

FOREST AND NATURE CONSERVATION CODE OF BEST MANAGEMENT PRACTICES OF BHUTAN

VOLUME I: GUIDING PROVISIONS



Department of Forests and Park Services

DEDICATION

A tribute to our benevolent Druk Gyalpo, His Majesty Jigme Khesar Namgyel Wangchuck, for His Selfless Service and Leadership to the People and Country.





MINISTER

མོ་ནམ་དང་ནགས་ཚལ་ལྷན་ཁག།
ROYAL GOVERNMENT OF BHUTAN
Ministry of Agriculture and Forests
Tashichhodzong
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MESSAGE



I applaud the Department of Forest and Park Services for coming up with the Forest and Nature Conservation Code of Best Practices of Bhutan which is an updated version of the erstwhile Forest Management Code of Bhutan, 2004. The erstwhile code only covered sustainable management of Forest Management Units. However, with the shift of forest management paradigm to include other important aspects such as climate change, wetland and watershed management, biodiversity conservation & monitoring, agroforestry, payment for ecosystem services etc., a more comprehensive guideline has become imperative. The

revised *Code* broadens the scope of applicability covering wide range of contemporary forestry practices providing detailed guidelines on the technical aspects of forest resources management and biodiversity conservation.

The revision of the *Code* is timely and will play a significant role towards sustainable management of our forest resources especially in light of the global climate change and its anticipated impacts on our fragile mountain ecosystems. The *Code* will also take into account the application of advanced technologies in forest management and biodiversity conservation and will provide strong emphasis on monitoring and evaluation of forest and forestry programs which has always been our weakness.

The revised *Code* will also become handy to our colleagues in the field as it will serve as the single source of scientific guideline for all forestry management regimes in the country.

With the publication of this *Code*, Bhutan joins many countries who manage their forest through such technical guidelines. Our country now establishes a robust technical guideline for management of all forest resources in the country and I am confident that it will fulfill our aspiration of bringing all forest resources under sustainable management fulfilling the objectives of our National Forest Policy and the Constitutional mandate of maintaining 60% of forest cover all times to come.

I would like to commend the efforts and hard work of our colleagues in the Department of Forest and Park Services, particularly those who were involved in the revision of this *Code* and I hope this code will be useful to wide range of stakeholders outside of the Department as well.

Tashi Delek!

Yeshi Penjor



ཨོ་རྒྱལ་དང་ནགས་ཚལ་ལྷན་ཁག།
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SECRETARY

MESSAGE



I commend the Department of Forest and Park Services in bringing out the revised Forest and Nature Conservation Code of Best Practices of Bhutan which presents a comprehensive technical guideline for sustainable management of forest resources and biodiversity conservation in the country.

The intricate combination of several programs and activities on sustainable forest management and biodiversity conservation is fundamental to sustainable development, from their vital role as climate regulator, carbon sequestration and the vital ecosystem services they provide. Sustainable management of these forest resources are therefore essential if these benefits for the environment and societies are to be maintained for future generations. Such long-term feats can be achieved only if we are able to manage the huge forest base resources holistically.

Such holistic achievement can only be possible through a science based technical guideline - the *Code*. Its implementation will also ensure that the forests in Bhutan are managed through the integration of good science, research, technology and decades of forest management experiences.

The code also provides consistent and transparent approach to planning and implementation of sustainable forest management plans, conservation plans and activities at all levels and across all other cross-cutting management regimes. The *Code* now provides the deep nexus in making appropriate science-based decisions on several forestry and conservation issues.

I would like to congratulate the Department and in particular the technical working group members for coming up with this code which is a milestone in our effort towards sustainable forest management and biodiversity conservation.

I urge all relevant stakeholders, government and non-government, besides the colleagues of the Department of Forest and Park Services to actively use and implement the Code in managing our forest resources for the benefit of present and future generations.

Tashi Delek!



Rinzin Dorji



དཔལ་ལྷན་འབྲུག་གཞུང་། སློབ་མཁན་དང་ཞུགས་ཆེན་གྱི་ཁག། ཞུགས་ཆེན་དང་སློབ་ཁག་ཞུགས་ཆེན་གྱི་ཁག་ལས་ཁྲུང་སྐད།

ROYAL GOVERNMENT OF BHUTAN

Ministry of Agriculture and Forests

Department of Forests and Park Services

Thimphu: Bhutan



DIRECTOR

FOREWORD



Forests have always played a key role in the livelihood of Bhutanese and is intrinsically intertwined with the social, culture and tradition of our country. In view of its pivotal role not only on socio economic development but also on climate regulatory function through several means and vital ecosystem services, sustainable forest resources management has always played a key role in sustaining our natural forest resources. Bhutan is one of the few countries in the world that enshrines forest and environmental conservation aspects in its Constitution. Article 5 of the Constitution of the Kingdom of Bhutan reflects

commitment to ensure that, in order to conserve the country's natural resources and to prevent degradation of the ecosystem, a minimum of sixty percent of Bhutan's total land shall be maintained under forest cover for all time. Bhutan also committed to remain carbon neutral at the 15th Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 2009 in Copenhagen, Denmark. In addition, the Intended Nationally Determined Contribution (INDC) submitted in September 2015 towards finalization of Paris Agreement further re-iterated Bhutan's pledge to remain carbon neutral. Today with over 71% of the total land of Bhutan under forest cover (2,717,161 ha), forests form an important and indispensable national asset sequestering around 8.5 million tonnes of carbon, generating continuous water flow to sustain our hydro power systems, providing timber and firewood resources to Bhutanese citizens etc.. Out of the total forest area (2,717,161 ha) about 33.29% (904,423.78 ha) fall within the Protected Area Systems (National Parks, Wildlife Sanctuaries and Strict Nature Reserve) and about 19.96% (542,346.32 ha) is managed as Forest Management Units, Community Forests and Local Forest Management Areas.

Therefore, in order to fulfill our international commitment to remain carbon neutral and constitutional mandate of maintaining 60% forest cover for all times to come besides harnessing other benefits such as social, cultural, economic and ecosystem services, it is imperative that the Department possesses a *Code* outlining science based management of the overall forests and biodiversity resources which will enhance the productive and ecological functions of our forest ecosystems. This *Code* has been developed through integration of good science, research, technology and decades of forest management experiences. It gives me a great pleasure in congratulating the entire Technical Working Group involved in the preparation of this *Code*. This *Code* will definitely strengthen the sustainable forest resources management and biodiversity conservation practices in Bhutan for eons to benefit the present and future generations.

Tashi Delek!

Lobzang Dorji

ACKNOWLEDGEMENT

The Forest and Nature Conservation Code of Best Management Practices of Bhutan is the combined effort of many contributors; current and old foresters who have laid foundation for forest management in Bhutan. The Forest and Nature Conservation Code of Best Management Practices of Bhutan, hereafter referred to as *Code* provides technical guidance for forest management by integrating all existing and updated technical guidelines for forest and biodiversity management in Bhutan.

The production of this *Code* has been possible only with the unwavering support and guidance of the Hon'ble Director, Department of Forests and Park Services; without whom the timely completion of the document was nothing but a distant dream. The valuable inputs, guidance and contribution of the Hon'ble Director provided a boost for the successful completion of the *Code*.

We would also like to acknowledge the valuable contribution of all the Functional Divisions and field offices for their contribution in the drafting of the document. The field experiences and technical knowledge of our colleagues in their subject of expertise was of immense help for the drafting of the document.

We would like to acknowledge the contribution of all pioneer foresters who has over the years developed and updated the forest management guidelines in Bhutan. The *Code* has been drafted and updated based on the experiences derived during the implementation of the existing Guidelines both within the country and elsewhere.

We would also like to thank the Watershed Management Division and REDD Readiness Proposal Project under the Forest Carbon Partnership Facility (FCPF) of the World Bank for unwavering financial support for the conduct of several workshops/meetings and printing of the *Code*.

Lastly, we would like to thank the Technical Working Group for their tireless effort and contribution in putting together the document. Their technical knowledge, expertise and above all their dedication towards their work has contributed a lot towards the completion of the *Code*.

Introduction

Forests constitute 71 % of the total land cover of Bhutan, with majority of the Bhutanese population dependent on forests for the both direct and indirect benefits. Forests constitutes one of the major natural resources of Bhutan and is one of the major contributors to the socio-economic development of Bhutan helping to alleviate rural poverty. However, the increasing population and developmental activities now exert immense pressure to the forests. The Royal Government of Bhutan under the visionary leadership of our Kings, has over the years, worked tirelessly towards fulfilling the needs of the people on forests, while simultaneously keeping in mind the immense importance of the conservation of the environment to fulfill Bhutan's commitment of relevant International Conventions.

The mandates and goals of the forestry sector have gone through many evolutions with changes in socio-economic development with changing times. The mandates of the Department in the 1950s was mainly to extract timber and harness all benefits from the forest, which over time slowly shifted towards biodiversity conservation, sustainable forest management, sustained flow of water resources, and encouraging participatory forest management.

The need for inclusion of several scientific tools and techniques into sustainable management plans to facilitate timber extraction, led to the development of the Forest Management Code of Bhutan (FMCB) 2004. The FMCB 2004 provided guidelines for the preparation and implementation of the Forest Management Plans for Forest Management Units only. However, with the shift of forest management paradigm to include important aspects such as participatory forest management and climate change, it was felt necessary to develop a more comprehensive *Code* encompassing other important functions of forest, such as protection, conservation, regulatory etc. besides the production services.

Secondly, all kinds of management regimes and practices which the Department of Forests and Park Services (DoFPS) has been carrying out until now are scattered, making it difficult for people to comprehend efforts of the Department, which has ultimately led to Bhutan being looked at as the role model in the world of conservation. It was therefore felt necessary to bring all efforts of DoFPS into one source, Forests and Nature Conservation Code of Best Management Practices of Bhutan, hereafter referred to as *Code*.

Code, would henceforth serve as the single source of scientific guideline for all forestry management regimes in the country and comprises of the following six volumes:

Volume I: Guiding Provisions

Volume II: National Forest Resources Assessment

Volume III: Sustainable Forest Management

Volume IV: Protected Area Management

Volume V: Cross-Cutting Management Regimes

Volume VI: Research and Development

The *Code* also takes into account the impacts of climate change, application of modern technology in forest management and provides strong emphasis on monitoring and evaluation of forest and forestry programs in the country.

ACRONYM

| | |
|--------|---|
| APA | Annual Work Plan |
| BLC | Bhutan Logging Corporations |
| BTC | Bhutan Tiger Center |
| CBD | Convention on Biological Diversity |
| CC | Climate Change |
| CITES | Convention on International Trade in Endangered Species of Wild Fauna and Flora |
| DHI | Druk Holding Investments |
| DLDD | Desertification, Land Degradation and Drought |
| DoFPS | Department of Forests and Park Services |
| DSS | Decision Support System |
| FCPF | Forest Carbon Partnership Facility |
| FIRMS | Forest information Reporting and Monitoring System |
| FMCB | Forest Management Code of Bhutan |
| FPED | Forest Protection and Enforcement Division |
| FREL | Forest Reference Emission Level |
| FRL | Forest Reference Level |
| FRMD | Forest Resources Management Division |
| GBCL | Green Bhutan Corporation Limited |
| GDC | Government Data Centre |
| GHG | Greenhouse gases |
| IWP | Individual Work Plan |
| LG | Local Government |
| Lidar | Light Detection and Ranging |
| MoAF | Ministry of Agriculture and Forests |
| MRV | Monitoring Reporting and Verification |
| NAP | National Action Plan |
| NAPA | National Adaptation Adaption Plan of Action |
| NASIP | National SMART Implementation Protocol |
| NCD | Nature Conservation Division |
| NECS | National Environment Commission Secretariat |
| NFI | National Forest Inventory |
| NFMS | National Forest Monitoring System |
| NGO | National Government Agencies and Non-Government Organizations |
| NRDCL | Natural Resources Development Corporation Limited |
| PAM | Policies and Measures |
| PES | Payment for Environmental Services |
| Radar | Radio Detection and Ranging |
| REDD+ | Reducing Emission from Deforestation and forest Degradation and the role of Conservation of forest carbon stocks, Sustainable Forest Management and Enhancement of forest carbon stocks |
| RGoB | Royal Government of Bhutan |
| RNR-RC | Renewable Natural Resources Research Center |
| SDG | Sustainable Development Goal |

| | |
|--------|--|
| SDSS | Spatial Decision Support System |
| SFED | Social Forestry and Extension Division |
| SMART | Spatial Monitoring and Reporting Tool |
| SRFL | State Reserve Forest Land |
| UN | United Nations |
| UNCCD | United Nations Convention on Combating Desertification |
| UNFCCC | United Nations Framework Convention on Climate Change |
| USP | Unique Selling Point |
| UWICER | Ugyen Wangchuck Institute of Conservation and Environmental Research |
| VES | Visual Encounter Surveys |
| WMD | Watershed Management Division |

DEFINITION

Antitragus refers to a lobe developed from the basal part of the outer margin of the ear.

Annual herb refers to non-woody herbaceous plant that completes its life cycle from germination to the production of seed and then dies, within one year.

Biannual herb refers to non-woody herbaceous plant that develop its vegetative structures in the first year, and complete its biological lifecycle in the second year by entering into dormancy period.

Calcar refers to a cartilaginous or bony spur like projection arising from the ankle that supports the interfemoral membrane.

Canine refers to a single tall and pointed tooth situated behind the incisors in each toothrow.

Echolocation refers to navigation in flight by means of the echo of sound pulses.

Forest refers to any land with trees spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover more than 10 percent.

Forest resources refers to the diverse reservoirs of biodiversity or forest produce grown or found in SRF land, alive or dead, which also generate widespread ecosystem services such as soil nutrients, air and water, providing several tangible and intangible benefits to humanity.

Incisor refers to a front tooth situated in front of the canine tooth in each toothrow.

Keeled refers to a ridge down the center of the scale, resulting in a rough or dull appearance.

Lateral refers to of or involving the side.

Lancet refers to present in the forms belonging to the genus *Rhinolophus*, it is the erect, subtriangular, posterior part of the nose leaf.

Metacarpal refers to one of the long bones of the hand of the bat extending from the carpal bones to the proximal phalanx of the finger.

Noseleaf refers to a simple to complex structure derived from the skin around the nose in some bats.

Perennial herb refers to non-woody herbaceous plant that grow and bloom over the spring and summer from their rootstock, die back in every autumn and winter.

Phalanx (plural Phalanges) refers to digital bone of a finger or toe.

Sella refers to a median anterior projection of the noseleaf of the genus *Rhinolophus*

Shrub refers to strata of woody perennial, which is smaller than a small tree in size, with a single or multiple stem without a definite crown.

Subshrub refers to a very small low shrub of woody perennials or annuals, comparatively smaller in size when compared to a shrub.

Small tree refers to although they qualify as tree but they are not dominant with considerable height and the size is literally smaller.

Tree refers to the most dominant strata comprised of woody perennial, with a single stem or trunk, growing to a considerable height and bearing lateral branches.

Tibia refers to the bone extending between the knee and the ankle.

Tragus refers to cutaneous projection at the opening of the external ear.

Ventral refers to of or involving the abdomen.

Xerophytes refers to a plant that can survive with very little water.

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1. GUIDING PROVISIONS

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1 Guiding Principle

1.1 Introduction

The Forests and Nature Conservation Code of Best Management Practices of Bhutan (hereinafter referred to as the *Code*) shall be used as the scientific guideline for sustainable management of forests and biodiversity resources in Bhutan. While management prescriptions for different management regimes are elaborated in the respective volumes, this chapter shall provide information on the overarching principle for the preparation and implementation of forest management prescriptions and practices in Bhutan.

This chapter also recognizes the legal and technical basis of forest management in Bhutan. While it is the mandate of the Department of Forests and Park Services (DoFPS) (hereinafter referred to as the “Department”) to sustainably manage the forests for present and future generations, it is important to establish a strong cooperation and linkage among different institutions both within and outside the Ministry of Agriculture and Forests (MoAF). It also takes into consideration the wider application of forest resources management principles and their contribution to national and international obligation of the Department and the Royal Government of Bhutan (RGoB).

1.2 Scope

The *Code* shall provide technical guidelines for the scientific management of forests and biodiversity resources, but not limited to, the State Reserve Forest (SRF) in Bhutan. The *Code* shall ensure that all SRF are managed scientifically to optimize use of their production, protection, conservation and ecosystem functions. The *Code* shall also recommend the best practices for management of private forest and other forest related services.

1.3 Objectives

The *Code* provides the Department with technical guidelines on the scientific preparation and implementation of forest management plans. Different volumes of the *Code* provide stepwise guidance on the management of the SRF under different management regimes. The overall objectives of the *Code* are to:

- Protect, conserve and improve the pristine environment and safeguard the biodiversity of the country as mandated by Article 5 of the Constitution of the Kingdom of Bhutan;
- Ensure that all state forests, wildlife and watersheds are managed scientifically as per the National Forest Policy, 2011;
- Guide management planners to prepare a holistic and sustainable forest management plans
- Ensure that objectives of the forest management plans are in accordance with National Policies and relevant legislations;
- Clearly define planning roles and responsibilities of different stakeholders and ensure that their interests are represented;
- Use and direct the available planning tools and processes in order to ensure the best possible use of resources;
- Ensure that forest management plans are based on reliable and appropriate data and information;
- Guide implementation of forest management and annual operational plans to help achieve the overall goals and objectives;
- Clearly define roles and responsibilities of the implementing agencies; and

- Undertake monitoring and evaluation as an essential and effective component of forest management planning and implementation tools.

1.4 Legal Frameworks

Forest and biodiversity resource management in Bhutan is guided by Forest & Nature Conservation and Environment legislations. The *Thrimzhung Chenmo*, 1957 provided for open access to use of forest resources with restrictions on hunting and poaching. These resulted to increasing pressure on forests (DoF 1987). Therefore, realizing the importance of the “*protection, conservation and scientific management of forests*”, the Bhutan Forest Act (BFA) 1969 was passed. Since then, many policies and legislations have been formulated to manage forests and environment in line with both national conservation policies and international conventions & treaties. The *Code* provides guidance for management of SRF; preparation and implementation of management plans, as per the requirements in Forest & Nature Conservation and other Environmental legislations.

Some of the notable policies and legislations on forest and biodiversity management include:

1.4.1 The Constitution of the Kingdom of Bhutan (2008)

The RGoB is tasked to protect, conserve and improve the environment and safeguard biodiversity. The Constitution mandates the Government to ensure that “*in order to conserve the country’s natural resources and to prevent degradation of the ecosystem, a minimum of 60% of Bhutan’s total land shall be maintained under forest cover for all time*”.

Article 5.1 of the Constitution further stipulates that “*Every Bhutanese is a trustee of the Kingdom’s natural resources and environment*”.

1.4.2 Policies

1.4.2.1 National Forest Policy (1974, 2011)

1.4.2.1.1 National Forest Policy 1974

The Policy recognized the importance of forests and its vital role in the physical balance and economic development of the country. Their important roles in protective functions with regard to soil, water and climate and their resultant influence on agricultural economy, development of hydro-electric projects and general welfare of not only Bhutan but also of the neighboring countries were well recognized.

The crucial policy driving Bhutan’s development then, was the National Economic Policy of Bhutan to achieve self-reliance. And the major share of contribution for the national exchequer to support the Economic Policy of Bhutan was expected from the forests.

However, given the geo-physical conditions of Bhutan and the necessity of maintaining soil and climatic equilibrium, the Policy mandated to maintain a minimum of 60% of the total land under forests, discouraged shifting cultivation, and necessitated setting aside forest areas for the protection and conservation of wildlife and other recreational areas.

The policy further visualized that forests can also serve as the source of raw materials for a wide range of industries, which could play an important role in the overall progress of the country.

