 are added. Again, some of them satisfy the condition, the squares with number 3 are added, and so on and so forth. It is essential to mention here that each unit was measured only once.

During the process of adding more units adaptively, a positive initial unit (numbered zero in the centre of the figure) is linked to four additional units in the first step. If all the added units (numbered 1 in the above given figure) satisfy the required condition, then a maximum of eight more units have to be added in the second step (but it depends how many units satisfy the condition). So, in this kind of process it is the repeated walking to fix the units, and taking measurements of the added units, that makes the procedure time consuming and complex. Therefore, to save the time and energy required, a systematic planning (during the field work preparation, a detection unit visit route should be planned along the contour) needs to be adopted for walking from one detection unit to another.

Annex 3: Faunal Diversity Assessment Methods

The methods used for monitoring fauna might vary and need to be adjusted according to species and sites. However, in general the following methods can be used.

Live Traps

Live traps are mechanical devices that can be used to directly capture the species. They allow direct observation of species, identification, tagging, and measurement before being released or collected as sample. However, legal provisions should be considered while employing this method.

- **Pitfall traps and Sherman traps** can be used for small mammals and ground-living arthropods.
- **Scoop nets, gill nets, casts nets, and traps** are also used to capture fish and other aquatic fauna.
- **Mist nets** for bats and birds, swift nets for butterflies, and light traps for moths.
- **Snares and traps** are set to capture large carnivores and herbivores.
- **Canopy spraying** using insecticides, and placing the nets below the canopy, can be done to collect information on canopy-dwelling insects. Baits and pheromones are often kept in traps to attract animals.

Traps should be positioned in a standardized way and monitored for a specific period.

Information obtained

Rarefaction curves (number of species as a function of number of samples/effort) can be used to calculate species richness. Diversity and behavior can be studied using this method. Large mammals can be darted for rescue and research.

Camera Traps

Camera traps are a popular non-invasive method of wildlife monitoring that can be used for large- to medium-sized mammals and birds. They are useful for monitoring nocturnal, elusive, and animals with large home ranges. The type and number of cameras, spacing, and total days of deployment can vary according to study objectives, study area, and species of concern. Systematically placed cameras at regular spacing can yield valuable information. One-two km camera spacing is recommended for a mammal survey. For medium-large carnivores and herbivores, 1 km spacing is recommended. For small carnivores and herbivores, 500 m to 1 km spacing should be used. Species showing unique physical patterns, as in cats, can be identified at individual levels using this method.

Information obtained

The images from camera traps can be extracted and analyzed using various available software. Camera traps can be used for species presence-absence information, species richness and diversity, species occupancy and distribution, relative abundance index, density and behavior, population estimation, encounter rates, and behavior studies.

Reconnaissance (Recce) Transects

This method involves observers walking through habitat freely on a path without following a fixed route. A GPS tracking log should be taken to record the length and exact route of the recce transect. Both direct and indirect observations should be recorded.

Information on species name, type of observation (direct sighting, sign, etc.), location and time of observation, type of sign (scrape, pellet, scat, browsing, peeling, etc.) and its status (fresh, old, etc.) should be recorded.

If the aim of the survey is to produce a comprehensive species inventory, the areas sampled must be representative of the habitat types present. If the aim is to compare species richness between different habitats, then the sampling effort in each habitat type should be standardized.

Information Obtained

Species list and richness, relative abundance, density, habitat use, and distribution

Transect Survey

This survey involves recording all species encountered when walking in a pre-defined path.

- Transects can be randomly or systematically located within each habitat.
- The distance between transects should be no less than 250m and the transect length should be between 1-2km, depending on habitat and terrain.
- Permanent marking should be done for regular monitoring transects.
- A GPS tracking log should be taken, and start and end points must be marked.
- For direct count species, record sex, age, and number. For indirect signs of animals (scat/dung, pellets, footprints, scrapes, breeding sites, nests, burrows, browsing, peeling, etc.), the species, sign type, and its freshness (fresh, old) should be noted.
- The location and time of the direct and indirect encounters must be noted.
- Disturbance (invasive species, livestock and human pressure, etc.), vegetation (dominant species, microhabitat types, crown cover), and other ecological and biophysical information are recorded for each segment of the transects.

This is useful for active species. Birds, butterflies, insects, amphibians, and reptiles can all be studied using this method. At least two observers and one data recorder should accompany the survey to reduce bias.

Information Obtained

Species richness, relative abundance, absolute density, encounter rates, habitat use, and distribution can be calculated using this method. It is important to standardize the survey efforts and reduce bias for appropriate analysis of the data collected using this method. Signs of different species might be easily confused, so it is essential that they are accurately identified before proceeding to data analysis.

Point Sampling

Point sampling can be used to monitoring birds and mammals. According to the study objective, study area and species vantage points are fixed at different sites. The species seen, numbers, distance from the point, time, and behavior variables are recorded. This method can also be used to monitor birds and herbivores, particularly ungulates like blue sheep. Point sampling in special habitats like water holes, salt licks, and cliffs are valuable for wildlife monitoring.

Information Obtained

Normally used for population estimation of birds. Relative abundance of ungulates and habitat use are also estimated from this method.

Plot/Quadrat Survey

Surveying in plots of fixed shape and size is another common method of biodiversity survey.

- Plots can be randomly or systematically placed within habitats, grids, or transects.
- Generally, plant diversity is measured using this method, in which trees, shrubs and saplings, and herbs and grasses are measured in 20x20m, 5x5m, and 1x1m plots, respectively.
- Environmental (altitude, slope, aspect, temperature, moisture, etc.) and ecological (canopy and ground cover, species composition, etc.) information is collected for the plots.

Regular monitoring of plots – i.e., multiple visits either for a short period or for the long term using permanent plots – can yield important information on spatial and temporal changes.

Information Obtained

Frequency, relative abundance index, density, species richness, diversity indices, detection probabilities, and habitat occupancies can be calculated.

Annex 4: High Conservation Value Forest Identification

Date: Site:

Evaluator:

Category	Description	Present	Potential	Absent	Remarks
HCV 1	Forest areas containing globally, regionally, or nationally significant concentrations of biodiversity values (e.g., endemism, endangered species, refugia)				
HCV 2	Forest areas containing globally, regionally, or nationally significant large landscape-level forests, contained within, or containing the management unit, where viable populations of most, if not all, naturally occurring species exist in natural patterns of distribution and abundance				
HCV 3	Forest areas that are in, or contain, rare, threatened, or endangered ecosystems				
HCV 4	Forest areas that provide basic services of nature in critical situations (e.g., watershed protection, erosion control)				
HCV 5	Forest areas fundamental to meeting the basic needs of local communities (e.g., subsistence, health)				
HCV 6	Forest areas critical to local communities' traditional cultural identity (e.g., areas of cultural, ecological, economic, or religious significance identified in cooperation with such local communities)				

Annex 5: Criteria, Indicators, and Verifiers

Indicators	Verifiers	Unit of Measurement
Ecosystem health and vitality/state indicators		
Forest		
Vegetation	Types	Nominal
	Area of each type	Ha
	Characteristics	Qualitative
Crown cover	Crown cover of trees	%
	Shrub cover	%
	Ground cover	%
Dead trees	Vol. of dead & fallen trees	M ³ /ha
	Area covered by CWD	M ² /ha
	Fine litter	4-point ordinal scale
Growing Stock		
Growing stock by	Pole size	m ³ /ha
species (Tree)	Mature tree	m ³ /ha
	Over-mature tree	m ³ /ha
Size class distribution	Pole size	No./ha
by species (Tree)	Mature tree	No./ha
	Over-mature tree	No./ha
Density by species (Shrub)	Mature Plant	No./ha
Distribution and	Utilizable biomass	Kg/ha
biomass of herbs by species	Plant density	No./ha
Regeneration		
Tree and shrub regeneration	Seedlings	No./ha
by species	Saplings	No./ha
	Coppices	No./ha
	Root suckers	No./ha
		No./ha
Herb regeneration by species	Young growth	4-point ordinal scale
Habitat characteristics of regeneration patches	Soil type	Nominal
	Humus quality	4-point ordinal scale
	Erosion features	Qualitative
	Moisture stress	Qualitative
	Wild animal signs	Qualitative
	Nursing role of shrubs, bamboo, and others	Qualitative
	Canopy gaps	Qualitative
	Disturbance (grazing, fire, insects, etc.)	Qualitative
Plant species diversity	Species richness	No. of species
	Species abundance	No. of species
	Species density	No./ha
Threat monitoring/pressure indicators		
Fire damage	Area	m ² /ha/year
	Frequency	No./year
	Type	Crown, ground, surface