1.4.2.1.2

1.4.2.1.3 National Forest Policy 2011

The National Forest Policy 2011 was formulated to keep up with changing times and the evolution of forest management concept of the SRF. Since 1957, Forest governance has transitioned from providing “free access” to “almost no access” to “managed access”.

The Forest Policy 2011 broadly stipulates to apply scientific management approaches to all of Bhutan’s forest and biodiversity resources for the benefit of people without compromising the conservation values and the constitutional mandate of maintaining a minimum of 60 % forest cover for all time.

The Policy while stating about different management regimes also has provisions on the forest-based industries and need of proper utilization and marketing in developing private sector and rural communities. Some of the main features of the Policy include a science-based participatory approach to forest governance and sustainable forest management with emphasis on efficient and environment friendly technologies for value-addition and waste minimization.

1.4.2.2 Timber Pricing and Marketing Policy 1999

In 1999, the RGoB introduced the new timber pricing policy, and simultaneously implemented the ban on export of round-wood and sawn wood. An additional ban on semi-finished wood product export was introduced in 2000. This Policy was intended to increase timber availability within the country and to simultaneously reduce timber price.

1.4.2.3 Bhutan Water Policy 2003

Bhutan Water Policy 2003 recognizes the importance of water in the fulfilment of the national objective of socio-economic development. The Policy, therefore, stipulates the need for coordinated *efforts* for conservation, development, utilization and management of water resources.

1.4.2.4 Bhutan Sustainable Hydropower Development Policy 2008

Bhutan Sustainable Hydropower Development Policy 2008, aims towards development of clean energy *to mitigate problems from Global warming and climate change*. The policy also recognizes the crucial role of the MoAF in protection and conservation of the watersheds resulting in sustained flow of water for hydropower development.

1.4.2.5 Economic Development Policy of the Kingdom of Bhutan 2016

Economic Development Policy of the Kingdom of Bhutan 2016 is guided by the overarching philosophy of Gross National Happiness (GNH) and identifies a broad range of economic growth opportunities such as Unique Selling Point (USP), one that builds on *Brand Bhutan*. It recognizes the success of Bhutan’s environmental conservation effort as one of the main drivers for developing the “*Brand Bhutan*” theme. This would entail further strengthening the protection of biodiversity, genetic resources and promotion of indigenous knowledge.

It further acknowledges the contribution of Bhutan’s commitment to remain carbon neutral in developing the “*Brand Bhutan*” and plans to explore to capitalize on the opportunities arising from the global trends towards low emission development while at the same time leapfrogging towards global best practices. Further, the Policy guides to stimulate economic growth through value addition and market diversification of natural resources in a sustainable manner with minimal ecological footprint.

1.4.3 Acts

1.4.3.1 Forest and Nature Conservation Act of Bhutan (1969, 1995)

The Bhutan Forest Act 1969 is one of the first Acts passed by the RGoB. The Act nationalized “*all land under which no person has acquired a permanent heritable and transferable right of use and occupancy*” as forests. It further identified and provided directives regarding the forest rights, uses, royalties and penalties. The Act stipulated that at least 60% of the country should remain forested at all times.

The Bhutan Forest Act 1969 was repealed and ratified in 1995. The Forest and Nature Conservation Act of Bhutan 1995 identified and outlined the requirement of management plan for production and protection of forest and wildlife. Emphasis was given to community and social forestry and, encouraged the participation of community and private individuals. The Act also provided the legal basis for defining management restrictions in the process of forest planning and function mapping.

1.4.3.2 Mines and Minerals Management Act of the Kingdom of Bhutan, 1995

The Mines and Minerals Management Act 1995 promotes a healthy growth of the mineral sector and is compatible with the social and economic policies of the RGoB and within the framework of sustainable development, protection of the environment and preservation of the Kingdom’s precious religious and cultural heritage.

1.4.3.3 Environmental Assessment Act 2000

This Environmental Assessment Act 2000 establishes procedures for the assessment of potential effects of strategic plans, policies, programs and projects on the environment, and for the determination of policies and measures to reduce potential adverse environmental impacts and to promote environmental benefits. This further necessitates the requirement of environmental clearance for any developmental activities. The Application for Environmental Clearance: Guideline for Forestry Activities, 2004 further defines the procedures and guidelines for the implementation of the Act especially with regard to the issuance of clearance in SRF lands.

1.4.3.4 Biodiversity Act of Bhutan 2003

The Biodiversity Act of Bhutan 2003 provides for the conservation and sustainable utilization of biological resources & associated traditional knowledge and ensures Sui Generis protection of plant varieties. It also authorizes the implementation of the Access and Benefit-sharing regime to derive additional benefits in a fair and equitable manner.

1.4.3.5 Land Act of Bhutan 2007

The Land Act of Bhutan 2007 provides for the leasing of state land for economic and various other activities. All *Tsamdro* (grazing) and *Sokshing* (forest land for collection of leaf litter) rights shall revert back to the State and convert to leasehold uses with management plans giving preference to previous rights holders.

1.4.3.6 National Environment Protection Act 2007

The National Environment Protection Act 2007 provides for the establishment of an effective system to conserve and protect the environment through the National Environment Commission or its successors, designation of competent authorities and constitution of other advisory committees, so as to independently

regulate and promote sustainable development in an equitable manner. The Act also calls for conservation and protection of wetlands, alpine regions, watersheds, and other vulnerable ecosystems in addition to the existing protected areas.

1.4.3.7 Waste Prevention and Management Act of Bhutan 2009

The Waste Prevention and Management Act of Bhutan 2009 promotes minimization and sound management of waste in the country through the 3 Rs (Reduce, Reuse and Recycle). The Act further identifies different agencies for regulation of waste in the country wherein it empowers the MoAF to ensure prevention and management of waste with respect to the agricultural sector, including live-stock and forestry.

1.4.3.8 Local Government Act of Bhutan 2009

The Local Government Act of Bhutan 2009 mandates Local Government to implement or undertake any activity consistent with other relevant laws and policies of the country that may conserve and enhance the environment within the limits of the areas under its jurisdiction. It further designates the Gewog *Tshogdue* to regulate and manage forestry activities in accordance with the Forest and Nature Conservation Act of Bhutan 1995.

1.4.3.9 Water Act of Bhutan 2011

The Water Act of Bhutan 2011 establishes water resources as a state property and ensures that it is protected, conserved and/or managed in an economically efficient, socially equitable and environmentally sustainable manner. It empowers the MoAF, to implement activities related to land-use and irrigation, watershed management, water resources in forests, wetlands and protection of catchment areas.

1.4.3.10 Road Act of Bhutan 2013

The Road Act of Bhutan 2013 defines and identifies different kinds of roads and ensures that all roads are constructed in compliance with road standards of Bhutan. 50 feet right of way on either side of national highway given to the Department of Road by the Road Act, has some impact on the forest cover which fall along the national highway. The Road Act gives authority to the Department of Roads for onsite utilization of timber resources solely for national highway development.

1.4.4 Rules

1.4.4.1 Forest and Nature Conservation Rules (FNCR 2000, 2003, 2006, 2017)

The Forest and Nature Conservation Rules (FNCR) 2000 was revised in 2003 and again in 2006 to mainly accommodate a broader scope of the power and duties vested by the FNCA 1995 which were not covered by earlier FNCR. The FNCA 1995 mandated the Department to manage SRF including Community Forests (CF), protect and conserve wildlife, soil & water and related natural resources of Bhutan. The FNCR 2006 issued authority and provisions for the preparation of management plans for Protected Area (PA), Forest Management Units (FMU), CF, NWFP (Non-Wood Forest Produce Management Area), Soil & Water conservation. Various amendments to the FNCR 2006 have been done over the year due to changing times but keeping in line with the provisions of the NFP 2011. Further, a separate amendment to the FNCR 2006 was carried out due to the adoption of the revised rule for the rural timber allotment as part of the implementation of the Government to citizen services programme. The FNCR 2006 was again revised in 2017 which was an amalgam of all the different amendments made to the FNCR 2006 and the provision on

the Rules on Biological Corridors (BC) 2007, which defined the protection status and prescription of the BC plan.

1.4.4.2 Tourism Rules and Regulations 2007

The Tourism Rules and Regulations 2007 identifies and empowers the Tourism Council of Bhutan to promote and manage the tourism programs in Bhutan. The Rule also requires tourists and tour operators to abide by the FNCA 1995 and other related legislations while undertaking nature recreation activities in the SRF.

1.4.4.3 Land Lease Rules and Regulations of Bhutan 2018

The Land Lease Rules and Regulations of Bhutan 2018 implements the provision of the Land Act of Bhutan 2007 and necessitates the requirement of forestry clearance for issuance of lease of SRF Land. Further, it strongly discourages and forbids lease of land registered under Government institutions and areas which are under different management namely designated Parks, Nature Reserve, PA, BC, Buffer Zones, CF, Critical Watershed, Wetland, High Risk Zones, *Nyes*, religious sites & important monuments and Restricted Zones. *However, the Secretariat can make exemptions for only those critical infrastructures of national importance and public need under only special circumstances as deemed relevant by it.*

1.5 Institutional Arrangements

The Department is the principal agency for preparation and implementation of the *Code*. The Department ensures that Forests are managed properly as per the legislations highlighted in 1.4 of this chapter and other national and international commitments. Forests are accordingly managed under different management regimes, namely, Protected Area systems including BC, FMU, Local Forest Management Area (LFMA), Watershed Management, CF and Non-Wood Forest Produce Management Areas. The Department fulfills its core mandates and functions through her functional and field offices.

1.5.1 Core Mandates of the Department

- Maintenance of a minimum of 60% of the country's geographical area under forest cover for all times to come as mandated by the Constitution of The Kingdom of Bhutan, through development and implementation of appropriate forestry programs;
- Protection, conservation, sustainable management and utilization of state forests, wildlife, forest land/soils, water sources and biodiversity through research and insightful application of good science and science-based management prescriptions as per the Constitution of the Kingdom of Bhutan; and
- Ensuring Bhutan's commitments to international and regional conventions, treaties and non-legally binding instruments through enactment of enabling policies, legislations, strategies, plans, and programs.

1.5.2 Core Functions

- Manage Bhutan's forests for sustainable production of economic and environmental goods and services, including long term sustainable supply of timber and other forest products to Bhutanese society;
- Maintain species persistence and ensure eternal sustainability of Bhutan's biodiversity, ecosystem services, natural habitats and cultural heritage;

- Provide effective and integrated watershed management, improve water and watershed conditions and contribute to sustained flow of water and thereby also enhancing livelihoods through provision of watershed services;
- Provide enabling environment for promotion of ecotourism and establishment of nature recreational areas to bring benefits to local communities and enhance conservation;
- Facilitate rural communities to manage forests sustainably for their socio-economic benefits, and to contribute to overall sustainable forest management at national level through the Community Forestry Programmes;
- Facilitate raising forestry crop on registered land of individuals or institutions and accrue ecological, social and economic benefits;
- Facilitate economically viable and efficient forest-based industry aimed at adding value to forest products and build capacity of private sector and rural communities to utilize, process and market forest products; and
- Carry out forestry research to generate information, knowledge, and technology to support policy formulation and development of appropriate forestry technologies.

1.5.3 Functional Divisions of the Department

The Department fulfils its mandates of formulating policies, programmes and providing technical backstopping to field offices through seven Functional Divisions namely, Forest Protection and Enforcement Division (FPED), Forest Resources Management Division (FRMD), Nature Conservation Division (NCD), Social Forestry and Extension Division (SFED), Watershed Management Division (WMD), Ugyen Wangchuck Institute of Conservation and Environment Research (UWICER) and the Bhutan Tiger Center (BTC). Field offices consist of fourteen Divisional Forests Offices (DFO) and ten Protected Area (PA) Offices consisting of National Parks/Sanctuary/Strict Nature Reserve offices which actually implement field activities.

1.5.3.1 Forest Protection and Enforcement Division (FPED)

FPED is mandated to undertake tasks related to protection of forest from pests and diseases, poaching, land inspection and utilization of non-wood forest products (sand and stone). The specific mandates are to:

- Contribute to development of pertinent policy, rules, regulations;
- Promote use of innovative technologies relevant to use of forest land, forest fire management, forest pest and disease management, anti-poaching and SMART monitoring activities;
- Facilitate governance and sustainable allocation (exchange, leasing, mining, quarrying, etc.) in SRF Land through timely clearance services;
- Monitoring, enforcement and assist in adjudication of forest offence cases related to timber, non-wood, wildlife and other forest resources;
- Coordinate holistic forest fire management activities in fire prone areas through effective guidance and services on fire prevention, suppression, awareness, rehabilitation of burnt areas, prescribed burn activities;
- Coordinate appropriate and timely response to manage forest pest and disease outbreaks and epidemics in SRF Land.
- Coordinate general forestry facilitation services including uniform drill, arms training, procurement of uniform, procurement and maintenance of communication equipment; and
- Coordinate and act as focal for national and international agencies for wildlife enforcement.

1.5.3.2 Forest Resources Management Division (FRMD)

FRMD is mandated to sustainably manage the forests of Bhutan, based on sound forestry science. The specific mandates are to:

- Conduct periodic forest resource potential assessments;
- Coordinate and conduct periodic National Forest Resources Inventory;
- Monitor forest cover change periodically;
- Develop and review sustainable forest management strategies, code and technical guidelines;
- Coordinate and provide technical backstopping to the Field Offices for planning and implementation of forest management plans for various management regimes (FMU, LFMA, and adhoc areas);
- Conduct periodic monitoring and evaluation of Sustainable Forest Management Plans (FMU, LFMA& Adhoc areas) implemented by the field offices;
- Review, collaborate and develop volume and biomass allometric equations;
- Provide geospatial services to all Functional Divisions, and Field offices;
- Facilitate service delivery for utilisation of timber resources;
- Provide technical assistance and facilitate development of wood-based industries; and
- House the Forest information Reporting and Monitoring System (FIRMS) & maintain data repository for the Department.

1.5.3.3 Nature Conservation Division (NCD)

NCD is responsible for the conservation of biological diversity and management of protected areas and is mandated to:

- Manage the natural heritages of Bhutan through assessment of existing protected area networks and identifying key conservation areas, when required by providing technical support to all the protected areas;
- Coordinate periodic national wildlife inventories and regular monitoring programmes to safeguard biological diversity;
- Develop strategic action plans to enable a thriving population of flagship species;
- Develop strategies to ensure healthy wildlife and enable harmonious coexistence between nature and people by managing the human-wildlife conflict incidences and also identify means to compensate the losses incurred by communities to wildlife;
- Respond to wildlife rescue calls in the locality and train field offices for similar action in their locality;
- Connect people with nature through conservation education and identifying nature-based opportunities for income generation;
- Assess the impacts of developmental works to the natural environment in protected areas for issuing forestry clearances;
- Explore alternative livelihood needs of the local people living in and around the protected areas, who are dependent on the resources in these areas; and
- Be a part of the global community in safeguarding biological diversity.

1.5.3.4 Social Forestry and Extension Division (SFED)

SFED is responsible for creating an enabling environment through technical backstopping for effective implementation of the decentralized social forestry activities. The mandates of the Division are to:

- Formulate and revise policies related to social forestry and extension program;
- Develop strategies, framework and guidelines for agroforestry, CF, NWFP and plantation programs;
- Technically backstop the planning and implementation of the social forestry and extension program;
- Facilitate and strengthen the capacity of the communities to sustainably manage forest resources by promoting participatory forest management and good governance;
- Facilitate and provide efficient and effective service delivery;
- Plan and implement education and communication programs to raise awareness on social forestry and extension programs;
- Develop proposals and programs relevant to SFED;
- Coordinate climate change mitigation and adaptation programs and activities related to social forestry and participatory forest management;
- Compile and maintain information on agroforestry, CF, NWFP and plantation in the country;
- Monitor and evaluate the social forestry and extension programs and projects; and
- Represent the Department at national and international forum(s) related to social forestry and extension program

1.5.3.5 Watershed Management Division (WMD)

WMD is the focal point for environment, climate change, rangeland and wetlands and is entrusted with primary responsibility of managing watersheds throughout the country. The specific mandates are to:

- Coordinate and provide technical backstopping to field offices in assessment and monitoring of watersheds, wetlands and other water sources;
- Coordinate watershed vulnerability assessment and classification of watersheds for management interventions in collaboration with field offices;
- Provide technical backstopping to field offices in identifying and implementing the watershed and wetland management improvement interventions;
- Coordinate Climate Change mitigation and adaptation programs within the Department;
- Coordinate and undertake the valuation of forest ecosystem services at national level;
- Provide technical backstopping for identification and establishment of Payment for Environmental Services (PES) schemes;
- Provide technical backstopping for identification of drying water sources including recharge areas and reviving drying water sources;
- Develop strategies and guidelines for watershed, wetlands, Reducing Emission from Deforestation and forest Degradation and the role of Conservation of forest carbon stocks, Sustainable Forest Management and Enhancement of forest carbon stocks (REDD+), PES, recharge area mapping and other water sources management; and
- Conduct capacity building on climate change mitigation and adaptation, REDD+ and PES for field offices.

1.5.3.6 Ugyen Wangchuck Institute of Conservation and Environment Research (UWICER)

The UWICER serves as the research and training wing of the Department. The core mandates are to:

- Conduct research in the fields of forestry, conservation and environment mainly on issues identified by the Department;
- Train new foresters and provide refresher courses to forestry professionals;
- Clear research proposals received from different proponents (Research Clearing House); and
- Develop technologies to be used by the Department and relevant agencies.

1.5.3.7 Bhutan Tiger Center (BTC)

The BTC serves as a *center for conservation, outreach and policy* on tigers and their habitat through science and education. BTC's mandates are to:

- Consolidate and coordinate all national efforts on tiger conservation;
- Coordinate research and advocate policy to ensure the persistence of tigers;
- Provide education/training and outreach resources to save tigers, its prey and its habitat; and
- Promote transboundary/international linkages to safeguard the long-term conservation of tigers.

1.5.4 Field Offices

Field Offices includes both the DFO and the PA Offices. The Functional Divisions formulate policies, programs, strategies and technical guidelines in sustainable forest management and utilization, community and social forestry programs, wildlife conservation, watershed management and climate adaptation & resilience. The field offices implement these plans and programmes.

The specific mandates of the field offices are as follows:

- Assess forest and biodiversity resources with technical support from respective Functional Divisions;
- Prepare, revise and implement management plan for different management regimes;
- Prepare and implement operational plan for different management regimes;
- Plan, prepare and implement annual and Five-year plans;
- Monitor and evaluate of various forest management regimes;
- Provide technical sanction and monitor forest plantations;
- Monitor transit and utilization of forest resources;
- Monitor the outbreak and manage forest and wildlife disasters (Pest and disease, forest fire, etc.);
- Implement Sustainable Forest Management, biodiversity and wildlife management activities (Anti-poaching, Human Wildlife Conflict, Rescue and Rehabilitation, thinning, habitat management, etc.);
- Initiate and implement nature-based ecotourism activities;
- Participate in formulation and enforcement of Forest legislations;
- Provide and facilitate delivery of forestry services;
- Conduct field inspection for issuance of forest clearance for various developmental activities;

- Provide technical assistance and promote people's participation in management of forest resources;
- Collaborate and coordinate with Local Government and other line agencies for implementation of forestry activities;
- Facilitate forest-based enterprise development;
- Provide technical backstopping to other agencies on forest related activities;
- Generate forestry and conservation related data and input to FIRMS;
- Conduct advocacy on forest legislations to general public;
- Facilitate forestry, wildlife and ecosystem research activities;
- Conduct feasibility assessment for PES schemes;
- Conduct extensive and intensive forest patrolling;
- Conduct and implement waste management programs; and
- Implement watershed management interventions.