Indicators	Verifiers	Unit of Measurement
Biomass removal	Timber	m ³ /ha/year
	Fuel-wood	kg/ha/year
	Fodder	kg/ha/year
	Grasses	kg/ha/year
	Bedding materials (leaf litter and syaula)	kg/ha/year
	Poles & implements	m ³ /ha/year
	Other NTFPs by products and species	kg/ha/year
Grazing	Area	Ha
	Livestock units	No./ha/year
	Period	Months/year
Encroachment	Area	m ² /year
Harvesting practices by products	Season	Degree of appropriateness
	Tools used	Degree of appropriateness
	Method/techniques	Degree of appropriateness
Illegal harvesting	Species	Types
	Area	No./Ha
	Frequency	No./year
	Person involved	No./year
	Season	Degree of appropriateness
Monitoring enhancing factors/response indicators		
Perception towards value of forest	Types of value	Number
	Direct use value	Descriptive
	Indirect use value	Descriptive
	Existence value	Descriptive
	Other value	Descriptive
Forest management operations and protection	Silviculture operation (thinning, pruning, singling-season)	Descriptive
	Plantation of timber species	Hectare
	Plantation of non-timber species	Hectare
	Protection methods	Types
	No. of encounter and charge to the hunters and illegal fellers	No./type
	Provision of management activities in operational plan	Yes/No
	Grazing system (rotation system implemented?)	Yes/No
	Is management plan implemented effectively	Yes/No
Forest product demand and distribution pattern	Timber demand	Cu. ft
	Firewood demand	Bhari
	Fodder and grasses demand	Bhari
	Agriculture implements	Cu. ft
	Is distribution system equitable?	Yes/No

Indicators	Verifiers	Unit of Measurement
Institution and governance	Established year	Date
	Member in FUC	No
	Female member	No
	Dalit member	No
	Committee meeting	No
	Participation of committee meeting	No
Income generation and fund mobilization	General assembly	No
	Bank account	No
	Total cash income	Rs
	Income this year	Rs
	Income from forest product	Rs
	Income from penalty	Rs
	Expense this year	Rs
	Expense in conservation activities	Rs
	Loan provided to FUG members	No
	Loan amount	Rs
	Account system	Yes/No
	Mitigation plan	Yes/No
	Implementation of threats mitigation plan	Yes/No
	Changes in threats status	%
	Poor people's perception of threats and its mitigation plan	4-point ordinal scale
	Medium people's perception to threats and its mitigation plan	4-point ordinal scale
	Rich people's perception to threats and its mitigation plan	4-point ordinal scale
Perception on key features of the biodiversity	Commitment of poor people to treats reduction	4-point ordinal scale
	Provision of habitat management	Yes/No
	Provision of red-listed species of flora and fauna	Yes/No
	Biodiversity registration book	Yes/No
	Delineation of important social and religious area	Yes/No
	Economically important species	Yes/No
	Other unique features	Yes/No

Annex 6: Data sheets for Floral Assessment

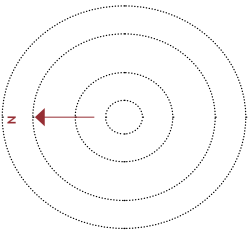
1. General data survey form

Phys.geog. Zone	district code int	Col int	Row int	Plot_ number int	UTM Map Zone int	longitude latitude deg	easting northing m	
Fixed points/ Witness trees								
number	fixed_point type		bearing deg	distance m	dbh cm			
1							N	
2							E	
3							S	
							W	
Sketch drawing for identifying and locating the fixed points/ landmark(s) respective to the CCSP								
						Plot variables:		
						positioning_method		
						date		
						crew_leader		
						FAO_land_use_class		
						trees_outside_forest_1		
						reachability_1		
						village_dev_committee		
						forest_name		
						bearing_to_settlement		
						distance_to_settlement		
						bearing_to_other_land_use		
						distance_to_other_land_use		
						aspect		
						slope		
						altitude		
						macrotopography		
Stand description:								
						forest_stand		
						reachability_2		
						FAO_land_use_class_2		
						LRMP_land_use_class		
						management_regime		
						soil_depth		
						penetration_depth		
						organic_layer_type		
						organic_layer_thickness		
						soil_texture		
						main_site_type		
						forest_type		
						origin		
						crown_cover		
						development_status		

2. Sample Plot Survey Form

General data

Phys geog Zone	district code int	Col int	Row int	Plot_ number int	UTM Map Zone int	longitude latitude deg	easting northing m							
Plot variables:								Stand description:						
positioning_method									Stand 1	Stand 2	Stand 3	Stand 4		
date								forest_stand						
crew_leader								reachability_2						
FAO_land_use_class								FAO_land_use_class_2						
trees_outside_forest_1								LRMP_land_use_class						
reachability_1								management_regime						
village_dev_committee								soil_depth					cm	
forest_name								penetration_depth					cm	
bearing_to_settlement								organic_layer_type						
distance_to_settlement								organic_layer_thickness					cm	
bearing_to_other_land_use								soil_texture						
distance_to_other_land_use								main_site_type						
aspect								forest_type						
slope								origin						
altitude								crown_cover						
macrotopography								development_status						