1.6 International Conventions

Bhutan is signatory to many international conventions and agreements to achieve the global goal of a greener and cleaner world to join efforts for global fight against illegal trade of forest resources and the impacts of Climate Change. The followings are some of the international conventions and agreements signed by Bhutan.

1.6.1 Convention on Biological Diversity (CBD)

The Convention on Biological Diversity (CBD) is an international legally-binding treaty adopted at the Earth Summit in 1992 and entered into force in December 1993. Bhutan became a party to CBD through ratification on 23rd November 1995. CBD encourages the conservation of biodiversity to achieve three main goals: *conservation of biodiversity; sustainable use of biodiversity; and the fair and equitable sharing of the benefits arising from the use of genetic resources*. These objectives are met by the Department through sustainable management of forest and conservation efforts implemented as per prescriptions of this *Code*.

1.6.2 United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC entered into force in 1994 with the main objective of stabilizing “*greenhouse gas concentrations in the atmosphere at a level that would prevent anthropogenic interference with the climate system*”. The convention is also the parent agreement for the Paris Agreement and Kyoto Protocol. Bhutan became signatory to the convention through ratification to Kyoto Protocol on 26 August 2002 and Paris Agreement on 19th September 2017.

Bhutan’s Policies and legislation described in Section 1.4 of this chapter provide strong support in mitigating and adaptation to climate change impacts. This *Code* provides prescriptions for planned adaptation to Climate Change (CC) through incorporation of climate components in planning, diversification of forest use, strengthened Monitoring, Reporting and Verification (MRV) systems in the planning processes.

1.6.3 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

CITES is an international agreement *ensuring that international trade in specimens of wild animals and plants does not threaten their survival*. Bhutan became party to the convention through accession on 15th August 2002, which came into force on 13th November 2002. All wildlife in Bhutan is protected by default through the FNCA 1995 and other legislations. Any movement of wildlife specimens, even for research purposes, has to be approved by the CITES authority in Bhutan.

1.6.4 United Nations Convention on Combating Desertification (UNCCD)

UNCCD focuses on addressing the negative effects of desertification, land degradation and drought (DLDD) on productive land and relevant ecosystems. Bhutan acceded to the UNCCD in August 2003. Forest fire and excessive use of forest resources has been identified as one of the major causes of land degradation in Bhutan (NSSC 2014). Therefore, Forest management activities are prescribed to have no, if minimal impact to the environment. Management Plans are prepared to sustainably manage the forest resources. This *Code* provides technical prescription to manage all SRF and beyond to adapt the issue of DLDD through adaptive planning processes. Furthermore, mitigation measures like post fire management activities, sustainable land management, in which plantation and water management forms an integral part, are also prescribed in the *Code*.

1.6.5 Ramsar Convention

Ramsar Convention was adopted in Ramsar, Iran, in 1971 but came into force only in 1972. Bhutan became a member through ratification on 7th September 2012. The two core objectives of Ramsar Conventions are, “*conservation & sustainable utilization of wetlands and stop encroachment and loss of wetlands*”. Volume V of this *Code* provides a detailed description of management of wetland and ramifications.

1.7 National Partners for Forest Management

The Department liaises with different stakeholders both within and outside the MoAF for the implementation of its programs.

1.7.1 Ministry of Agriculture and Forests (MoAF)

The MoAF is the parent Ministry for the Department and guides the Department in achieving its goals and objectives. The Department liaises with other line Department and agencies within the Ministry to conserve, protect and promote sustainable management of forests, wildlife, other biodiversity and water resources.

1.7.2 Local Governments (LG)

The LG is an important partner for forest management in the country and is entrusted to undertake activities consistent with relevant laws and policies of the country which may conserve and enhance the environment within the limits of the areas under its jurisdiction. Therein, while the LG has a direct stake in the CF and NWFP groups, they also form an integral part during the planning process for FMU, LFMA and PA plans.

1.7.3 National Environment Commission Secretariat (NECS)

NECS is mandated to look after broad issues related to the environment in Bhutan. NECS ensures that all developmental activities in the country are implemented in line with environmental norms and standards. The Commission further strives to *put in place the necessary controls, regulations and incentives to the*

private/public sectors, to achieve sustainable development through judicious use of natural resources. All forest management in Bhutan including proposed development activities in the SRF are prescribed and implemented in strict compliance to forest and other Environment legislations in Bhutan.

1.7.4 Natural Resources Development Corporation Limited (NRDCL)

NRDCL is a State-Owned Enterprise (SOE) under the Druk Holding and Investments (DHI) and is the main implementing agency for FMU management plan prescribed in Volume III of this *Code*. It was first initiated as a Logging Division of the Department and later upgraded to Bhutan Logging Corporation (BLC) under the Royal Charter in 1984. NRDCL is also tasked to extract and dispose off any tree removed from SRF, Government institutional registered land and mandated to manage sand, stone and boulders.

1.7.5 Green Bhutan Corporation Limited (GBCL)

Green Bhutan Corporation Limited (GBCL) was established in 2017 as State Owned Enterprise, to promote clean and green Bhutan. GBCL is mandated to carry out plantation work besides landscaping, urban greening, consultancy and floriculture amongst others. The Department provides budget and technical sanctions for plantation and ensures that the GBCL carries out plantation in the SRF as per the prescriptions under this *Code*.

1.7.6 Royal Society for Protection of Nature (RSPN)

The Royal Society for Protection of Nature (RSPN) was established in 1987 as a citizen-based NGO devoted to the conservation of Bhutan's unique environment. RSPN focuses on environmental education and conservation of flagship species. It is also a strong partner of the Department on water and waste management as well.

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2. Forest Management in Bhutan

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2 Forest Management in Bhutan

2.1 Introduction

2.1.1 Background

Majority of Bhutanese people are dependent on the forest for food, shelter and fuelwood. Bhutanese people and nature have coexisted in harmony through centuries, even worshiping nature as part of our tradition and pre-Buddhist religion called *Bonism*. After establishment of the Department of Forests in 1952, scientific management of forest resources was initiated. Scientific forest management, then, was mainly focused on timber extraction resulting in opening more forest offices in Southern Bhutan. Accordingly, a Working Plan Division was established in 1963-66 to prepare working plan for sustainable commercial utilization of timber resources. However, lack of Bhutanese technical expertise and manpower was a major hindrance and it was only in 1974 that proper scientific forest management gained momentum in Bhutan.

Another major challenge was the large-scale exploitation and encroachment of State Reserved Forest (SRF) Land. The *Thrimzhung chenmo* 1959 allowed for open access to Forest resources but with restriction on poaching and hunting only. These necessitated the nationalization of forests with enactment of the Bhutan Forest Act of 1969. Further, major emphasis was placed on afforestation in northern Bhutan and restoring the depleted forest reserves in southern Bhutan during the second five-year plan (DoF, 1987).

The vision to protect wild animals existed even before any modern law came into existence. As such, the first protected area was declared in 1966 with the establishment of the Manas Game Sanctuary. The Manas Game Sanctuary was later upgraded to a wildlife sanctuary with the identification of one national park and four wildlife sanctuaries including the Manas Wildlife Sanctuary by the National Forest Policy (NFP), 1974. The NFP, 1974 placed major emphasis on the conservation of forest and wildlife. It also stated the need of National Parks and Wildlife Sanctuaries for management of forest and wildlife. Accordingly, two wildlife circles were established in 1976; one in Sarpang and the other in Thimphu (RGoB 2002). They were later merged as a Nature Conservation Circle in 1991, now renamed and restructured as the Nature Conservation Division.

Further, the NFP in 1974 envisaged to manage all forests under scientific management. However, the major objective of the NFP was to fulfill the overall objective of the National Economic Policy of Bhutan; *achievement of self-reliance*. Plans and programs were accordingly designed to meet the contemplated growth rate of 10 % per annum with revenue generated from forests. This required an inventory of national resources which was duly completed through the Pre-Invested Survey (PIS) (1974-1981), with support from the Government of India. The PIS provided information of the total growing stock of the country and potential areas for timber extraction. Accordingly, FMU and other timber extraction plans were prepared based on the results of the PIS.

There was however a gradual paradigm shift from a commercial timber extraction approach to forest management focused more on conservation and later combined with participatory forest management. The Royal Kasho issued by His Majesty the King in 1979 encouraged people's participation in forest management. Subsequently, social forestry activities were initiated in 1985 with 2nd June being declared as the Social Forestry Day. Schools and institutions were involved in nationwide plantation during the Social Forestry Day on 2nd June every year. Some of the important forestry activities such as plantation, forest fires, facilitation of rural house building timber allotment, etc., were decentralized to the Dzongkhag in the early 1990s.

Today, forest management in Bhutan is an amalgam of all the principles of sustainable forest management with the expectation that Bhutanese people will also take full responsibilities of protecting Bhutan's forest resources for the benefit of future generations. SRF are managed under five main management regimes, namely, the Protected Area (PA), Biological Corridor (BC), Forest Management Unit (FMU), Local Forest Management Area (LFMA) and Community Forests (CF). Other management regimes such as watershed, NWFP, etc., would be subsumed in one of the five major management regimes. Any natural/man-made disasters (pest & diseases, forest fires, etc.) which offset the above five management regimes, are managed under the most appropriate scientific prescriptions (e.g., Sanitation operations).

2.1.2 Forests in Bhutan

In Bhutan, Forests is technically defined as “any land with tree spanning more than 0.5 hectares with trees higher than 5 meter and a canopy cover of more than 10 percent” under the National Forest Policy (NFP) of Bhutan, 2011 and FNCRR, 2017. Bhutan has a forest cover of 71 % of the total land cover (FRMD, 2016, 2017). Forests are broadly classified into broadleaved and conifer forest. Broadleaved forest constitutes 65 % of the total forest cover while the remaining 35 % is conifer forest (FRMD, 2016, 2017). This translates to a total growing stock of 1001 million m³ with an average growing stock of 261 m³ per hectare. There are eleven forest types in Bhutan namely Subtropical Forest, Warm Broadleaved Forest, Cool Broadleaved Forest, Evergreen Oak Forest, Dry Alpine Scrub, Juniper-Rhododendron Scrub, Chirpine, Bluepine, Spruce, Hemlock and Fir forests (Grierson & Long, 1983).

The cool broadleaved forest has the highest growing stock in the country with 438 million m³ while dry alpine scrub has the least with only 0.10 million m³ (FRMD, 2016). Since Bhutan has more area under Broadleaved forest, the growing stock is higher in this forest type. This is a major challenge for Bhutan where people prefer conifer species for construction which is much less in comparison to Broadleaved forests.

The total biomass of forest is estimated to be 972.91 million tonnes (241 t d.m ha⁻¹), which corresponds to about 457 million tonnes of carbon (113 t C ha⁻¹) and an annual above ground biomass increment per hectare estimated to be 2.01 tha⁻¹ in forest (FRMD, 2018).

2.2 Principles of Forest Management

Bhutan aims to protect, manage and conserve forest, wildlife and other biodiversity resources to ensure social, economic and environmental well-being and happiness of present and future generations. The principles of forest management in Bhutan has changed over time with the changing scenarios; from solely focused on timber extraction for economic purpose to conservation and now sustainable forest management through both science and community participation. Today, forest management in Bhutan is an amalgam of five major management regimes.

Since 2005, FAO adopted the following seven common thematic areas (or criteria) of SFM as a basis for FAO's Global Forest Resources Assessment (FRA). These thematic areas (or criteria) are:

1. Extent of forest resources;
2. Biological diversity;
3. Forest health and vitality;
4. Productive functions of forest resources;
5. Protective functions of forest resources;

6. Socio-economic functions; and
7. Legal, policy and institutional framework.

Further, all United Nation member states joined for a universal call for an action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030, and adopted the Sustainable Development Goals (SDGs) in 2015. The 17 SDGs are integrated in overall planning, policy framework and implementation. All forest management activities are targeted towards achieving the SDGs particularly SDG 1 (end poverty in all its forms everywhere), SDG 3 (Good Health and Wellbeing), SDG 6 (Clean Water and Sanitation), SDG 13 (Climate Action) and SDG 15 (Life on Land) to protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss (Wangdi et al 2016).

These Principles of forest management and the SDGs are deeply embedded into the forest management practices in Bhutan and are explained herein.

2.2.1 Sustainable Forest Management (SFM)

The vision of the Department is to “*sustain Bhutan’s forest & biodiversity resources for the wellbeing of present and future generations lasting for thousands of years*”. This called for a management practice in place to ensure that forest & biodiversity resources are managed sustainably. Management Plans for FMU and LFMA are prepared on the principles of SFM. The FMU and LFMA are identified and prepared to meet the increasing demand of people on timber and other forest resources in the country.

The foundation for SFM in Bhutan was laid with the preparation of plans for the first working scheme in 1963-64 by the working plan division. Working schemes for two areas (Manas and Gaylegphug) were approved by the Royal Government of Bhutan in 1964-65 (Seltzer 1991). Major emphasis was given on the establishment of working plans to extract timber and harness all benefits from the forest as forests was seen as a major component of the socio-economic development of Bhutan and a means to alleviate rural poverty. However, lack of manpower and expertise was a major challenge resulting in temporary closure of the working plan division. It was operationalized only after the NFP 1974 was passed by the Royal Government. The major objective of NFP was to fulfill the overall objective of the National Economic Policy of Bhutan and accordingly plans and programs were designed to meet the contemplated annual growth rate of 10 % in revenue generation from forests. This necessitated a requirement for proper planning and extraction of timber. Scientific forest management, then, was done with the sole objective of extracting timber for commercial purposes in Bhutan.

It was only in 2004 that the Forest Management Code of Bhutan, which was solely designed for FMU was approved by the Government to provide prescriptions for management of FMU. Though the primary objective for the FMU is production of timber to meet the rural and commercial purposes, it also contains appropriate prescriptions for other cross cutting activities such as, NWFP, grazing, conservation, etc. Until 2015, Forest Resources Management Division (FRMD) prepared management plans for FMU as per prescriptions provided by FMCB 2004 and sent them to Divisional Forest Offices (DFO) for implementation in their respective jurisdiction. With the technical capacity of field offices enhanced, the Department decentralized preparation of the management plan to respective DFO with the technical support from FRMD.

The DFO prepares management plans for FMUs under their respective jurisdictions based on the forest resource potential assessment (FRPA) carried out by FRMD. The FRPA has identified 15.66 % of the forest land outside the protected area network and major watersheds (45% slope)(FRMD, 2013) as potential timber production area. Since then, this area has been explored and managed under the existing regimes.

Further, areas outside FMU and other management regimes are managed as LFMA. This is in line with the provisions of NFP 2011 and FNCRR 2017 to bring all SRF Land under sustainable management with scientific management plans. The main objective of the LFMA is to meet timber demand of rural people.

Volume III of this *Code* provides detailed prescriptions for the preparation and implementation of scientific management plans for FMU and LFMA.

2.2.2 Participatory Forest Management

Participatory forest management is believed to be one of the important components of forest management especially in a country like Bhutan where people coexist with nature. Today, the Social forestry programs such as Community Forestry (CF), NWFP management, Private Forestry, Agroforestry, etc., are gaining momentum. Further, special programs are implemented to conserve and protect heritage sites in and around forest areas.

Social forestry gained prominence during the fourth five-year plan with Royal Command in 1979 to involve people in tree planting programme across the country (DoF, 1987). Plantation is one of the major activities of the Department. The Social Forestry Section was created in 1989 to plan and monitor plantation and other community forestry programs in the country.

The involvement of people in forest management became more pronounced through the implementation of the FNCA 1995 and FNCR 2000, which emphasized on the social & community forestry programme as one of the additional components of SFM. CF program in Bhutan is a major shift from conventional forest management wherein degraded SRF Land near the vicinity of settlement is given to Community for management under the guidance of Department. The first CF in Bhutan was established in 1997 at Dozam under Drametse Gewog, Mongar Dzongkhag. Thereafter, Community Forest Management Groups are formed in each CF, who are involved in forest management and decision-making. The process for preparation and implementation of the management plan for CF is detailed in Chapter III, Volume III of this *Code*.

2.2.3 Conservation of Biodiversity

Conservation of biodiversity and forest health monitoring are some of the integral programs of the Department. While conservation activities are implemented by all field offices focusing on protection of flora and fauna, rescue and rehabilitation of wildlife and implementation of zero poaching strategy are more pronounced in the Protected Area (PA) Networks, though such activities do take place outside of PA systems.

The PA Network in Bhutan consists of the National Parks, Wildlife Sanctuaries, Strict Nature Reserves and Biological Corridors. Bhutan has about 51.44 % of the total land area under the PA network. PA management plans are prepared to conserve biodiversity of Bhutan through collective network of PA. PA in Bhutan differ from PA in many parts of the world as there are human settlements/habitation inside the PA systems.

Manas Game Sanctuary was the first PA, declared in 1966, with the objectives of protecting the vast diversities of wild animals especially birds and tigers. The Manas game Sanctuary was later upgraded to a wildlife sanctuary with the identification of one national park and four wildlife sanctuaries by the National Forest Policy of 1974.

Further, in 2000, Her Majesty the Queen Ashi Dorji Wangmo Wangchuck, gifted Biological corridors (BC) as “*a gift to the Earth from the people of Bhutan*”. The BC is a recognized strategy to maintain ecological resilience (Wangchuk, 2007) and reduce genetic erosion due to inbreeding (RGoB, 2002).

Though the primary objective of the PA network today in Bhutan is conservation of both floral and faunal diversity, it also encompasses other objectives such as ecotourism, resource allocation for the people living inside the PA, watershed management amongst others. Volume IV of this *Code* provides detailed prescriptions for the preparation and implementation of PA management Plan.

2.2.4 Conservation of Soil and Watershed

Forest soils provide physical support, supply nutrients and moisture for growth of plants, and store elements for recycling back to trees. Forest floors, which comprise of diverse plant materials form habitats for animals and microorganisms, facilitate and buffer precipitation inputs. Soil organisms digest organic matter and mix it with mineral soil, contributing to soil structure, porosity, and nutrient availability. Worldwide, forest floors and soils are said to hold more organic carbon than any other components of any other terrestrial biome. Management practices and natural disturbances can affect all of these soil properties. In brief, soils support all living beings including humans and their farm lands. Therefore, Bhutan with more than 70% forest cover and large variety of floral and faunal diversity, conservation of forest soils becomes even more important.

As such, conservation of forest soils and watershed is another key mandate of the Department. Identification and management of critical watersheds, wetland, degraded and deforestation is a priority and appropriate activities are needed to manage these areas. All management areas shall conduct forest function mapping and then identify critical watershed areas and soil conservation areas apart from other important functions and prescribe appropriate management measures, such as, plantation and land management activities amongst others. Conservation of soil and watershed are important to sustain continuous flow of water to feed the hydropower systems which earns one of the highest revenue for Bhutan in addition to providing clean drinking water and supporting agricultural farming to attain food self-sufficiency policy of the Ministry of Agriculture and Forests. This is an integral part of forest management planning and is described in detail in Volume V of this *Code*.

2.2.5 Forest Health and Climate Change

Climate change is human induced and forests play a significant role in mitigation and adaptation of the negative impacts of climate change. Forests in Bhutan serve as a carbon sink, sequestering millions of tonnes of CO₂. However, accelerated rate of climate change has negative impacts on forest ecosystems, namely, shift in tree range, forest growth pattern, forest fire, pest and disease infestation and other biotic and abiotic responses.

This *Code* provides possible guidance for management of forest areas to benefit from climate change mitigation and adaptation processes. While Volume III and IV provide guidance on the preparation and implementation of management plans for forest areas, Volume V prescribes guidance for watershed management, forest fire management and pest & disease management.

Further, permanent sample plots are laid by the Ugyen Wangchuck Institute for Conservation and Environment Research (UWICER) to study the impact of climate change on forest ecosystems in Bhutan. Biomass and carbon assessment were also carried out as part of the 1st National Forest Inventory and shall form an integral part of the NFI hereafter.

2.2.6 Research and Capacity Building

Recognizing the importance of Forest education and technical capacity in forest management, the Department gives more emphasis on strengthening local institutions and enhancing the capacity of local forestry personnel in forest management, biodiversity conservation and climate change adaptation & mitigation.

In the absence of technical capacity, forests were managed with the help of Foresters from other countries. Bhutanese were trained by Indian Foresters in India in 1960s and 70s. It was only in 1971 that a forest training institute was established in Kalikhola (present day Lhamoizingkha), which was later shifted to Taba in 1977 and renamed as the Bhutan Forest Institute (BFI). BFI provided certificate level courses to foresters.

The Natural Resources Training Institute, now the College of Natural Resources (CNR) was established in 1991 and provided diploma level courses while for higher degrees (Bachelor and Master level courses), people were sent to India and other countries. Today, UWICER provides certificate level courses for foresters and the CNR provides degree courses in Forestry and Environment management.

The Department shall also focus on building the capacity of in-service forestry staff to work with the changing times and technology. While the functional divisions provide theme and program-based training, UWICER is mandated to impart regular and upgradation courses and training to all forestry staff.

2.2.7 Meeting National and International Goals and Obligations

Bhutan has many national and international goals and obligations to comply with especially on forest management in Bhutan. The management plans should be prepared in line with this Code, which will fulfill the provisions of the Forest Legislation, FYP under the overall aegis of the GNH Principles. This would reaffirm Bhutan's commitment to take urgent action to combat climate change and its impacts through fulfillment of goals and obligations to the international conventions and agreements.

2.2.8 Legal, Policy and Institutional Framework

Strong policies, legal and institutional framework form the foundation of forest management in Bhutan. With the visionary leadership of our beloved Monarchs, Bhutan had always placed great importance on protection and conservation of forest and environment. To protect, conserve and manage forests and environment, the Government created the Forest Department in 1952. Further, the Bhutan Forest Act 1969 was one of the first Acts to be passed by RGoB. Since then, numerous legislations were passed to keep in line with changing times and need of the people. Further, Bhutan is one of the few countries in the world which has devoted an article to protect, conserve and improve the pristine environment and safeguard the biodiversity of Bhutan in her Constitution. In order to conserve Bhutan's natural resources and to prevent degradation of the ecosystem, the Constitution mandates maintaining a minimum of 60% of Bhutan's land cover under forest cover for all times. This is one of the core mandates of the Department. The Department, with support of other line agencies in the Ministry of Agriculture and Forests and other stakeholders ensures that the forests, wildlife and other biodiversity resources are protected and managed sustainably. These are explained in detail under 1.4 Legal Frameworks and 1.5 Institutional Arrangements, Volume 1 of this *Code*.

2.3 Forest types in Bhutan

Bhutan has altitudes ranging from 130 m.a.s.l in the south to more than 7500 m.a.s.l in the north, because of which forests of Bhutan are highly diverse in terms of species composition. Major forest types of Bhutan

in relation to elevation and precipitation are shown in Figure 2.1 (redrawn by Davidson (2000) from Dick and Yonten (1996) with data from Grierson and Long (1983)), and Table 2.1.

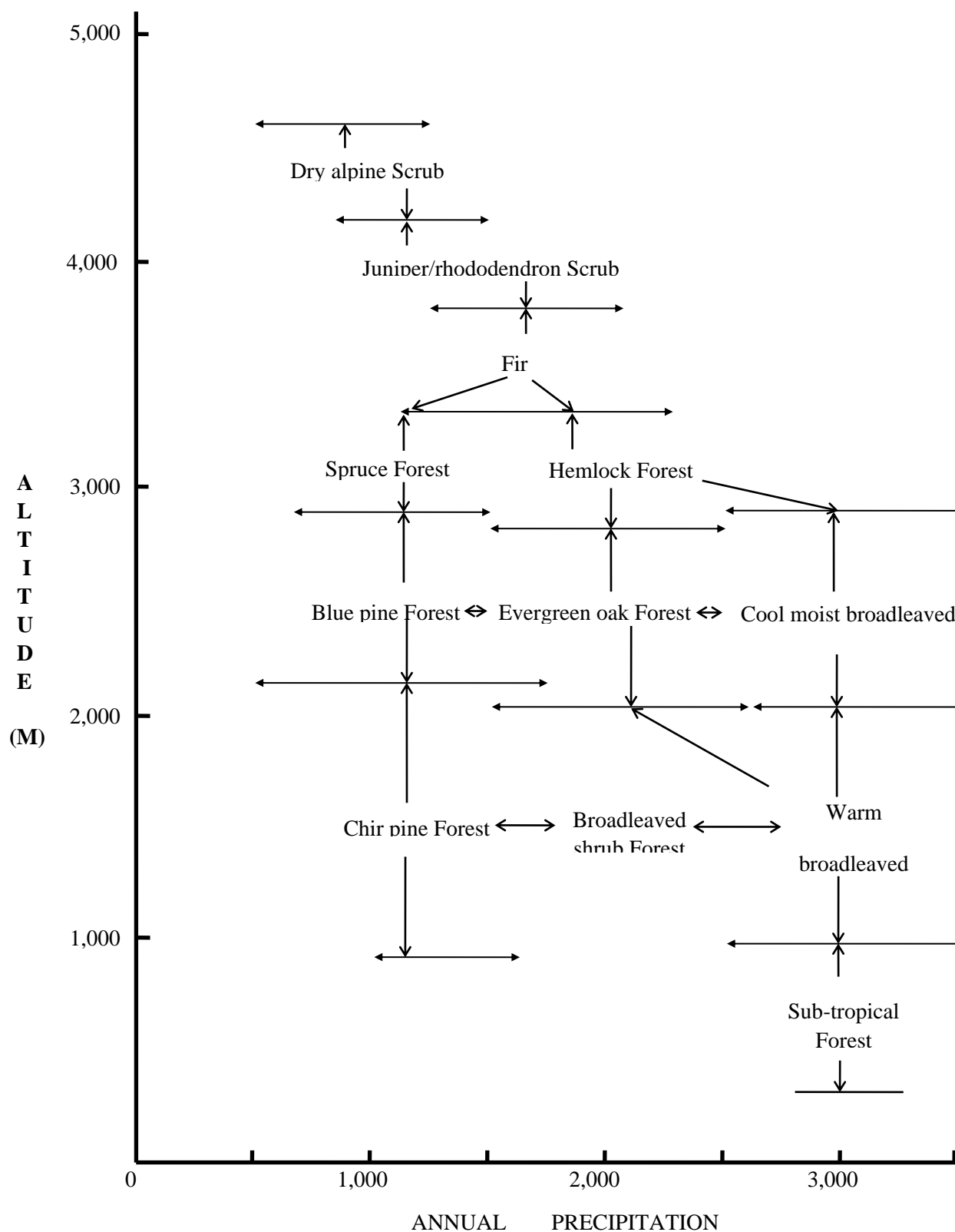


Figure 2.1 Major forest types in Bhutan

Table 2.1 Forest types

| Forest type | Altitudinal range | Precipitation | Characteristics | Species |
|--------------------------|---------------------|---------------|--|--|
| Subtropical Forest | 200-1000 m (-1200m) | 2500-5000 | <ul style="list-style-type: none"> Contain many tropical genera and species, forming dense jungle | <i>Gmelina arborea</i> , <i>Chukrasia tabularis</i> , <i>Acrocarpus fraxinifolius</i> , <i>Ailanthus grandis</i> , <i>Bombax ceiba</i> , <i>Duabanga grandiflora</i> , <i>Shorea robusta</i> , <i>Pterospermum acerifolium</i> , <i>Aquilaria agallocha</i> |
| Chir Pine Forest | 900-1800 m (-2000m) | 1000-1300 | <ul style="list-style-type: none"> Found in open dry forests in the deeper dry (rain shadow) valleys, shallow soils and southerly aspects. Pure, single-storied, even-aged stands (Dorji & Chong, 1998). Relatively resistant to fire | <i>Pinus roxburghii</i> , <i>Buddleja asiatica</i> , <i>B. bhutanica</i> , <i>Cycas pectinata</i> , <i>Cymbopogon flexuosus</i> , <i>Euphorbia royleana</i> , <i>Ficus oligodon</i> , <i>Grewia sapida</i> , <i>Indigofera dosua</i> , <i>Osyris lanceolata</i> , <i>Rhus paniculata</i> , <i>Securinega suffruticosa</i> , <i>Solanum erianthum</i> , <i>Woodfordia fruticosa</i> , <i>Ziziphus incurva</i> |
| Warm Broad-leaved Forest | 1000-2000m (-2300m) | 2300-4000 | <ul style="list-style-type: none"> Contains mixed evergreen and deciduous broad leaved species | <i>Alangium chinense</i> , <i>Alnus nepalensis</i> , <i>Altingia excelsa</i> , <i>Betula alnoides</i> , <i>Bischofia javanica</i> , <i>Callicarpa arborea</i> , <i>Castanopsis indica</i> , <i>Cordia obliqua</i> , <i>Dendrocalamus hookeri</i> , <i>Dichroa febrifuga</i> , <i>Engelhardia spicata</i> , <i>Entada pursaetha</i> , <i>Euodia fraxinifolia</i> , <i>Firmiana colorata</i> , <i>Helicia nilagirica</i> , <i>Lithocarpus elegans</i> , <i>L. pachyphyllus</i> , <i>L. fenestratus</i> , <i>L. dealbatus</i> , <i>L. listeri</i> , <i>Macaranga pustulata</i> , <i>Maclura cochinchinensis</i> , <i>Maesa spp.</i> , <i>Mussaenda roxburghii</i> , <i>Ostodes paniculata</i> , <i>Pouzolzia sanguinea</i> , <i>Rhaphidophora eximea</i> , <i>Schima wallichii</i> , <i>Stereospermum personatum</i> , <i>Trevesia palmata</i> , <i>Wendlandia puberula</i> |
| Evergreen Oak Forest | (1800-)2000-2600m | 2000-3000 | <ul style="list-style-type: none"> Common in drier areas They apparently receive a lower rainfall than Warm broad-leaved forests, and composition varies according to altitude and rainfall. Dominated by <i>Quercus</i> species. At a lower levels <i>Castanopsis hystrix</i> and <i>C. tribuloides</i> are often dominant, higher up <i>Quercus lamellosa</i> becomes common; | <i>Quercus lamellosa</i> , <i>Q. lanata</i> , <i>Q. glauca</i> , <i>Q. semecarpifolia</i> , <i>Acer campbellii</i> , <i>Castanopsis hystrix</i> , <i>C. tribuloides</i> , <i>Elatostema hookerianum</i> , <i>E. sessile</i> , <i>Galeola lindleyana</i> , <i>Juglans regia</i> , <i>Pilea symmeria</i> , <i>Skimmia arborescens</i> , <i>Symplocos lucida</i> |

| | | | | |
|--------------------------|--------------------|-----------|---|---|
| | | | with increasing dryness more xerophytic <i>Quercus</i> species and sometimes <i>Pinus wallichiana</i> appear | |
| Cool Broad-leaved Forest | 2000-2900m | 2000-3000 | <ul style="list-style-type: none"> Found on moist exposed slopes Mixed forest in which oaks are less common and other trees, both deciduous and evergreen, e.g., <i>Persea</i> spp, <i>Exbucklandia</i> spp, etc., are more abundant together with dense shrubs, climbers and epiphytes | <i>Acer campbellii</i> , <i>A. sterculiaceum</i> , <i>Betula alnoides</i> , <i>Beilschmiedia sikkimensis</i> , <i>Brassaiopsis alpina</i> , <i>Chirita lachenensis</i> , <i>Corylopsis himalayana</i> , <i>Daphniphyllum himalense</i> , <i>Elatostema monandrum</i> , <i>E. obtusum</i> , <i>Exbucklandia populnea</i> , <i>Helwingia himalaica</i> , <i>Ilex fragilis</i> , <i>Lecanthus peduncularis</i> , <i>Lindera neesiana</i> , <i>L. pulcherrima</i> , <i>Michelia doltsopa</i> , <i>M. kisopa</i> , <i>Persea clarkeana</i> , <i>Persea fructifera</i> , <i>Pilea bracteosa</i> , <i>Rosa moschhata</i> , <i>Rubus lineatus</i> , <i>R. pentagonus</i> , <i>R. treutleri</i> , <i>Schisandra grandiflora</i> , <i>Symplocos dryophila</i> |
| Blue Pine Forest | 2100-3000(-3200) m | 700-1200 | <ul style="list-style-type: none"> Large stands of pure secondary forest and require thinning Early successional colonizer Sensitive to fire and susceptible to mistletoe and grazing | <i>Pinus wallichiana</i> , <i>P. bhutanica</i> , <i>Arisaema consanguineum</i> , <i>Berberis asiatica</i> , <i>Berchemia edgeworthii</i> , <i>Ceratostigma griffithii</i> , <i>Cotoneaster griffithii</i> , <i>Elaeagnus parviflora</i> , <i>Euonymus grandiflorus</i> , <i>Indigofera heterantha</i> , <i>Jasminum humilie</i> , <i>Leptodermis scabrida</i> , <i>Lonicera quinquelocularis</i> , <i>Lyonia ovalifolia</i> , <i>Ophiopogon intermedius</i> , <i>Philadelphus tomentosus</i> , <i>Polygala sibirica</i> , <i>Prinsepia utilis</i> , <i>Quercus griffithii</i> , <i>Q. semecarpifolia</i> , <i>Rhododendron arboreum</i> , <i>Rosasericea</i> , <i>Spiraea canescens</i> , <i>Zanthoxylum armatum</i> |
| Spruce Forest | 2700- 3100(-3200)m | 500-1000 | <ul style="list-style-type: none"> Mixed with Blue Pine and Oak on dry sites and with Fir, Larch, Hemlock and Yew; the latter two occupying wetter sites. Sensitive to drought, bark beetle wind, snow breakage and other pest and disease | <i>Piceaspinulosa</i> , <i>Picea brachytyla</i> , <i>Acer cappadocicum</i> , <i>A. pectinatum</i> , <i>Berberis praecipua</i> , <i>Enkianthus deflexus</i> , <i>Larix griffithiana</i> , <i>Lindera heterophylla</i> , <i>Osmanthus suavis</i> , <i>Pyrola sikkimensis</i> , <i>Ribes takare</i> , <i>Rosa macrophylla</i> , <i>Salix daltonia</i> , <i>Salvia campanulata</i> , <i>Taxus baccata</i> |
| Hemlock Forest | 2800-3100m | 1300-2000 | <ul style="list-style-type: none"> Dominant in humid sites with or without humus layer More common in the main mountain ridges below the Fir forests throughout the central and northern part of Bhutan. | <i>Tsuga dumosa</i> , <i>Arundinaria griffithiana</i> , <i>Betula utilis</i> , <i>Buddleja colvilei</i> , <i>Daphne bholua</i> , <i>Gaultheria fragrantissima</i> , <i>Larix griffithiana</i> , <i>Litsea sericea</i> , <i>Maddenia himalaica</i> , <i>Magnolia globosa</i> , <i>Panax pseudo-ginseng</i> , <i>Rhododendron falconeri</i> , <i>R. hodgsonii</i> , <i>R. keysii</i> , <i>Rubus calophyllus</i> , <i>R. pentagonous</i> , <i>Sorbus thibetica</i> , <i>Viburnum mullaha</i> |

| | | | | |
|----------------------------|-------------|-----------|--|---|
| Fir Forest | 3300- 3800m | 1300-2000 | <ul style="list-style-type: none"> Requires relatively high precipitation, part of which is obtained as condensation. A thick layer of moss with Rhododendron, sub-alpine bamboo, Primula, and <i>Bryocarpum hamalaicum</i> characterizes the undergrowth. Few Hemlocks (<i>Tsuga dumosa</i>) and Birches may also be present. Toward the tree line (at 3 600 to 3 800 m) the Fir forests become stunted and grade into Juniper and Rhododendron scrub. | <i>Abies densa</i> , <i>Arundinaria maling</i> , <i>Betula utilis</i> , <i>Bryocarpum himalaicum</i> , <i>Daphne bholua</i> , <i>Juniperus pseudosabina</i> , <i>Maddenia himalaica</i> , <i>Primula denticulata</i> , <i>Prunus rufa</i> , <i>Rheum acuminatum</i> , <i>Rhododendron cinnabarinum</i> , <i>R. hodgsonii</i> , <i>Ribes takare</i> , <i>Rubus fragarioides</i> , <i>Skimmia laureola</i> , <i>Sorbus foliolosa</i> , <i>Viburnum nervosum</i> |
| Rhododendron-Juniper scrub | 3700-4200 | | <ul style="list-style-type: none"> Moist vegetation occurring above tree line in northern and central region. Consist of scattered shrubs of <i>Juniperous</i> sp, <i>Rhododendron</i> sp but with rich herb layer appearing during monsoon season. | <i>Juniperus recurva</i> , <i>J. squamata</i> , <i>Rhododendron lepidotum</i> , <i>Morina nepalensis</i> , <i>Pedicularis megalantha</i> , <i>Phlomis tibetica</i> , <i>Potentilla arbuscula</i> , <i>Primula sikkimensis</i> , <i>Thalictrum chelidonii</i> , <i>Trollius pumilus</i> , <i>Gaultheria trichophylla</i> . |
| Dry Alpine Scrub | 4000-4600 m | | <ul style="list-style-type: none"> More xerophytic vegetation found Higher altitude than Juniper-Rhododendron Scrub | <i>Aconitum orochryseum</i> , <i>Astragalus acaulis</i> , <i>Chesneyanubigena</i> , <i>Cremanthodiumthomsonii</i> , <i>Ephedra gerardiana</i> , <i>Meconopsiscaldieriana</i> , <i>Rheum nobile</i> , <i>Rhododendron anthopogon</i> , <i>Salix lindleyana</i> , <i>Saussureagossypiphora</i> , <i>S. obvallata</i> , <i>Saxifraga moorcroftiana</i> , <i>Tanacetumgossypinum</i> , <i>Thermopsisbarbata</i> |

2.3.1 Subtropical Forest

Forests along the southern foothills may be broadly classified as subtropical forest, forming dense jungle on steep slopes and river banks. Natural Sal forests (*Shorea robusta*) occurs as scattered patches in Sarpang and Samtse Dzongkhags.

2.3.2 Chir Pine Forest

Chir Pine forests in Bhutan are confined to low altitude, xerophytic forests which usually occur in the deeper dry/rain shadow valleys namely, Mo Chhu/Sunkosh river, Kuri Chu and Kholong Chhu/Drangme Chhu systems. These valleys have a very long dry season during which forest fire is common, and heavy rain occurs only in the monsoon season when abundant herbs, especially grasses, appear. Grazing is widespread but Chir Pine needles are not palatable to cattle.

Chir Pine trees and saplings are usually resistant to fire/burning but the shrub layer is more susceptible and therefore poorly developed. Usually, other trees species are not found in this type of forests. The pines are able to expand or maintain their position through infrequent ‘hot’ fires that destroy all competing under-growths. If the fire is frequent and ‘light’, the undergrowth may not be killed but the very young pine seedlings are vulnerable. Under such repeated conditions, Pine stands can be degraded over time.