3. Tally and Sample Tree Survey Form

[illegible]

4. Dead Tree and Disturbances Survey Form

General data

Phys. geog. Zone	district code int	Col int	-	Row int	Plot_ number int	UTM Map Zone int	longitude latitude deg	easting northing m			

Dead trees

	tree_ number	species code	Species spelled if necessary	diameter at_base cm	diameter at_tip cm	length m	number	cause_of_ disturbance	intensity

Disturbances

5. Shrub, Seedlings, and Saplings Survey Form

General data									
Phys. geog. Zone	district code int	Col int	-	Row int	Plot_ number int	UTM Map Zone int	longitude latitude deg	easting northing m	
			-						
Shrub general									
	Sub-plot	crown_cover %						Seedlings and saplings	
	N							sub- number	species code
	E							plot	species spelled if necessary
	S								frequency
	W								mean_ height m
Shrub tally form									
sub-plot	shrub_ number	species code	species_name spelled if necessary	frequency	diameter cm	mean_ height m			

6. Non-Timber Forest Products

General data									
Phys.	district	Col	-	Row	Plot_ number	UTM Map Zone	longitude latitude	easting northing	
geog.	code	int		int	int	int	deg	m	
Zone	int								
			-						
Non-Timber Forest Products									
NTFP	usage	importance							

Annex 7: Herbarium Collection Methodology

Botanical collections are essential to our understanding on flora and plant communities. A good-quality herbarium reference collection provides the following:

- A tool for plant identification;
- A data source for research on the taxonomy and distribution of plant groups and for writing handbooks and floras
- An historical record of plant locations, and of a collector's contribution to the science of botany
- A repository for voucher specimens related to published scientific reports
- An educational resource for learning to recognize the plant species of an area; and
- Accurate and permanent documentation of botanical information that adds credibility to data collected in vegetation surveys.

Herbarium collection methodology

A herbarium is defined as a collection of plants that usually have been dried, pressed, preserved on sheets, and arranged according to an accepted system of classification for future reference and study.

In fact, it is a great filing system for information about plants, both primary in the form of actual specimens of the plants, and secondary in the form of published information, pictures, and recorded notes.

Preparation of a herbarium involves:

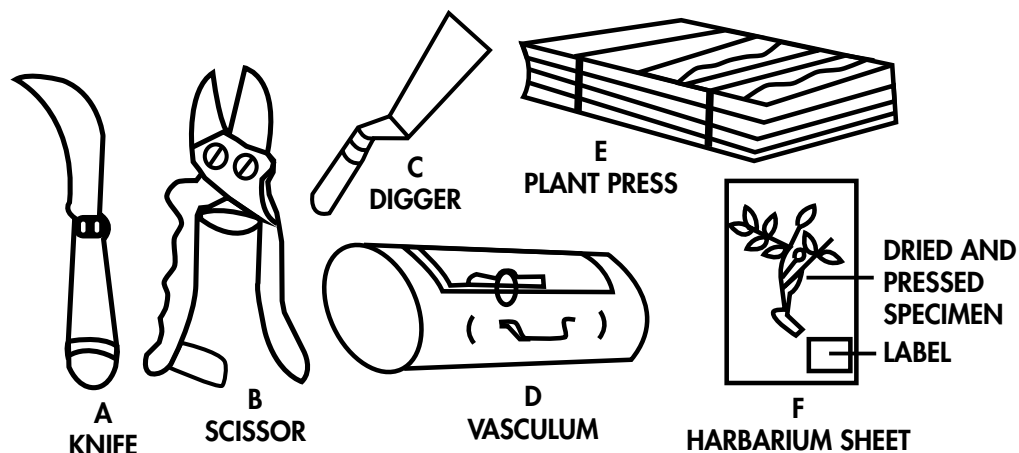
- Field visits
- Collection of specimens
- Drying
- Mounting on an herbarium sheet
- Preservation
- Labelling
- Proper storage.

a) Field visits and specimen collection

A complete specimen possesses all parts, including root system, flowers, and fruits. Therefore, regular field visits are necessary to obtain information at every stage of growth and reproduction of a plant species. In the field, the tools required are mainly a trowel (digger) for digging roots, scissors and knife for cutting twigs, a stick with a hook for collection of parts of tall trees, a field note book, a polythene bag, and old newspaper and magazines.