2.3.3 Warm Broadleaved Forest

Warm broadleaved forest is essentially a type of subtropical forest, but occurs at a higher altitude with a lower rainfall and contains a mixture of evergreen and deciduous broad-leaved tree species. Many tropical genera are absent and more temperate genera appear. The transition from lower into higher zone is gradual. In deeper valleys this formation occurs far into the interior, as in Kholung Chhu valley south of Trashiyangtse. However, it is most abundant throughout southern Bhutan on the hills north of Gelephu and Deothang and in the Mewan chhu valley.

2.3.4 Evergreen Oak Forest

Evergreen Oak forests are a very characteristic feature of some parts of central Bhutan, especially around Trongsa and on the hills above Mongar. They apparently receive lower rainfall than Warm broad-leaved forests and composition varies according to altitude and rainfall. At a lower level, *Castanopsis hystrix* and *C. tribuloides* are often dominant, higher up *Quercus lamellosa* becomes commoners; with increasing dryness more xerophytic *Quercus* species, e.g., *Quercus lanata*, and *Q. semecarpifolia*, and sometimes *Pinus wallichiana* appear. The shrub layer is often poorly represented, whilst the shady humid forest floor is dominated by small herbs, e.g., Urticaceae and bryophytes.

2.3.5 Cool Moist Broadleaved Forests

Cool moist broad-leaved forest occurs above warm broadleaved forest with cooler climate and are generally mixed forest in which oaks are less common, and other trees, both deciduous and evergreen, e.g Lauraceae, *Exbucklandia*, etc., are more abundant together with dense shrubs, climbers and many epiphytes. In Bhutan, Cool Broad-leaved forest is extensive in some of the eastern Dzongkhags (e.g., around Tshilingor-Wamrong–Khaling stretch) and on the steep hillsides of South east of Sengor.

2.3.6 Blue Pine Forest

Blue Pine forest occupies the inner dry valleys of Bhutan where rainfall is very low except during the monsoon season. It is best developed in Haa, Paro and Thimphu valleys in the west and in Bumthang further east. It is often dominant and act as pioneer colonist of burnt or disturbed ground. Tree species commonly associated with Blue Pine are *Quercus griffithii*, *Q. semicarpifolia*, *Q. lanata*, *Populus ciliata*, etc., but many xerophytic shrubs also occur and herbs are common during the monsoon season. There is a gradual transition between this forest type and Evergreen oak forest and with Spruce, Hemlock and Fir forests on the moisture slopes above the main valley. When Blue Pines are found mixed with Spruce, Hemlock and Fir, they get protected from forest fires and often attain a greater stature than in the valleys. It is very susceptible to forest fires.

2.3.7 Spruce Forest

Though Spruce forest is often found mixed with Fir and Hemlock or with Blue Pine, Larch, Oak, Maple, Birch, etc., a separate Spruce forest type can frequently be recognized. Spruce forest generally occupies drier site than Hemlock forest at a similar altitude. Together with Blue Pine, it may form a sort of pioneer forest. It is commonly found in Thimphu, Paro, Haa, Wangdue Phodrang and Bumthang Dzongkhag. *Picea spinulosa* is the common species in western Bhutan, but in Eastern Bhutan, it is found mixed with *Picea brachytyla*.

2.3.8 Hemlock Forest

Hemlock forest is similar to Spruce forest but occupies wetter sites. Shrubby and arborescent Rhododendrons are frequent and the high humidity is ideal for dense growth of epiphytic and terrestrial ferns, lichens and bryophytes. Hemlock mixed with other montane conifers are common. In Bhutan, Hemlock forest is common on the main mountain ridges below the Fir forests, throughout the central and northern part of the country.

2.3.9 Fir Forest

Fir forest is the characteristics of highest forested ridges, where large tracts are covered by virtually no tree species other than scattered Hemlock and Birch patches in some locations. The dense canopy provides a humid environment for a luxuriant understory of Rhododendron and other shrubs, and the mossy ground layer supports many small herbs, e.g., *Primula* species and *Bryocarpum himalaicum*. As in Hemlock forest, in addition to the high rainfall, considerable mist-precipitation occurs from the frequent cloud cover.

2.3.10 Rhododendron-Juniper forest

It is mostly characterized by Rhododendron and Junipers but with rich herb layer appearing during the monsoon. Damp grassy meadow is commonly found in this forest type.

2.3.11 Dry Alpine Scrub

This is characterized by xerophytic vegetation and found higher altitude than Juniper-Rhododendron Scrub

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3. Climate Change and Forests

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3 Climate Change and Forests

3.1 Climate Change and its Impacts

Increasing emissions of Greenhouse gases (GHGs) from industrial development coupled with loss of forests (FAO, 2010) have led to warming up of the Earth and the evidences are clear. The average temperature has risen by almost 0.9°C over the past century and is projected to rise by 2 to 3°C over the next hundred years (Stocker et al., 2013). The warming trend is expected to be more than 0.3°C higher in the mountainous regions like Bhutan (Wester et al., 2018). Climate models show a likely increase in Bhutan's annual average temperature by 1°C from 2010 to 2039, and by 2°C from 2040 to 2069 (NEC, 2011). Small changes in average temperature translates to large and potentially dangerous shifts in weather and climate, termed as Climate Change. As these and other changes become more pronounced, the forest ecosystems are and shall become more vulnerable to climate change impacts.

Bhutan emits approximately 3.814 million tonnes of carbon dioxide annually from the sectors of Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU) and Waste (NEC, 2020) while the net absorption capacity of its forests is 8.539 million tonnes of carbon dioxide annually (DoFPS, 2020), making it one of the few countries with negative carbon emissions. The cornerstone of this achievement is the country's sustainable forest management, strong regulatory measures, effective monitoring and addressal mechanism supported by the constitutional mandate of maintaining a minimum of 60% forest cover. However, Bhutan's status as a neutral carbon emitter does not make it immune to the impacts of climate change. Forest loss has been increasing in the country due to various drivers of deforestation and forest degradation (WMD, 2017). Forest ecosystems and climate change are closely linked as they impact each other. Human-induced climate change threatens forest ecosystems and loss of forest ecosystems intensifies the impacts of climate change (MEA, 2005).

Climate change is already affecting Bhutan's huge biodiversity resources as evident from the increasing incidences of natural hazards (e.g., glacier lake outburst floods, flash floods, droughts and forest fires). The cascading effects in Bhutan are changes in availability of water sources, species composition and variety, altitudinal species range shift, changes in phenology, and increased incidences of invasive species, pests and diseases. Most reports claim that about 70 % of the water sources in the Himalayan region are now half of what they were some years back, while as many as five per cent of the waterfalls that were once a common sight have dried up. Recent report on drying up of springs and water sources, indicates that about 2.3 % have already dried up and 34.1 % are drying in Bhutan.

Climate change increases the incidence of droughts. By reducing plant resistances to biotic disturbances, drought interacts with insect herbivores and pathogens to create coarse scale disturbances. At the global level insects, diseases and severe weather events damaged about 40 million hectares of forests in 2015 mainly in temperate and boreal domains (FAO, 2020). Bhutan already recorded 39 incidences of bark beetle outbreaks between 2004 and 2014. Droughts may also influence forest fire regimes and increase forest fire frequencies as well as intensities. The forest fire incidences of 1998/1999 were caused due to prolonged dryness in the country.

Climate change is anticipated to have great adverse impacts on the natural ecosystems, composition and functions, biodiversity and human livelihoods in the Himalayas (Shrestha et al., 2012; Xu et al., 2009); which shall further affect the diverse range of ecosystem services, vital for self-sustenance of the natural systems and societal wellbeing at large. It is predicted that changes shall first happen at boundaries between different ecosystems. In the alpine ecosystem, there are indications of increasing area under

Juniper scrub forests while availability of alpine plants is decreasing (RGoB, 2011). The receding glaciers and less availability of snow water will also impact the alpine vegetation in terms of change in species composition, structure and function of alpine meadows and might lose economically important species. There is also record of Blue Pine encroaching into Spruce/Maple/Birch forests and the report on the upper limit of ever-green broadleaved forest being strongly correlated to winter temperature (Wangda & Ohsawa, 2006) and thus the probability of shifting the upper limit with increasing temperature exists. However, with rising temperature and moisture stress, the fir forests (which already suffered mortality in 1980 due to moisture stress (Gratzer et al., 1997)) and the montane cloud forests of Bhutan (Wangda & Ohsawa, 2010) become highly vulnerable.

Climate change also impacts species in terms of changes in distribution and population status. The threatened, vulnerable and endemic species are most at risk due to climate change. For instance, the shrinkage of alpine ecosystems shall threaten the existence of animals like Himalayan field mouse and other high-altitude animals. The increasing encroachment by invasive species (RGoB, 2011) which are expedited by climate change shall lead to decline in native species diversity and fodder for the animals. The invasive species are also known to invade freshwater ecosystems and have ramifications on the native aquatic species.

Climate change can disrupt the provision of various ecosystem services from forests and this is serious threat for a country like Bhutan where the ecosystem services are vital to sustain rural livelihoods and national development (Tenzin, 2016). Therefore, as a highly vulnerable country, it is recommended to be better prepared to reduce the impacts of the climate through various climate change adaptation and mitigation initiatives.

3.2 Climate Change Adaptation and Mitigation Initiatives

Climate Change Adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change.

Climate Change Mitigation refers to the activities that are carried to reduce the greenhouse gas concentrations in the atmosphere. Mitigation can happen through efforts aimed to reduce emissions and enhance sink to increase carbon dioxide removals from the atmosphere.

With blessing of the visionary Monarch, Bhutan has always stressed on sustainably managing and conserving the forest resources because of which many policies and action plans were developed. Various policies and action plans have led to conserving and managing the rich biodiversity of the country and have provided the required adaptation and mitigation measures to climate change. All these documents also recognize that addressing climate change, achieving environmental, economic and social aspects of sustainability requires a multifaceted approach from all sections of society both at national and international level.

At international level, there are various initiatives aimed at bringing parties together in jointly combating climate change. Bhutan is party to the United Nations Convention on Biological Diversity (UNCBD), United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention to Combat Desertification (UNCCD), and United Nations Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES). Bhutan participates in such international forums so as to contribute in tackling climate change impacts as well as benefiting from the international communities for mitigation and adaptation towards climate change in the Country.

3.2.1 National Strategy and Action Plan for Low Carbon Development

The RGoB made a commitment to remain carbon neutral for all times to come in 2009 at the UNFCCC COP 15 held at Copenhagen. In order to fulfil the commitment, RGoB prepared the National Strategy and Action Plan for Low Carbon Development in 2012. The main aim of the strategy was to ensure that the national emissions of GHG remain less than the national sequestration capacity of the forests by maintaining forest sink capacity and at the same time making efforts to reduce emission from the other sectors. The strategy provides various scenarios analyzing the development paths from 2005 till 2040 and presents a number of short- and medium-term interventions against each scenario to achieve sustainable economic development through green growth. Additionally, to compliment the strategy, low emission development strategy for three sectors (Transport sector, Urban and Rural Settlements in Bhutan and Industrial) with high emission potential have been developed.

3.2.2 Nationally Determined Contribution (NDC)

In 2015, Bhutan ratified the Paris Agreement with a pledge to strengthen the global response to the threat of climate change by keeping a global temperature rise in this century well below 2 degrees Celsius. As part of the agreement, Parties are required to submit how they intend to achieve the maintenance of global target below 2 degree Celsius in the form of Nationally Determined Contributions (NDCs), which describes the climate actions of each Country post 2020. Each NDC reflects the country's ambition for reducing emissions, taking into account its domestic circumstances and capabilities.

As a party to the Paris Agreement, Bhutan submitted its NDC to UNFCCC in 2015 (NEC, 2015). The NDC builds on the carbon neutral pledge which Bhutan had made at COP 15 at Copenhagen whereby, Bhutan committed to remaining carbon neutral with sustained global support. Based on existing strategies and action plan, the NDC identifies 10 key priority areas under the adaptation and 9 key priority areas under the mitigation as shown in Box 3.1.

| | |
|------------|---|
| Adaptation | <ol style="list-style-type: none">1. Increase resilience to the impact of climate change on water security through Integrated Water Resource Management (IWRM) approaches.2. Promote climate resilient agriculture to contribute towards achieving food and nutrition security.3. Sustainable forest management and conservation of biodiversity to ensure sustained environmental services.4. Strengthen resilience to climate change induced hazards.5. Minimize climate-related health risks.6. Climate-proof transport infrastructure against landslides and flash floods, particularly for critical roads, bridges, tunnel and trails.7. Promote climate resilient livestock farming practices to contribute towards poverty reduction and self-sufficiency.8. Enhancing climate information services for vulnerability and adaptation assessment and planning.9. Promote clean renewable and climate resilient energy generation.10. Integrate climate resilient and low emission strategies in urban and rural settlements. |
| Mitigation | <ol style="list-style-type: none">1. Sustainable Forest Management and Conservation of Biodiversity to ensure sustained environmental services.2. Promotion of low carbon transport system.3. Minimize GHG emission through application of zero waste concept and sustainable waste management practices.4. Promote green and self-reliant economy towards carbon neutral and sustainable development.5. Promote clean renewable energy generation.6. Promote climate-smart livestock farming practices to contribute towards poverty reduction and self-sufficiency.7. Promote climate smart agriculture to contribute towards achieving food and nutrition security.8. Energy demand side management by promoting energy efficiency in appliances, building and industrial processes and technologies.9. Integrate climate resilient and low emission strategies in urban and rural settlements. |

The NDC emphasizes the importance of adaptation and mitigation for Bhutan's forests, given future climate change impacts on its mountainous ecosystems. For Bhutan to remain carbon neutral and to keep the emissions on track as specified under the mitigation mechanism, forest sink capacity has to be maintained and managed while efforts have to be made to reduce emission from the other sectors as per the key priority areas provided in the NDC.

3.2.2.1 Priority 1: Sustainable management and conservation of ecosystem services through:

- Sustainable management of Forest Management Units (FMUs), Protected Areas (PA), Community Forests (CF) and Local Forest Management Area (LFMA).
- Enhancing forest information and monitoring infrastructure through periodic national forest inventories and carbon stock assessments
- Forest fire, Pest & diseases management and rehabilitation of degraded and barren forest lands

Under the adaptation, the following priority areas and strategies for the forestry sector are mentioned:

3.2.2.1.1 Priority 1: Increase resilience to the impacts of climate change on water security through Integrated Water Resource Management (IWRM) approaches including:

- Water resources monitoring, assessment, and mapping
- Integrated watershed and wetland management

3.2.2.1.2 Priority 2: Sustainable forest management and conservation of biodiversity to ensure sustained environmental services through:

- Sustainable management of Forest Management Units (FMUs), Protected Areas (PA), Community Forests (CF), Local Forest Management Area (LFMA), and private forests

3.2.2.1.3 Priority 4: Strengthen resilience to climate change induced hazards through:

- Forest fire risk assessment and management.
- Assessment and management of risk and damage from windstorms on agricultural crops and human settlements.
- Forest Pest and diseases risk assessment and management.

3.2.3 National Adaptation Programme of Action (NAPA)/National Adaptation Plan (NAP)

In recognition of the vulnerability of forests, water systems, glacial flows and agricultural production, the RGoB prepared a National Adaptation Plan of Action in 2006 (NEC 2006). This plan helps to prioritize medium to long-term climate risks and provides appropriate response measures for implementation. The NAPA, 2006 was updated in 2012 and 2017 to identify other following priority areas:

- Landslide Management and Flood Prevention
- Disaster Risk Reduction and Disaster Management Planning Interventions; and providing emergency medical services to vulnerable communities
- Enhancing National Capacity in Weather Stations and Seasonal Forecasting in Bhutan
- Application of Climate-Resilient and Environment-Friendly Road Construction Nationwide
- Community-Based Food Security and Climate-Resilience
- Flood Protection of Downstream Industrial Areas
- Rainwater Harvesting and Drought Adaptation, and
- Community-Based Forest Fire Management and Prevention.

The National Adaptation Plan of Action compliments existing regulatory and policy instruments that are geared towards protecting the environment. Based on the NAPA 2006, 2012 and 2017, certain priority projects were implemented. Bhutan has also initiated developing a long-term adaptation plan

called the National Adaptation Plan (NAP). The NAP and NAPAs shall provide guidance in implementing the climate change adaptation activities. Under NAPA-2006, only promotion of community-based forest fire management and prevention was included as one of the prioritized projects targeted to reduce the risk of forest fires. This activity was implemented as part of revised NAPA-2012.

3.2.4 Reducing Emission from Deforestation and Forest Degradation and the role of Conservation of forest carbon stocks, Sustainable Forest Management and Enhancement of forest carbon stocks (REDD+)

REDD+ stands for countries' efforts to reduce emissions from deforestation and forest degradation, and foster conservation, sustainable management of forests, and enhancement of forest carbon stocks. REDD+ is a mechanism developed by Parties to the UNFCCC. It creates a financial value for the carbon stored in forests by offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. Developing countries would receive results-based payments for results-based actions.

The REDD+ in Bhutan builds on the strong foundations in environmental, forestry and land use policies and institutional arrangements that are pre-existing and substantially contribute to REDD+ readiness. The main goals and objectives of the Bhutan REDD+ Programme are to:

- prepare the country to engage in, and benefit from results-based payments (if feasible);
- strengthen existing forest policy and management systems, information, data, participation, methods, and other human and institutional capacity for management and development of forests in Bhutan.

As part of the REDD+ readiness preparation, Bhutan has developed the following components as required by the Warsaw REDD+ implementation framework:

- National REDD+ Strategy & Action Plan which outlines the policies and measures to reduce emissions from the forestry sector and increase forest carbon stock for sequestration of CO₂e from other sectors
- National Forest Monitoring system to track forest cover changes over time
- National Forest Reference Emission Level (FREL) /Forest Reference level (FRL) to track the performances of Bhutan's effort to reduce emission and increase carbon stock
- Safeguard framework to prevent negative impacts of mitigation activities

REDD+ represents an opportunity for Bhutan to reduce deforestation and forest degradation, strengthen a number of climate change response measures across a range of areas, as articulated in the Policies and Measures (PAMS) outlined in the National REDD+ Strategy & Action Plan. The National REDD+ Strategy & Action Plan shall serve as the low emission development strategy for the forestry sector so as to ensure that carbon emission from the forestry sector is within the established baseline of the FREL and FRL.

In order to ensure the low emission from the forestry sector, 10 PAMS along with key actions are proposed, which are listed below:

1. Strengthen institutional and sectoral capacity to achieve sustainable forest management
2. Strengthen the effectiveness of existing policies and approaches
3. Strengthen cross sectoral land use planning, coordination and collaboration
4. Strengthen EIA processes for infrastructure proposals

5. Achieve a highly diversified and technology-based timber supply chain
6. Adopt fire management approaches that limit impacts on the environment and communities
7. Establish plantations to provide sustainable wood-based products supply, increase carbon stock and enhance biodiversity
8. Promote the development of enterprise that sustainably manage NWFP
9. Broaden opportunities for income generation from ecosystem services
10. Develop climate smart approaches in agriculture

There is an urgent need to incorporate climate smart provisions/aspects on how we manage our forest ecosystems and natural resources henceforth. All management plans in the future must be climate-smart and include all aspects of adaptation and mitigation of the various climate change impacts. It is also critical for Bhutan, with a forest cover of more than 70% and an ambitious goal of staying carbon neutral, to emphasize on research and development to understand the future imminent risks to the forest's ecosystems.

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4. National Forest and Biodiversity Monitoring System

National Forest Monitoring System

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4 National Forest and Biodiversity Monitoring System

4.1 Introduction

The Constitution of the Kingdom of Bhutan, 2008 requires maintaining 60% of the total geographical area of the country under forest cover in perpetuity. This important constitutional wisdom is intended to ensure long term environmental sustainability; and secure the needs and wellbeing of the present and future Bhutanese citizens. Therefore, appropriate plans, programs and strategies are being implemented by the Department of Forests and Park Services (DoFPS) to monitor changes over time, both in terms of extent and quality.