To avoid damage during transportation and preservation, at least 5-G specimens of a plant

should be collected. The collected specimens are transported in a vasculum (specimen box) to prevent wilting; livery-collected specimens must be tagged with a field number, and necessary information should be recorded in a field note book.



b) Pressing and drying

The specimens are spread out between the folds of old newspapers or blotting sheets, avoiding overlapping of parts. The larger specimen may be folded in "N" or "W" shapes. The blotting sheets with plant specimens should be placed in the plant press for drying. After 24 to 48 hours, the press is opened.

c) Mounting

The dried specimens are mounted on herbarium sheets of standard size (41 x 29 cm). Mounting is done with the help of glue, adhesive, or cello-tape. The bulky plant parts, like dry fruits, seeds, cones, etc. are dried without pressing and are placed in small envelopes called fragment packets. Succulent plants are not mounted on herbarium sheets but are collected in 4% formalin or FAA (Formalin Acetic Alcohol).

d) Preservation

The mounted specimens are sprayed with fungicides like a 2% solution of mercuric chloride.

e) Labelling

The herbarium label is an important and essential part of permanent plant specimens. The size and shape of the label may vary slightly, but it will usually be rectangular and range between 10 x 15 cm (4 x 6 in.). The best position for the main label is generally thought to be the bottom right; this makes the label easier to read when kept in genus covers, which open on the right-hand side. Ideally, a space should be left above the label to allow for the future attachment of determination slips. Generally, the herbarium label should contain the following information:

1. Heading: Name of the institution in which the specimens originated/deposited.
2. Scientific name: Genus, specific epithet, author, or authors
3. Family
4. Locality
5. Range, latitude, and longitude
6. Habitat
7. Date of collection
8. Name of collector(s)
9. Determined by
10. Remarks

f) Storage

Properly dried, pressed, and identified plant specimens are placed in thin paper folds (specimen covers), which are kept together in thicker paper folders (genus covers), and finally, they are incorporated into the herbarium cupboards in their proper position, according to a well-known system of classification. In India, Bentham and Hooker's system of classification is used for this purpose. Type specimens are generally stored in separate and safe places.

Annex 8: Data Sheets for Faunal Assessment

1. Camera Trapping Data Sheet

Form 1: Camera Trapping Details											
Block ID:		GPS No:				Date:					
Sub-Block ID:		District/Municipality Site Name:									
Team Leader:		Other Information									
NS	Camera ID	Grid ID	Date Deployed	Date Ended	GPS Location (UTM)		Site name	Habitat Type	Major five Species	Aspect	Remarks
					Northing, Easting	Elevation (m)					
Habitat Type: SF - Sal Forest; MF - Mixed Forest; KS-SK - Khair-Sissoo/Sissoo-Khair Forest; PF - Pine Forest; GL - Open/Grassland; WL - Wetland/Riverbanks; Ag - Agriculture											
Aspect: N - North; S - South; E - East; W - West; NE - North East; NW - North West; SE - South East; SW - South West											

2. Individual Camera Trap Details

Block ID:		Camera ID:		Team Leader:		Date:
Sub-Block ID:		SD Card ID:		Group Members:		
Grid ID:		Camp Location:		District/Municipality/VDC/Subdivision Name:		
GPS No:		Habitat Type:		Management Regime: NF/CF/PF/PA/CoF/RF/LF		
Trap Day	Date	Time	Exposure Details		Weather Condition	Remarks (Trap Response)
			SE	EE	Total	
1						
2						
3						
4						
5						
6						
7						
GF: Government Forest; CF: Community Forest; PF: Protection Forest; PA: Protected Area; CoF: Collaborative Forests; RF: Religious Forest; LF: Leasehold Forest						
Habitat Type: SF - Sal Forest; MF - Mixed Forest; KS-SK - Khair-Sissoo/Sissoo-Khair Forest; PF - Pine Forest; GL - Open/Grassland; WL - Wetland/River						
Weather Condition: Clear, Partly Cloudy, Overcast, Drizzle, Rain						

3. Occupancy Survey, Faunal Species

Block ID:	Team Leader:				Date:				
Sub-Block ID:	Group Members:								
Grid ID:	Camp Location:				District/Municipality/VDC/ Subdivision Name:				
GPS No:	Habitat Type:				Management Regime: GF/CF/PF/PA/CoF/RF/LF				
Start Time, End Time	Start GPS		E	N	End GPS		E	N	Alt.
Segment	Trail	GPS location	Species Name	Sign Type	Habitat Type	Terrain Type	Aspect	Remarks	
A	(Foot path, Cattle trail, Ridge line, River bank) E: N: Ele: E: N: Ele:	WP:		If Direct Sighting (Number)				(Photo #; Sample #. etc.)	
B									
C									
D									
Segment A: 0-500 m; Segment B: 501-1000m; Segment C: 1001-1500m; Segment D: 1501-2000m									
Habitat Type: SF - Sal Forest; MF - Mixed Forest; KS-SK - Khair-Sissoo/Sissoo-Khair Forest; PF - Pine Forest; GL - Open/Grassland; WL - Wetland/River; Ag - Agriculture									
Sign Type: Pugmark/Footmark; Scat/Pellet/Droppings (Old, New, Fresh); Trails, Scrapes, Scent Marks, Call, Feathers/Hairs									
GF: Government Forest; CF: Community Forest; PF: Protection Forest; PA: Protected Area; CoF: Collaborative Forests; RF: Religious Forest; LF: Leasehold Forest									
Terrain/Substrate Type: Rock, Sand, Gravel, Litter, Logs, Flat, Undulated, Ridge, Valley, Dense Forest, Open Forest, Swamp									

4. Occupancy Survey, Disturbance, and Threats

Block ID:	Team Leader:		Date:					
Sub-Block ID:	Group Members:							
Grid ID:	Camp Location:		District/Municipality/VDC/ Subdivision Name:					
GPS No:	Habitat Type:		Management Regime: GF/CF/PF/PA/CoF/RF/LF					
Start Time:	Start GPS		End GPS					
End Time:	Easting:		Easting:					
	Northing:		Northing:					
	Elevation:		Elevation:					
Segment	Foot path, Cattle trail, Ridge line, Gorge course, River course	GPS location	Species Name	Sign Type/ Direct Sighting (Number)	Habitat Type	Terrain Type	Aspect	Remarks (Photo #; Sample #, etc.)
		WP:						
		E:						
		N:						
		Ele:						
		WP:						
		E:						
		N:						
		Ele:						
		WP:						
		E:						
		N:						
		Ele:						
		WP:						
		E:						
		N:						
		Ele:						
		WP:						
		E:						
		N:						
		Ele:						
Segment A: 0-500 m, Segment B: 501-1000m; Segment C: 1001-1500m; Segment D: 150 -2000m								
Habitat Type: SF - Sal Forest, MF - Mixed Forest; KS-SK - Khair-Sissoo/Sissoo-Khair Forest; PF - Pine Forest; GL - Open/Grassland; WL - Wetland/River, Ag - Agriculture								
Sign Type: Pugmark/Footmark; Scat/Pellet/Droppings (Old, New, Fresh); Trails, Scrapes, Scent Marks, Call, Feathers/Hairs								
GF: Government Forest; CF: Community Forest; PF: Protection Forest; PA: Protected Area; CoF: Collaborative Forests; RF: Religious Forest; LF: Leasehold Forest								
Terrain/Substrate Type: Rock, Sand, Gravel, Litter, Logs, Flat, Undulated, Ridge, Valley, Dense Forest, Open Forest, Swamp								

5. Occupancy Survey, Herpetofauna, and Amphibians

Block ID:		Team Leader:				Date:				
Sub-Block ID:		Management Regime:	GF/CF/PF/PA/CoF/Rf/LF							
Grid ID:		Camp Location:				Habitat Type:				
GPS No:		District/Municipality/VDC/Subdivision Name:				Weather Condition:				
Start, End Time		Start GPS				End GPS				
	Easting	Northing	Micro Habitat/ Substrate	L i f e Stage / Sex	Elevation	Easting	Northing	Elevation		
Segment ID	Species Name	Number			Time	GPS		Remarks		
S.N.						WP	Northing	Easting	Elevation	Photo #; Sample #
1										
2										
3										
4										
5										
6										
Segment A: 0-500 m; Segment B: 501-1000m; Segment C: 1001-1500m; Segment D: 1501-2000m; GF: Government Forest; CF: Community Forest; PF: Protection Forest; PA: Protected Area; CoF: Collaborative Forests; RF: Religious Forest; LF: Leasehold Forest Habitat Type: SF - Sal Forest; MF - Mixed Forest; KS-SK - Khair-Sissoo/Sissoo-Khair Forest; PF: Pine Forest; GL - Open/Grassland; WL - Wetland/River; Ag - Agriculture Micro Habitat/Substrate: R - On Rock; CR - Crevice in rock; W - In Water; EW - Edge of Water; W - In wood/Stump/Log; CL - Crevice in Log; T - In Tree; GB - On Bare Ground; G - On Grass; L - In Litter; B - In Burrow; Rd - On Road/Trail Weather Condition: Clear; Partly Cloudy; Overcast; Drizzle; Rain Life Stage/Sex: Adult (A); Sub-Adult (SA); Juvenile (J); Male(M); Female (F)										