Notwithstanding this national requirement, Bhutan as a member of United Nations Framework Convention on Climate Change (UNFCCC) and responsible party working towards containing global climate change, endeavors to establish and implement National Forest Monitoring System (NFMS), which is envisaged to enable monitoring the loss and/or gain of the forest cover over the period of time. Various tools and techniques such as field based National Forest Inventory (NFI) and Remote Sensing (RS) & Geographic Information System (GIS) are utilized to monitor the changes. With time, new improved tools and techniques are envisaged to emerge with which the NFMS can be further improved. Therefore, new and emerging techniques and technologies should be adopted as and when they become available to monitor forest cover changes overtime.

Further, area and species-specific Biodiversity monitoring works were carried out. However, many other diverse taxa like the small mammals, invertebrates, herpetofauna were least studied and their monitoring has been given due importance. As such the ecological significance and benefits accrued from the biodiversity is also not adequately understood in Bhutan. The lack of full knowledge on the vastness of the diversity that exists within the country can be attributed to lack of full-scale inventory of biodiversity, the lack of standard survey methodologies, monitoring protocols, and data management systems. Therefore, the Department recognizes biodiversity monitoring in the Protected Areas (PA) and Divisional Forest Offices (DFO) as an important requirement.

4.2 National Forest Monitoring System

4.2.1 National Forest Inventory (NFI)

The National Forest Inventory (NFI) involves collecting data and information on forests and allied resources for compilation, assessment and analysis to enable appropriate policy and appropriate management decisions. The assessment covers a large range of biophysical and socio-economic variables and thus, provides a broad and holistic view of land use for the country as a whole. In particular, the information shall be used to plan, design and implement national policies and strategies for sustainable use and conservation of forestry ecosystems, and also to understand the relationship between forest and tree resources and users.

NFI is envisaged to provide a clear picture of the condition of the forests, the species composition, standing volume, increment, etc. NFI in combination with the RS tools and techniques shall enable monitoring of changes in forest cover and forest resources over time. NFI carried out between 2009-15 provided the quantitative baseline required for sound forest management in the country. Periodic NFI shall ultimately lead to proper understanding of the forest dynamics which in turn shall lead to formulation of sound policies and implementation of appropriate programs on sustainability, development of appropriate technology, proper monitoring, etc. Periodic NFI combined with RS

technology shall enable much faster, cost effective and more precise monitoring of Bhutan's forests which shall help to ensure maintaining 60% forest cover for all time as mandated by the Constitution.

NFI is also a requisite exercise of Measuring, Reporting, and Verification (MRV) Component of National Forest Monitoring System (NFMS) of REDD+ program. The objectives and methodology for the conduct of NFI is explained in detail in Chapter 2 (National Forest Inventory) under Volume II (National Forest Resources Assessment) of this *Code*.

4.2.2 Remote Sensing and Geographic Information System

Remote Sensing (RS) is the science of acquiring information about the Earth's surface without actually being in contact with it. Most frequently used RS data includes optical satellite, lidar and radar imageries. Optical satellite imageries are based upon the principle of reflected sunlight. It is a passive remote sensing technology and the amount of sunlight that satellite can remotely sense is dependent on the reflectivity of the surface of which the sunlight is reflecting. Light Detection and Ranging (Lidar) is active remote sensing technology that measures distance to a target by illuminating the target with laser light and measuring the reflected light with a sensor. Radio Detection and Ranging (Radar) is an active RS detection system that uses radio waves to determine the range, angle, or velocity of objects. Radar technology produces images of an area independent of solar illumination and are not affected by cloudy or dusty conditions as in the case of optical RS instruments.

Geographic Information System (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data. RS and GIS are complementary technologies that, when combined, enable improved monitoring, mapping, conservation and management of forest and wildlife resources.

The use of RS in forestry and wildlife conservation have steadily increased, promoted largely by better integration of satellite imagery with GIS technologies and databases, as well as implementations of the technology that better suits the information needs of the forest and wildlife managers. The most important forest information obtained from integration of RS and GIS can be broadly classified into following categories:

- Detailed forest inventory data
- Monitoring of forest health and natural disturbance
- Assessment of forest structure in support of sustainable forest management
- Monitoring and mapping of landscape ecology, wildlife habitat and biodiversity

Forest inventory is primarily based on stand boundaries derived from interpretation of satellite imagery. Stand boundaries are vector-based depictions of homogeneous units of forest characteristics. These stand polygons should be described by a set of attributes that typically includes species composition, stand height, stand age and crown closure. Lidar has vast potential for direct measurement and estimation of several key forest characteristics. Lidar is used to measure and map canopy height, sub-canopy topography and the vertical distributions of intercepted surfaces between the canopy top and the ground. The other forest structural characteristics, such as above ground biomass are modelled or inferred from these direct measurements. Radar data at higher incidence angles has potential applications in characterizing forest vegetation parameters such as tree height, basal area and total tree biomass. Radar should be used for forest cover mapping, monitoring and estimation of total above-ground forest biomass.

Fire, insects and disease are among the major natural disturbances that alter the forest landscape. Integrated RS and GIS supports the detection and mapping of pest and disease outbreak and damaged

areas. Modelling and prediction of outbreak is carried out to provide data on GIS-based pest management decision support systems. Integrated RS and GIS fire support systems are used in real-time, near real-time and post fire application. Near real-time RS and GIS systems are used on daily observations from coarse resolution satellites such as the AVHRR (1 km pixel) and MODIS (250 m to 1 km pixel) to detect fire hotspots by DoFPS. Post fire applications largely entail mapping the extent of burnt area from satellite imagery and assessing the fire damage to vegetation.

Land use and land cover information is readily obtained by classifying the remotely sensed data. Remote Sensing can provide repeatable and consistent methods to develop these data layers such that changes over time can be monitored. The improvements in forest management also depend on increased understanding of ecological processes within the carbon, nutrient and hydrological cycles. Remotely sensed data provides key inputs to models of carbon flux.

The use of remotely sensed data together with other spatial dataset integrated within a GIS environment can greatly enhance the habitat assessment and monitoring process. GIS and RS plays a vital role in wildlife analysis and modelling. RS and GIS technology can also be used in mapping the endangered species to understand the environmental factors responsible for extinction of species.

In the last decade, unmanned aerial systems popularly known as drones have been the subject of growing interest in both the civilian and scientific spheres and indeed taken remote sensing technology to a greater height for study of the environment. Drones offer a relatively risk-free and low-cost technology to systematically observe natural phenomena at high spatial-temporal resolution. Because of these reasons, drones have tremendously gained popularity in forest and wildlife monitoring. Compared with satellite and airborne RS technologies, drones can fly at low altitude and at low speed, allowing them to take ultra-high spatial resolution (1-20cm) imagery and thereby collect near to earth data on biological and biophysical variables. Use of drones also avoids many limitations associated with satellite data, including the lack of sufficient spatial resolution to detect and measure certain biophysical properties, lack of sufficient temporal resolution to detect changes in phenology and stand structure due to disturbance events, and long duration cloud contamination. Application of drone in forestry comprises of:

- Forest Type Mapping for planning
- Canopy Gap Mapping for monitoring illegal logging
- Mapping land use change to detect deforestation
- Mapping forest degradation
- Mapping outbreak of pest and diseases
- Mapping wildlife habitat, habitat fragmentation and degradation
- Monitoring wildlife
- Rescuing wildlife
- Detecting traps set poachers
- Forest fire mapping and monitoring
- Mapping plantation and monitoring
- Mapping natural regeneration and monitoring
- Mapping forest and studying species shift forest dynamics

4.2.3 Spatial Decision Support System

Spatial Decision Support System (SDSS) is an interactive, computer-based system designed to support a user or group of users in achieving a higher effectiveness of decision making while solving a semi-structured or unstructured spatial decision problem which are characterized by many actors, many

possibilities, and high uncertainty. This system integrates database management systems with analytical models, using expert knowledge, where analysis and result could be viewed through graphical display.

SDSS is divided into two components viz. DoFPS spatial database and Decision Support System (DSS) tool kit to support decision making in issuance of forestry clearance in Bhutan. DoFPS spatial database is hosted on a server at Government Data Center (GDC), Serbithang, Thimphu. A spatial database is a database that is optimized for storing and querying data that represents objects defined in a geometric space. Spatial database allows the representation of geometric objects such as points, lines and polygons. All of DoFPS spatial data is stored in the DoFPS spatial database. The database includes a portal to view the integrated data and the access to data is limited to only forestry personnel with defined user rights.

DoFPS is authorized to issue forestry clearance for any developmental activities falling within the State Reserved Forest (SRF) land. Issuing forestry clearance at times is a complex process which requires making spatial decisions. The process of how spatial database is integrated with field situation leading to an unbiased spatial based decision is depicted in figure 4 below.

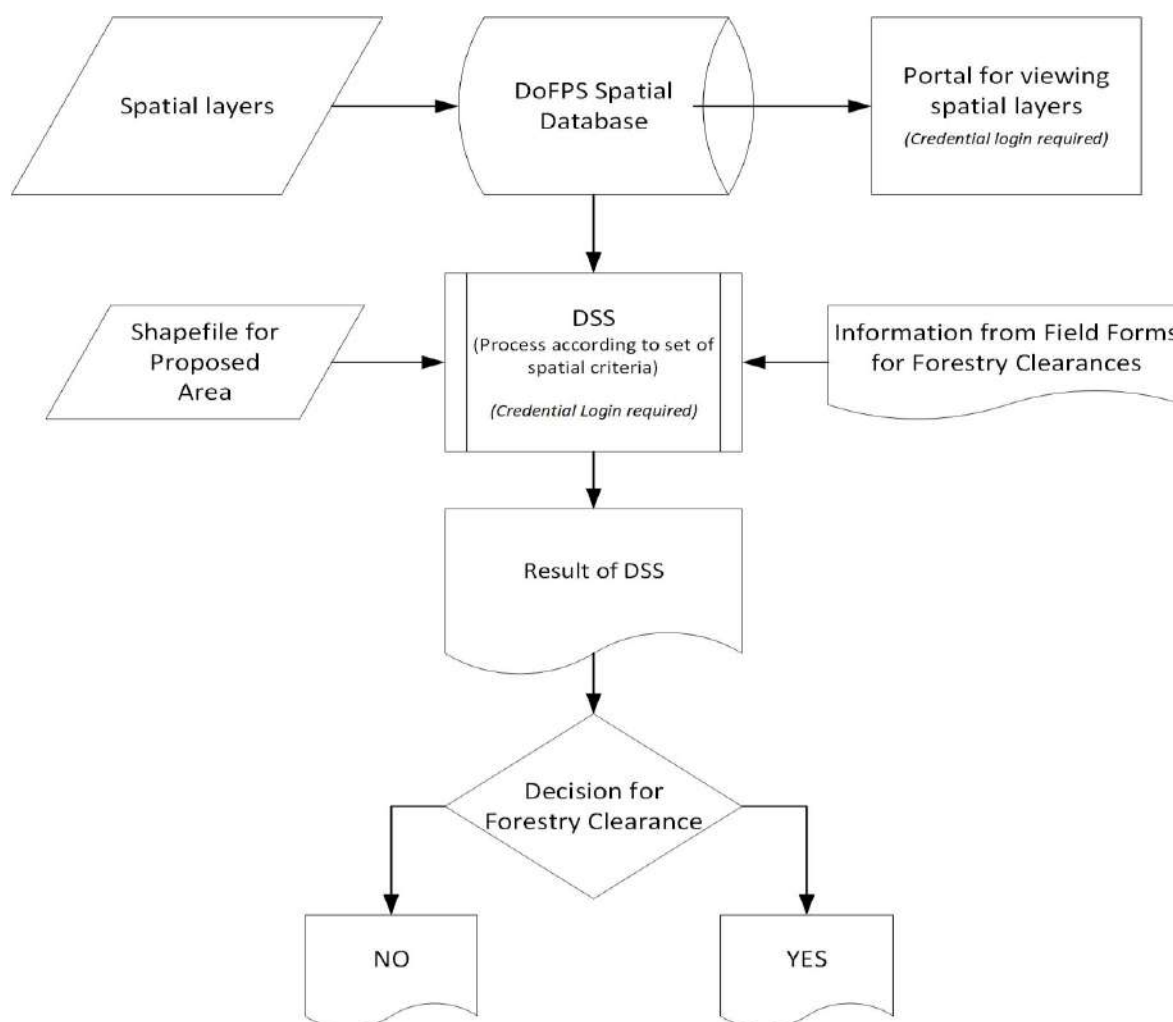


Figure 4.1 SDSS

Spatial decision making requires information produced from numerous sources and gauging against multiple factors that cannot be captured by the ordinary process. The DSS tool kit pulls the relevant spatial data from the database and performs multicriteria analysis using decision rules to provide necessary information for making decisions. The tool kit is web-based and accessibility to the system is limited to only forestry personnel with defined user rights.

4.2.4 Spatial Monitoring and Reporting Tool (SMART)

SMART is an interactive interface wherein, decisions of the management administered during SMART patrol planning can be physically implemented by the SMART patrol team at various levels. Whatever activities are planned can be documented and presented back to management in form of raw data or information analyzed within the SMART interface. Unlike other software, SMART has diverse functionalities including data collection, storage and analysis. Moreover, the SMART software is open source and periodically gets reviewed/updated.

Therefore, the national SMART data model is designed to cover all forestry and conservation services as spelt out in the Forest and Nature Conservation Rules and Regulations (FNCRR) 2017, 2020 and other technical regulations.

The scope of SMART implementation encompasses the following:

- Taking spatio-temporal stock of all forestry and conservation services and monitoring activities of the DoFPS for desired inferences.
- Delivering data for informed decision making at various levels for better planning and management of forest and wildlife resources.
- Curbing poaching and illegal forest resource harvesting by strategizing staff deployment based on spatio-temporal trend analysis and hotspot mapping.
- Encouraging, motivating and incentivizing hard working rangers through the individuals' quantum of services rendered for management, monitoring and conservation of the country's forest and wildlife resources.

In addition, the level of SMART implementation across the PAs and DFOs is not uniform, some PA and DFO have reached advanced stages while others are just initiating. Hence, the requirement of National SMART Implementation Protocol (NASIP) is crucial to standardize the overall SMART implementation and information management across all implementers under the Department.

4.2.5 Forest Information Reporting and Monitoring System

Forest Information Reporting and Monitoring System (FIRMS) is an online database system designed to streamline the information management system of the Department. FIRMS is an updated version of the erstwhile Forest Information Database and is aimed to capture all information and data pertaining to the forestry resources and services and facilitate in planning, monitoring and evaluation of programs and subprograms. Protocols on flow of forestry data/information are shown in figure 4.2.

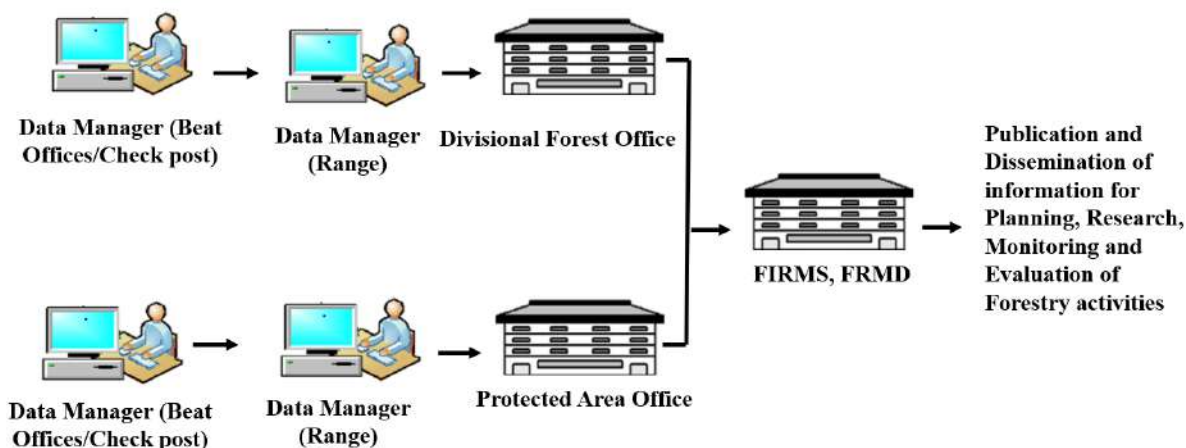


Figure 4.2 FIRMS information flow

It collects information on all core services provided by the Department besides maintaining information of the core programs of the Department. It is a multi-tier system whereby data are punched in by front line staff on a real time basis. Information punched in by the data manager in all field offices are cleaned and verified by the respective field and functional divisions. The Department uses the forestry data for analysis and publication of the annual forestry statistics besides submission of country level information to national and international offices. Further, baseline and progress achievement information for planning and policy formulation including the FYP are fed through the FIRMS (Figure 4.2).

4.3 National Biodiversity Monitoring

4.3.1 Background

Bhutan's location in the Eastern Himalayan biodiversity hotspot (Myers et al. 2000) coupled with great altitudinal variation, is endowed with remarkable biodiversity and ecosystem complexity (Gillison, 2012). While Bhutan prides in its rich biodiversity, knowledge on the vastness of the diversity that exists within the country is limited (NBC, 2019). Therefore, full scale inventory to capture the wealth of the country's wild biodiversity is a priority. Maintaining biodiversity is important as there is limited knowledge on which individual species is critical for sustaining the ecosystem or which individual species may be useful in the future. Most of the biological resources are useful for human sustenance through provision of natural products and genetic material while some can serve as ecological indicators (Heller & Zavaleta, 2009).

While the country is biologically diverse, most of the surveys and researches were limited to taxonomic groups such as mammals, birds, and plants. The most bio-diverse groups by far are the invertebrate groups, including taxa such as molluscs, dragonflies and damselflies, beetles, bees and wasps, true flies, moths and butterflies. However, these groups remain largely unstudied (NBC, 2019). As such the ecological significance and benefits accrued from the biodiversity is also not well-understood in Bhutan. Of the known species, most of the information comes from the protected areas whereas biodiversity checklist from the Divisional Forest Offices is rare. Bhutan completed its first NFI focusing largely on the traditional parameters such as forest cover, basal area, tree count and growing stock in 2016 (FRMD, 2018) with less focus on the true wildlife diversity of the country. Similarly, national level wildlife surveys such as the National Tiger Survey, National Snow Leopard Survey and National Elephant survey were too focused on the target species and did not cover the biodiversity assessment of other taxa. Therefore, the Department recognizes biodiversity monitoring programmes in the PA and DFOs

as an important requirement using standard protocols and methods. Furthermore, given the significance of the people's participation in conservation and management of natural resources including wild biodiversity, social surveying protocol is developed to understand their socio-economic status and perceptions towards conservation.

This section outlines the monitoring protocol for six broad taxa, namely, mammals, birds, insects, aquatic biodiversity, herpetofauna, and plants. Among the mammals, monitoring programme shall be conducted for different mammal groups such as large mammals, small and medium sized terrestrial mammals, and volant mammals. For, plants, birds, fishes, and herpetofauna, a general taxa-based monitoring programme shall be done. However, for insects, current monitoring programme shall focus on five groups of insects: *Coleoptera*; *Hymenoptera*; *Odonata*; *Lepidoptera*; *Orthoptera*.

4.3.2 Objectives

The main objectives of developing the Biodiversity Monitoring and Social Surveying Protocol of Bhutan is to set a standard tool for monitoring the biodiversity in the country and assess the socio-economic status of people who depend on the biodiversity for their livelihood. With biodiversity monitoring and social surveying programme instituted using the standard protocols, the programme should strive towards achieving the following aims;

- i. Establish a baseline data for species diversity across broad taxa in each PA and DFO, which shall lead to the development of national biodiversity database.
- ii. Understand the distribution, occupancy and habitat use of the species in Bhutan.
- iii. Record temporal and spatial changes (effect of climate change) in relation to the baseline data.
- iv. Assess socio-economic status of the people depending on wild biodiversity.
- v. Understand the people's perception towards changes in natural ecosystems, and their perception towards conservation.

4.3.3 Scope and Limitations

This is intended to serve as a guide for periodic monitoring of biodiversity and understanding socio-economic conditions of people who depend on biodiversity for their livelihood. In addition, the protocol can also be utilized to conduct periodic surveys for developing conservation management plans and during opportunistic monitoring of the species while conducting various surveys and patrolling.

However, for specific scientific research purposes, techniques and methods can deviate from what has been prescribed in this protocol. Protocol of each taxa is expected to guide in laying the sub grids within the national grids. However, depending on the species of focus and objectives of the monitoring, field survey layouts and field techniques should be adapted to fit in the sampled national survey grids.

While efforts should be put to conduct annual monitoring of biodiversity in the sampled grids by allocating resources by respective PA and DFOs, monitoring should also be aligned with other wildlife surveys and researches as an opportunistic measure. This is particularly important owing to the limited resources to conduct annual monitoring programmes separately. There is the urgency to assess the trends in biodiversity change in the face of anthropogenic disturbances and climate change impacts.

4.3.4 Data management systems

Effective management of data collected over various surveys and researches has always been a challenge in the Department. Lot of costs are entailed in conducting various biodiversity surveys, wildlife surveys and socio-economic surveys resulting in huge quantities of data being collated over the

years, especially in PAs for developing its management plans. However, data storage and sharing among the agencies is very weak, which makes comparative analysis from periodic surveys very difficult. It is, therefore, important that data obtained from various wildlife and biodiversity surveys including social surveys are securely stored and effectively managed.

4.3.4.1 Data storage

The data generated from biodiversity monitoring surveys and socio-economic surveys should be securely stored at the respective PA and DFOs while a copy each should be submitted to the data repository center of the Department and NCD. The data collected during each monitoring programme and survey should be sequentially stored. Both raw data and processed data should be stored with clear reference points and all raw data in analogue form should be transformed into digital format. Irrespective of the data storage stations, the ownership of the data shall remain with the department and sharing and usage of the stored data will require prior approval of the department. For biodiversity data, data storage should be strictly referenced to the Biodiversity Monitoring Grid (BMG), while data arising from social survey should be referenced to the villages and gewogs within the dzongkhag. Biodiversity data should be stored as per the following schematic diagram;

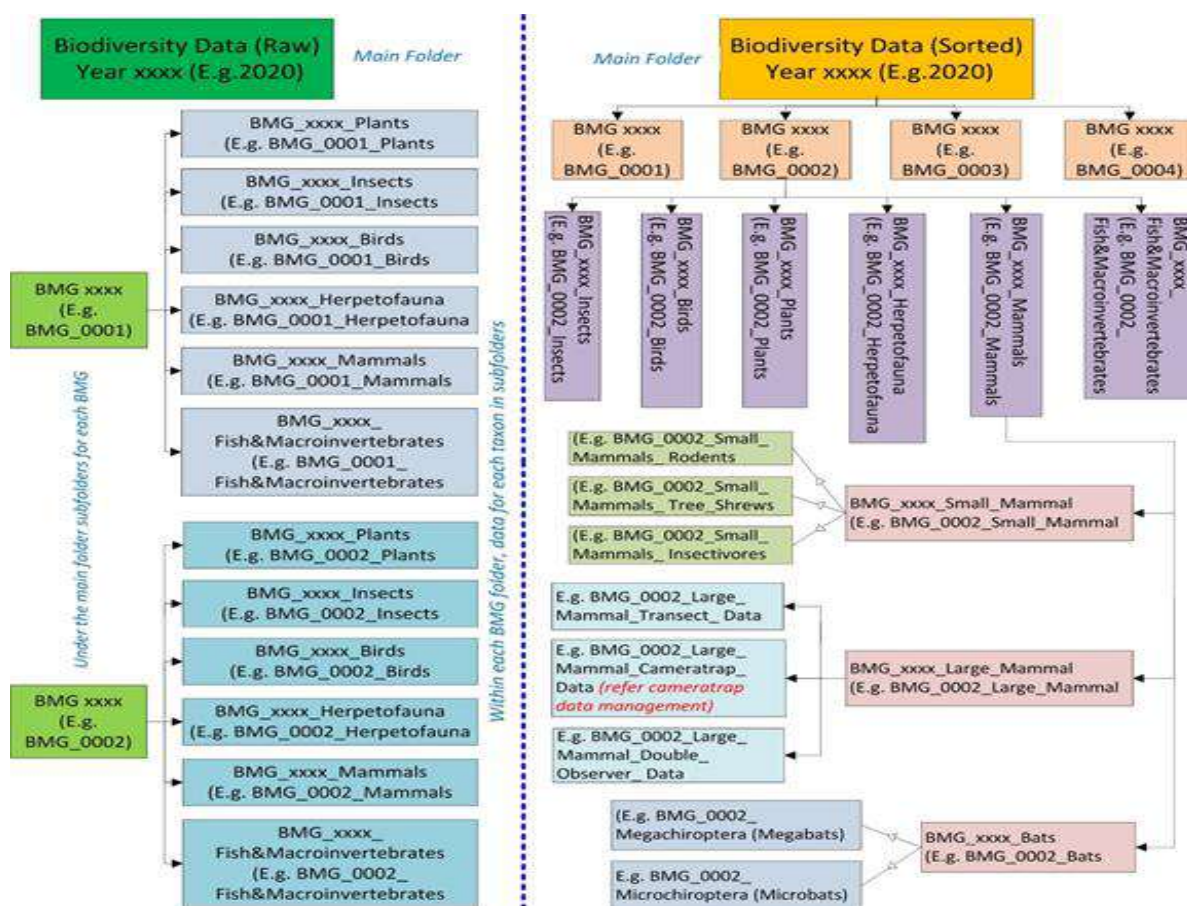


Figure 4.3 Diagram showing the general data management guide for biodiversity data for each field office

4.3.4.2 Data sharing

Data sharing is an important part of the overall data management plan. The department shall classify data into different categories and make the non-sensitive data accessible to the general public based on requests made to the Department and the Department shall reserve the right to charge on the shared data. The data user should follow the terms and conditions prescribed by the Department and should

give due credits and authorship to original data sources. For foreigners, access to data shall be restricted unless there is formal representation by a national counterpart and the national counterpart shall ensure that the data is not misused and used only for the stated research purpose mentioned in the initial application.

4.3.4.3 Data Use and Ethics

The data should be used for producing reports at the respective field offices on the status of biodiversity and socio-economic condition. At the national level, national biodiversity and socio-economic status reports should be produced at least once in five years. Reports should be produced with highest ethical standards and should portray the actual species and ecosystems dynamics and socio-economic status as revealed by the data. Reports and publications should be peer reviewed by the national and external subject specialists, and finally endorsed by the Department.

For the third-party users who acquired the data from the Department, the data shall be used only for the purposes as specified in their application form and as approved by the Department. Under no circumstances, the primary data shall be altered or falsified. Any users using the data or information leading to any publications such as journal papers, reports, online publications, books, etc. should give due acknowledgement to the Department. In the case of any publication produced by using the data under this framework by a research team who has members from a foreign country, the first authorship shall be given to the Bhutanese counterpart in addition to providing due acknowledgement of the data source.

4.4 National Forest and Biodiversity Monitoring System

4.4.1 Biodiversity Monitoring Protocols

4.4.1.1 Reference Grid

Biodiversity monitoring shall be an annual event and confined in the Biodiversity Monitoring Grids (BMG) of 4x4 km (

Figure 4.4). This grid corresponds to the 4X4 km grid around the National Forest Inventory (NFI) Cluster Plot, and as such, the NFI Plot ID number shall be used for Biodiversity Monitoring Grid (BMG) as well. However, there is difference between NFI Cluster Plot and BMG. The NFI Cluster Plots are fixed plots for carrying out inventory of forest resources at regular intervals for multipurpose forest ecosystem health monitoring whereas, BMG is a fixed grid with the elbow plot of the NFI Cluster plot in the centre of the BMG. Biodiversity monitoring can be confined within the BMG and not necessarily on a predefined site in the grid. There are a total of 2424 Biodiversity Monitoring Grids assigned across the country, with grid numbers starting from 0001 to 2424. However, since the monitoring of biodiversity shall be a periodic event, monitoring shall be done in a few sampled grids in each Field Offices (Protected Area (PA) and Divisional Forest Offices (DFO) after stratified random sampling of the grids across different habitats and elevation gradients. Efforts shall be made to monitor the biodiversity in the same grids during the subsequent monitoring. For taxa specific sampling design within the sampled grids, methods prescribed in the taxa-based Monitoring Protocol shall be used.

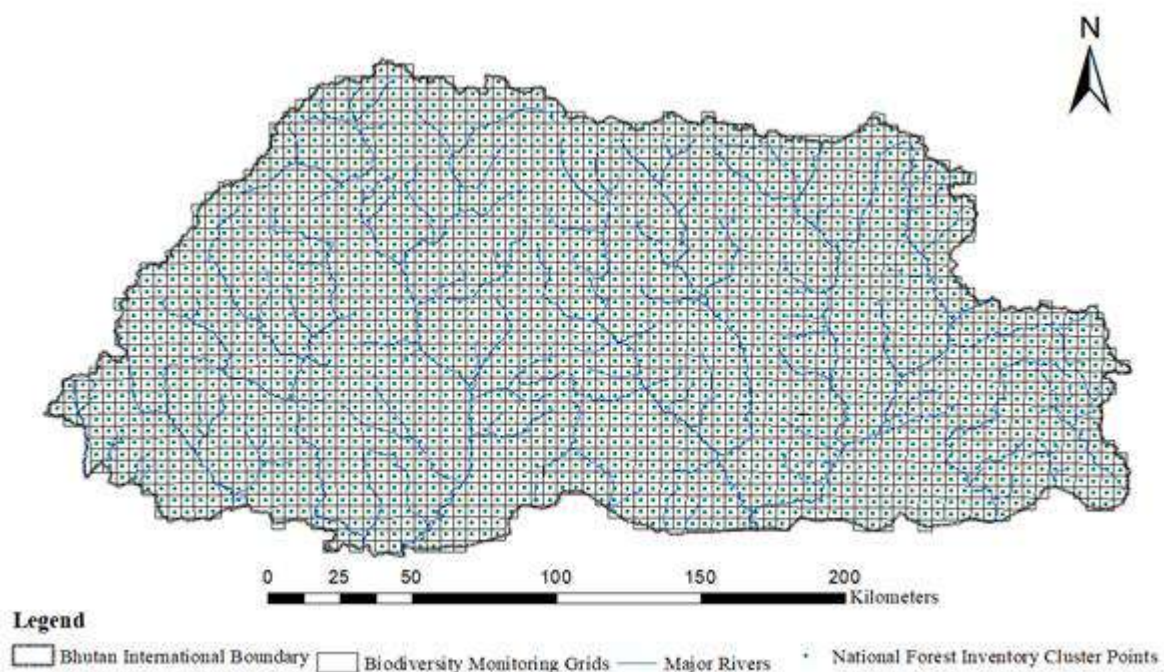


Figure 4.4 Biodiversity Monitoring Grids of Bhutan (Actual monitoring shall be done in sampled grids in each PA and DFO).

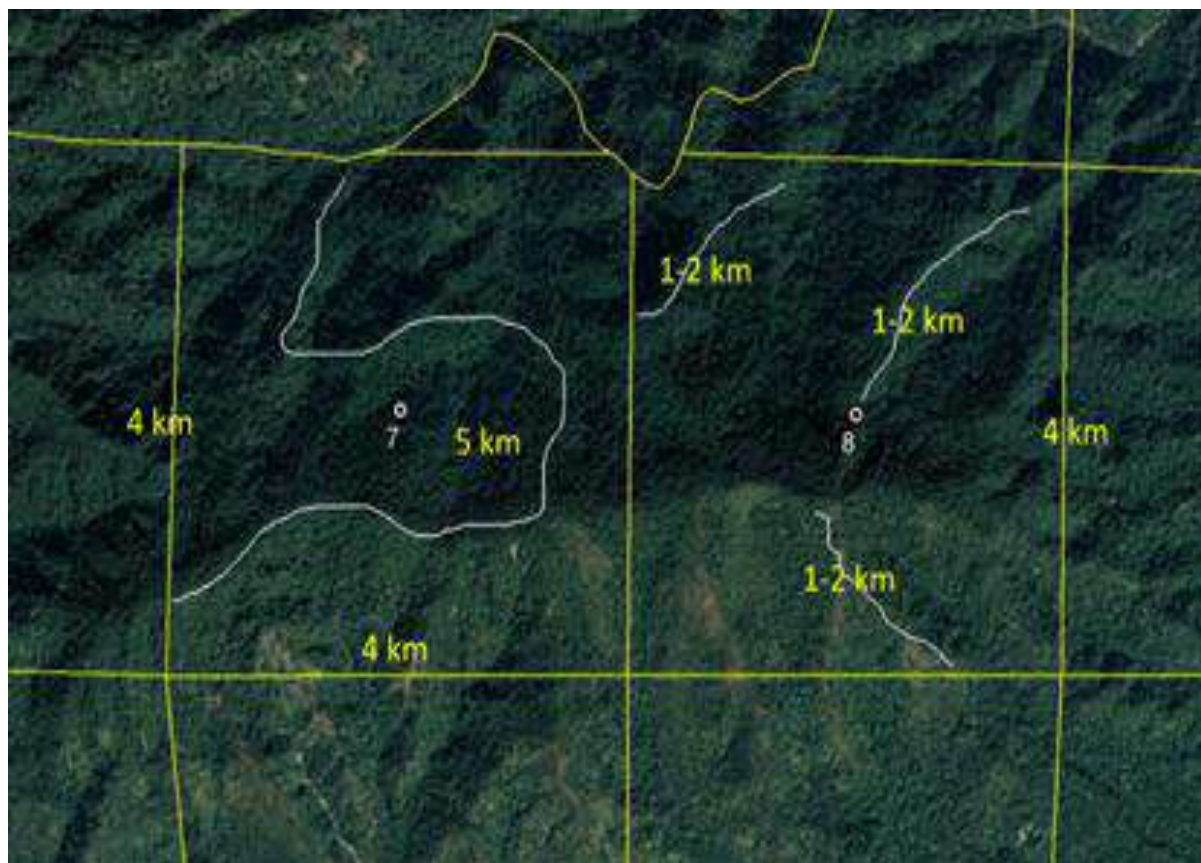


Figure 4.5 Survey grid (4x4 km) with 5 km transect

Cautionary note

Monitoring should be conducted during the season which is most suitable for detection and identification flora and fauna. The observation of a 'zero' (an apparent absence) may represent either the true absence of a species or alternatively, non-detection in spite of presence of that species. Accounting for the possibility of 'false absences', may have serious consequences in many respects.

The solution to the problem of confounded occurrence and detection lies in conducting replicate observations of a closed system (Burnham & Overton 1978; MacKenzie et al. 2002, 2006; Royle & Nichols 2003; Tyre et al. 2003). Detection probability may vary in time because of monitoring specific conditions and in space owing to site-specific characteristics (Bailey, Simons & Pollock 2004). Flexibility in the timing of monitoring may be required to ensure the best chance of detection and collection of adequate data inside the plot. Consider all four seasons as supplementary monitoring period to collect comprehensive data over time. For e.g., the detection and identification of species inside the herd plot is very poor during winter at higher elevation. Therefore, monitoring can be done in lower elevations during winter. Likewise, avoid heavy monsoon season and extreme weather events in the south. Shift the location of monitoring elsewhere which are not affected by monsoon, as an alternate option.

4.4.1.2 Large Mammal Monitoring Protocol

4.4.1.2.1 Transect survey.

Direct observation is often not an efficient method to detect mammal species in the forest with thick ground and canopy cover as the detection is very low. Mammals often leave indirect evidence of their presence such as tracks, hairs, scats, dung piles, scent marks, or scrapes. Monitoring mammal through signs has been commonly used (Plumptre, 2000). Trail transect survey is an inexpensive method commonly used for monitoring of mammals over time to determine species distribution of most carnivore groups, including several felids and many ungulates. Given the relative ease and low cost of data collection, detection/non-detection or patch occupancy methodologies have become one of the most commonly used monitoring methods currently in use, and one that is increasing in popularity (Marsh & Trenham 2008). Transect survey can be the best option to monitor mammals given limited financial and human resources.

4.4.1.2.1.1 Survey design and methods

- Mammal transect survey should be carried out in the sampled biodiversity monitoring grids of 4x4 km in the PA and DFOs and using the survey form as prescribed in Table 4.1.
- In the respective assigned grids, mammal transect surveys should be carried out at least once in a year in the same grid during the same season and in the same transect trails.
- Within each 4x4 km grid, a trail transects of 3-5 km depending on the accessibility of the area should be walked to cover major habitat types within the grid.
- Mammal sightings and mammal signs including tracks, scats, dung, scratch marks, etc., which are encountered on the trail transect should be recorded.
- If the area is inaccessible, search for 3-5 shorter trail transects of each at least 1 km for mammal and mammal signs (Figure 4.6).

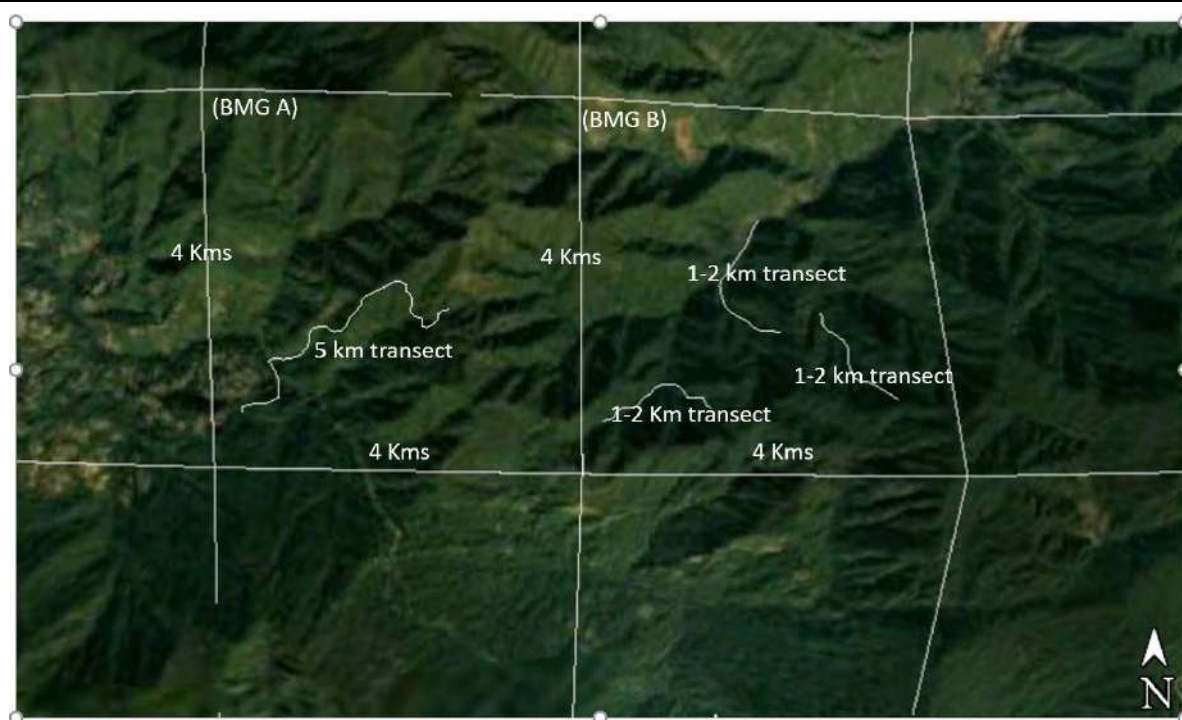


Figure 4.6 Survey grid (4x4 km) with 5 km transect BMG A: Where a single long transect is executed; BMG B: where three shorter transects are executed)

- GPS location at every 500m distance traversed should be recorded in the datasheet even if there is no animal or sign observed.
- In case of direct sighting, species, GPS location details, number of animals seen and sex and age of the animal should be recorded as per the datasheet in the Table 4.1.
- For encounter of animal signs, record species, sign type, GPS location details and habitat type of the areas as per the datasheet.
- In case of animal trails, each trail set is considered as one sign (not each pugmark as one sign). If an animal continues to walk along a trail for a long distance in the same direction, then this should also be considered as one sign.
- If no sign is seen on the track for over 50 m, then encountering a fresh track set is considered as a new sign.
- Photographic records with proper scale reference and GPS location should be taken if there is difficulty in sign identification.