6. Bird Point Count Form

Block ID:		Team Leader:				Date:
Sub-Block ID:		Group Members:				Weather Condition:
Grid ID:		Habitat Type:				Wind:
Point Count Station ID:				Camp Location:		Cloud %:
WP		Northing		Easting		District/Municipality/VDC/Subdivision Name:
						Management Regime: GF/CF/PF/PA/CoF/RF/LF
S.N.		Bird Name		Number		Distance (m)
						Aspect
						Micro Habitat
1						
2						
3						
4						
5						
6						
7						
8						
GF: Government Forest; CF: Community Forest; PF: Protection Forest; PA: Protected Area; CoF: Collaborative Forests; RF: Religious Forest; LF: Leasehold Forest						
Habitat Type: SF - Sal Forest; MF - Mixed Forest; KS-SK - Khair-Sissoo/Sissoo-Khair Forest; PF - Pine Forest; GL - Open/Grassland; WL - Wetland/River; Ag - Agriculture						
Micro-Habitat: T1 - Upper Canopy; T2 - Mid-Canopy; T3 - Lower Canopy; S – Shrub; G - Grass/Ground; DT - Dead Tree; W – Water; EW - Edge of Water;						
		FC - Flying above canopy; FF - Flying within forest		Weather Condition: Clear; Partly Cloudy; Overcast; Drizzle; Rain; Snow		
Wind: Calm (no movement); Light (leaves rustle); Moderate (branches move); Strong (tops of trees move)						

7. Bird Transect Count Form

Date:		Block ID:	Sub-Block ID:	Grid ID	Segment ID		
Team Leader:							
Group Members:		Start Info					
Camp Location:		Nothing	Easting	Elevation	Cloud %	Wind	
Habitat Type:							
Weather Condition:		End Info					
District/Municipality/VDC/Sub-division Name:		Nothing	Easting	Elevation	Cloud %	Wind	
Management Regime: GF/CF/PF/PA/CoF/RF/LF							
S.N.	Bird Species Name	Number	Distance	Weather Condition	Aspect	Micro Habitat	Remarks
1							
2							
3							
4							
5							
6							
7							
GF: Government Forest; CF: Community Forest; PF: Protection Forest; PA: Protected Area; CoF: Collaborative Forests; RF: Religious Forest; LF: Leasehold Forest							
Habitat Type: SF - Sal Forest; MF - Mixed Forest; KS-SK - Khair-Sissoo/ Sissoo-Khair Forest; PF - Pine Forest; GL - Open /Grassland; WL - Wetland/River; Ag - Agriculture							
T1 - Upper Canopy; T2 - Mid-Canopy; T3 - Lower Canopy; S – Shrub; G - Grass/Ground; DT - Dead Tree; W – Water; EW - Edge of Water; FC - Flying above Canopy; FF - Flying within Forest							
Micro-Habitat							
Weather Condition: Clear; Partly Cloudy; Overcast; Drizzle; Rain; Snow							
Wind: Calm (no movement); Light (leaves rustle); Moderate (branches move); Strong (tops of trees move)							

8. Pitfall Trap Survey Form

Block ID:	Team Leader:				Date:											
Sub-Block ID:	Group Members:				Management Regime: GF/CF/PF/PA/CoF/RF/LF											
Grid ID:	Camp Location:				Habitat Type:											
GPS No:	District/Municipality/VDC/Subdivision Name:				Weather Condition:											
Pitfall Trap Station	GPS Info:		Northing		Easting		Elevation						Trap Place Description:			
Species Name	Photo/Sample No.	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Remarks				
GF: Government Forest; CF: Community Forest; PF: Protection Forest; PA: Protected Area; CoF: Collaborative Forests; RF: Religious Forest; LF: Leasehold Forest																
Habitat Type: SF - Sal Forest; MF - Mixed Forest; KS-SK - Khair-Sissoo/Sissoo-Khair Forest; PF - Pine Forest; GL - Open/Grassland; WL - Wetland/River; Ag - Agriculture																
Weather Condition: Clear; Partly Cloudy; Overcast; Drizzle; Rain; Snow																

9. Mist Net Bat survey form

Block ID:	Team Leader:					Date:							
Sub-Block ID:	Group Members:					Management Regime: GF/CF/PF/PA/CoF/RF/LF							
Grid ID:	Camp Location:					Habitat Type:							
GPS No:	District/Municipality/VDC/Subdivision Name:					Weather Condition:							
Mist Net Station	GPS Info:	Easting		Elevation		Trap Place Description:							
		Northing	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Remarks
Species Name	Photo/ Sample No.												
GF: Government Forest; CF: Community Forest; PF: Protection Forest; PA: Protected Area; CoF: Collaborative Forests; RF: Religious Forest; LF: Leasehold Forest													
Habitat Type: SF - Sal Forest; MF - Mixed Forest; KS-SK - Khair-Sissoo/Sissoo-Khair Forest; PF-Pine Forest; GL - Open/Grassland; WL - Wetland/River; Ag - Agriculture													
Weather Condition: Clear; Partly Cloudy; Overcast; Drizzle; Rain; Snow													

10. Butterfly survey form

Date:		Block ID:		Sub-Block ID:		Grid ID		Segment ID			
Team Leader:		Group Members:									
		Start GPS						Overcast type		Wind	Cloud %
Camp Location:		End GPS									
Habitat Type:		Weather Condition:									
District/Municipality/VDC/Subdivision Name: Management Regime: GF/CF/PF/PA/CoF/RF/LF											
S.N.	Species	Photo/Sample ID	Number	Micro Habitat	Aspect	Remarks/Notes					
1											
2											
3											
4											
5											
6											
7											
GF: Government Forest; CF: Community Forest; PF: Protection Forest; PA: Protected Area; CoF: Collaborative Forests; RF: Religious Forest; LF: Leasehold Forest											
Habitat Type: SF - Sad Forest; MF - Mixed Forest; KS-SK - Khair-Sissoo/Sissoo-Khair Forest; PF-Pine Forest; GL-Open/Grassland; WL - Wetland/River; Ag - Agriculture											
Micro-Habitat:	T1-Upper Canopy; T2 - Mid-Canopy; T3 - Lower Canopy; S - Shrub; G - Grass/Ground; DT - Dead Tree; W - Water; EW - Edge of Water; FC - Flying above Canopy; FF - Flying within Forest										
Weather Condition: Clear; Partly Cloudy; Overcast; Drizzle; Rain; Snow			Overcast Type: C = clouds, F = fog, S = smoke, H = haze, N = none;								
Wind: Calm (no movement); Light (leaves rustle); Moderate (branches move); Strong (tops of trees move)											

Annex 9: Data Sheet for Community Forest Inventory

1. Tree-DBH and Height Measurements

Tree - DBH and height measurements							District:	Strata:	Plot No.:
Slope condition			Condition 3					Condition 4	
Condition 1			Condition 2						
A D			A B D	B D		A D		A D	
SN	Fork? a,b...	Species	DBH (cm) measured at breast height (1.3m)	Angles formed by top and base of the tree		Distance to the tree (m) (D)	Slope condition (see figure above)	Tree height (m)	Remarks
				top (A)	base (B)				
			.	0	0	.		.	
			.	0	0	.		.	
			.	0	0	.		.	
			.	0	0	.		.	
			.	0	0	.		.	
			.	0	0	.		.	
			.	0	0	.		.	
			.	0	0	.		.	
			.	0	0	.		.	
			.	0	0	.		.	
			.	0	0	.		.	
			.	0	0	.		.	
			.	0	0	.		.	
			.	0	0	.		.	
			.	0	0	.		.	
			.	0	0	.		.	

* Appropriate slope correction has been applied and measurements are done within circular plot with horizontal diameter 8.92 m (area 250 sq. m.)

* All trees within the plot with DBH \geq 5 cm have been measured

* The species of unidentified trees have been recorded as Sp 1...Sp 2; likewise and distinguishable characteristics are noted as comment

2. Regeneration and Sapling Survey Form

District:	Strata:	Plot No.:
Regeneration (below 1 cm DBH) – measure within a 1 m circular plot		
S.N.	Species	Total Count
1		
2		
3		
4		
5		
6		
Sapling (1 cm to 5 cm) -- measure within 5.64 m circular plot		
S.N.	Species	DBH (cm)
1		
2		
3		
4		
5		
6		

3. Dead Wood Measurement Form

[illegible]

4. Densiometer Measurement Form

8. Densiometer Measurement Form (DeMF)					District:		Strata:		Plot No.:	
Grid cell	North		East		South		West		Average	
	Number of Sky squares	Number of Canopy squares	Number of Sky squares	Number of Canopy squares	Number of Sky squares	Number of Canopy squares	Number of Sky squares	Number of Canopy squares	Number of Sky squares	Number of Canopy squares
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										