[illegible]

4.4.1.2.1.2 Data collection from opportunistic encounter

- Mammal sightings or signs encountered during patrolling or while discharging other forestry related activities such as tree marking, watershed surveys, forest resource enumeration, etc., should be recorded in datasheet.
- Suspected species, GPS location, habitat type and sign type shall be recorded.
- Photographic records with proper scale reference and GPS location shall be taken if there is difficulty in sign identification.

4.4.1.2.1.3 Data compilation, storage, analysis and reporting

- After every field monitoring program, data gathered in the transect survey datasheet shall be entered into spreadsheet for further analysis and storage.
- Species wise data entry shall be done as per the format in Table 4.2 (one spreadsheet for each species).
- Copy of compiled data shall be submitted to the National Data Repository Center for storage, analysis and reporting.
- Analyzed data shall be reported as species status updates on regular basis through technical reports, policy briefs, scientific papers, etc.

4.4.1.2.3.2 Camera Trap Installation Methods

Camera traps are particularly well-suited to surveying terrestrial mammals, especially those known to use roads or trails as travel paths. Placing cameras on such paths therefore, is efficient and increases detection rates. In forested environments, cameras can easily be attached to trees with bungee cords, nylon webbing straps and other binding ropes/wire. In areas with few or no trees, stakes can be used effectively.

Surveyor must keep in mind the following while installing camera traps:

- Setup the camera that best suits ones need. Setting up of image pixel, capture time lapse and movie length depends on the trapping duration and SD card memory. However, it is recommended to set image size at 3 MB and video length at 10 seconds as images in these resolutions are good enough to identify animals.
- Do not to place cameras too close to trails because digital cameras tend to slow trigger speeds resulting in numerous blank photos or partial pictures and battery exhaustion.
- Cameras must be placed at 2-4 m from the center of the trail (Figure 4.7).

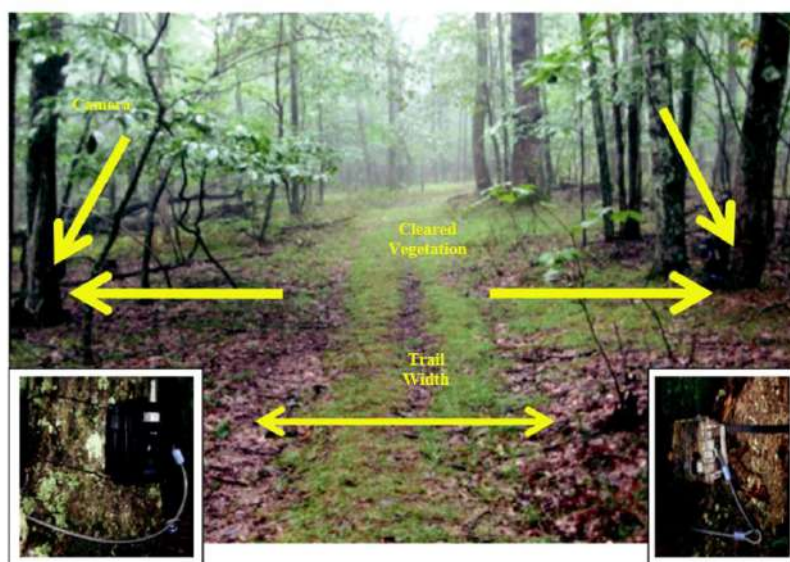


Figure 4.7 Example of field camera placement with 2 cameras per station

- Cameras should also not be placed far off the field of view, beyond 6 - 8 m shall be hard to distinguish animals, especially for smaller species. Refer flash illumination specifications of each camera model to maintain appropriate distance.
- Place/fix camera at 20-40 cm or knee height of tree or stake. Bit of height adjustment would be required for elephant and large ungulates to ensure full body capture.
- In case of difficulty in accommodating two cameras on a single station, you can station one camera at that station and another within 50 m along same trail.
- Cameras should be placed parallel to the ground to ensure effective capture.
- Avoid placing cameras directly facing each other, as white flashes can create washout in the opposing camera. The issue is relatively minor for infrared flash built-in cameras.
- In case of using two cameras, place one camera on right and another on left side of trail.
- Ensure that the camera is not against sun and moving objects within the detection zone to avoid capturing ghost/black picture.
- Once the camera trap is set, fill the datasheet provided (Table 4.3) and then arm the camera.

4.4.1.2.3.3 Camera functionality check and maintenance

Camera trap placed at a site is usually subject to theft and malfunction due to extreme weather conditions, battery drain-out and damage by wild animals. Therefore, timely monitoring is necessary to ensure its functionality and replacement. Surveyors must bear in mind the following during monitoring:

- Surveyor should always bring extra cameras and batteries when replacement is required.
- It is advisable to do first camera check in 10 days of trapping to make sure everything is operational and to determine photographic rates and battery status.
- After the initial camera check, monitoring can be done twice a month.
- In the subtropical climatic condition, especially in the growing season (April – October) site clearing of each camera shall be required to avoid obstruction within the detection zone.
- Monitoring of cameras beyond 21 days is risky, because you can lose weeks of data if an early malfunction occurred or a camera was damaged by an animal or even stolen.
- During the monitoring of camera traps, you should record battery drain (%), photographs taken and general malfunction if any in the remark's column of form (Table 4.3). This shall help to evaluate the performance of camera.
- It can be very easy to lose track of what data came from which camera when downloading memory cards to a computer. An easy solution is to tag each camera with a placard that has station code, camera number, and date. Alternatively, a stake can be placed into the ground within the camera's viewfinder that documents the station code and camera number. However, the placard method is preferred because the date written on the placard can later be used to recalibrate a camera whose data/time stamp becomes corrupted.
- All cameras should be set to display both time and date on the image as this information is essential in future analyses.
- All cards should be downloaded at the end of each camera check or at the end of monitoring date so long SD card storage permits.
- Ensure cleaning and drying of camera trap right after retrieval from the field.

Table 4.3 Data Form for Camera Trap Installation, Monitoring & Retrieval

| Grid No | Camera ID | Date (yyyy/mm/dd) | Time | Setup/Monitoring/Retrieval | Altitude | Aspect | Habitat | Surveyors | GPS Latitude [N] | GPS Longitude [E] | Remarks |
|---------|-----------|-------------------|------|----------------------------|----------|--------|---------|-----------|------------------|-------------------|---------|
| | | | | | | | | | Degree decimal | Degree decimal | |
| | | | | | | | | | | | |
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| | | | | | | | | | | | |

4.4.1.2.3.4 Data Compilation, Storage, Analysis and Reporting

- The camera trap installation/monitoring/retrieval form should be entered into a spreadsheet by the surveyor.
- The respective PA/DFO should keep a copy of raw data (camera trap images) saved in separate folder giving proper grid and station Ids for data security. While one set of data is kept as raw, the other set should be sorted species wise for each camera trap station (Figure 4.8). Details of the captured image such as time of capture and number of individuals in the image need to be entered into the spreadsheet manually or using relevant applications such as ReNamer or CameratrappR, as prescribed in Table 4.4.

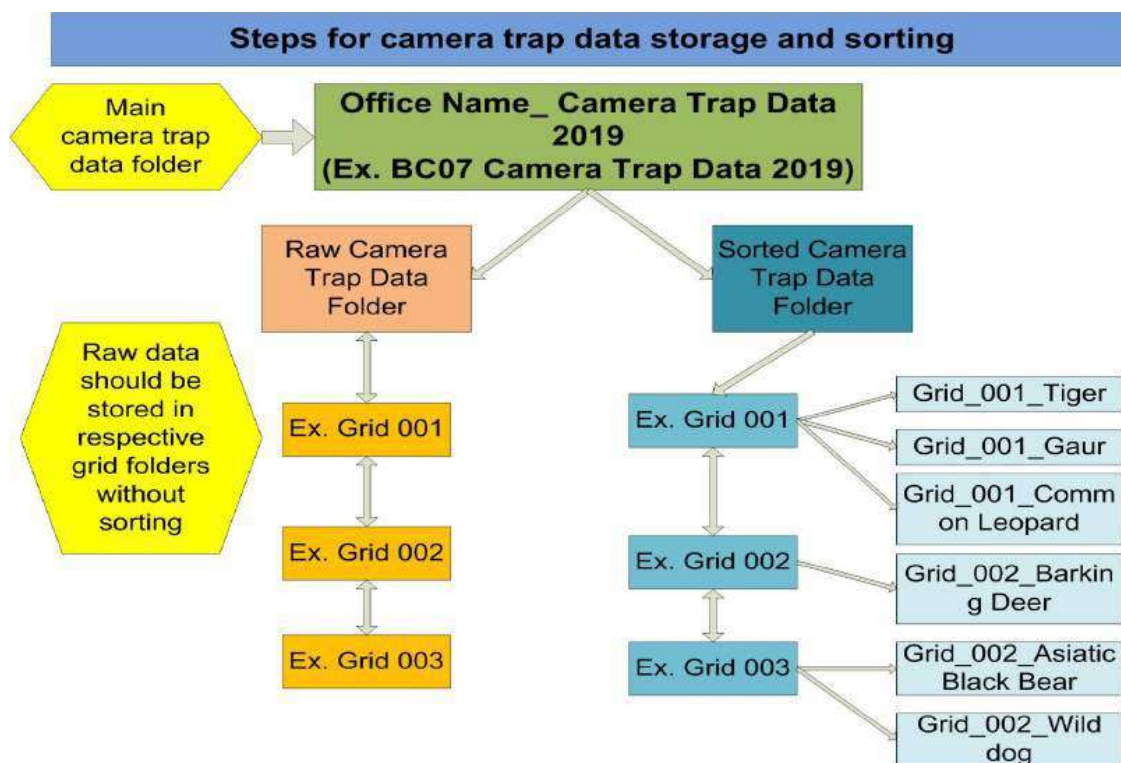


Figure 4.8 Schematic diagram showing steps of camera trap data sorting and organization

- The copy of both raw and sorted data should also be submitted to National Data Repository Centre of the Department.
- Useful summary data such as total number of species captured, total number of trap nights for an entire survey, the total number of photographs “events” for each species and trap rates for each species for an entire survey can be presented through reports.

- ✓ You can consider four age groups of classifications; infant, juvenile, sub-adult, and adult.
- ✓ The findings of each observer should be compared upon reaching base camp at the end of each survey day to check if both observers have encountered entirely new troop/herd/ individuals or the same ones. This is done to check if an observer has missed any member of group or an entirely new group. In case of minor differences in group size of a commonly observed group, the higher of total number of individuals observed will be accounted for computing average group size. The solitary individuals observed during the survey should be noted along with location coordinates and other ancillary attributes. For determining troop composition and age classification, both observers should agree on the number of individuals in each class (for groups that were commonly seen by both) after arriving at the camp.

4.4.1.2.4.2 Data Compilation, Storage, Analysis and Reporting

- The camera double observer survey form should be entered into a spreadsheet by surveyor. The copy of spreadsheet should also be submitted to National Data Repository Centre of the Department.
- The animal abundance can be estimated and can be shared through reports.

Table 4.5 Data Form for Double Observer Count

| Observer number: | | | | | | Name of Observation Place: | | | | |
|------------------------|-------------------|----|-------------|-------------------------|----|--------------------------------------|--------------------------------|-------------------|-----------------|---------|
| Name of Observer: | | | | | | Geog: | | | Dzongkhag | |
| Transect No: | | | Start Time: | | | End Time: | | | | |
| Lat (decimal degrees): | | | | Long (decimal degrees): | | | Aspect | | Slope | |
| Observation Date: | | | Elevation: | | | Time of Observation: | | | | |
| Group No | Group Composition | | | | | Unique ID marks of the group members | Vegetation type of Observation | Activity of group | Weather pattern | Remarks |
| | AM | AF | SA | JU | IF | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| Any other observation: | | | | | | | | | | |

Note: AM= Adult Male (>5 years), AF=Adult Female (>5 years), SA=Sub-Adult (2-5 years), Ju=Juvenile (1-2 year) & IF=Infants (<1year)

4.4.1.3 Small Terrestrial Mammal Monitoring Protocol

Small mammals include Rodentia (mice, rats, squirrels, porcupines, beavers, voles, hamsters), Eulipotyphla (shrews), Lagomorpha (rabbits, hares, pikas) and Chiroptera (bats). Even though terrestrial small mammals are often quite abundant, they are rarely observed and (except in snow or sand) their tracks are rarely seen and hard to identify them till species level. However, they can be easily sampled with sufficient numbers of traps or pitfalls. Most of the small mammal can be monitored using live trappings except the bats and can be easily handled requiring relatively little specialized equipment.

4.4.1.3.1 Sampling Design

4.4.1.3.1.1 Site selection

Everything that are carried out in the monitoring process; where to set the traps, number of traps, how long to sample, and how to analyze the data would depend on the purpose of the monitoring being carried out. The purpose of this monitoring protocol is to account the species diversity of small mammals, and all monitoring works shall be done in the sampled biodiversity monitoring grids of 4x4 km. Within the sampled biodiversity monitoring grids, specific site for monitoring can be sampled accounting different forest types and elevation gradient. Habitat stratification is necessary to compare species diversity and relative abundance of small mammals among different habitat types.

4.4.1.3.1.2 Setting of trap line

Within the sampled grid and in the randomly selected site in different strata, transect line should be laid for conducting the monitoring works. The transect line (straight or meandering) has an advantage over grids or webs because transects have been shown to yield greater numbers of captures, individuals captured, and species captured (Fricke et al., 2009). Transects also sample a greater area as compared to grid trapping (Pearson & Ruggiero, 2003). Transect lines can be placed within or at the centre of the sampled grid of 4x4 km if access is realistic. For each sampled stratum (Forest types/Habitat types) inside the sampled grid, two transect lines each measuring 100-150 meters and 100 meters apart can be established (Figure 4.9) so that you can walk up one line and crossover to come down the second line and traverse the same distance, finishing where you started. Trap line of 100-150 m long, with traps placed every 10 to 15 m has been widely used, though with little adaptations to locality (Hoffmann *et al.* 2010).

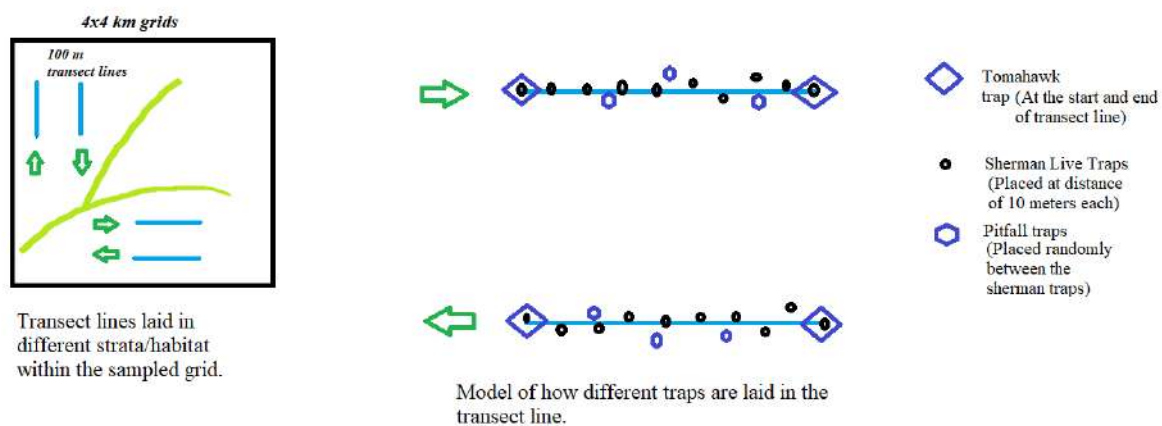


Figure 4.9 Trap layout and design within the monitoring

4.4.1.3.2 Methods

Live trapping offers an effective way for monitoring species diversity and abundance in the given location. Live trapping enables opportunities for handling of the animal to identify the species and its sex. Samples (e.g., tissue, blood, ecto-parasites) and biometric data, such as weight and measurements can also be collected for their detailed assessment. Based on the location of the traps set, key environmental parameters and microsite variables can be collected. Live trapping is not applicable to all the small mammal species due to specific habitat requirements (volant nature and arboreal dwelling). Sherman trap, Tomahawk and pitfall traps are commonly used methods in live trapping. Modified mink trap with added nest box can be used for some arboreal species particularly for squirrels. For each species recorded during the trapping, all body measurements as specified in the small mammal trapping form (Table 4.6) are mandatory so that species can be identified based on observations and measurements.

Table 4.6 Data form for Terrestrial Small Mammal Monitoring

| | | |
|---|--------------------|--|
| Data Collection Sheet | | |
| Collector: _____ | Range/Unit: _____ | Division/Park: _____ |
| GPS Coordinates | | |
| Inventory Grid Cell | | |
| Latitude: _____ | Longitude: _____ | Elevation: _____ |
| General Locality: Village: _____ | Gewog: _____ | Dzongkhag: _____ |
| Grid No: _____ | Transect ID: _____ | Trap ID: _____ |
| Start Date: _____ | End Date: _____ | |
| GPS Location/elevation for start & end points trap; | | |
| 1) 1 st Trap: _____ | 2) End Trap: _____ | |
| Habitat: _____ | | |
| Trap Location of the capture: | | |
| Latitude: _____ | Longitude: _____ | Elevation: _____ |
| Morphometric Measurement | | |
| Body weight: _____ gms; Head body length: _____ cm; Tail length: _____ cm; Hind foot length: _____ cm; Ear length: _____ cm | | |
| Males: | | |
| Testes: _____ | Descended: _____ | Non descended: _____ |
| Females: | | |
| Nipples: _____ | Prominent _____ | Not Prominent _____ |
| Pelage: | | |
| Juvenile: _____ | Sub adult _____ | Adult _____ |
| Materials Saved: | | |
| Skin _____ | Skull _____ | Tissues _____ Ectoparasites _____ Hair samples _____ |
| Date of collection: _____ Collection No: _____ | | |
| Species: _____ Photo of Animal: Full Dorsal _____ Ventral _____ Lateral _____ | | |
| Weather and other note: _____ | | |

For standard body measurement, the protocol as prescribed in this document shall be followed;

4.4.1.3.2.1 Sherman Live Traps

Sherman live trap has become the standard, foldable, portable and efficient trap choice for most small terrestrial mammals (Figure 4.10). Sherman trap comes in several sizes but the standard model LFA-TDG, 7.5 x 9 x 23 cm is the most widely used trap. Larger models are also available (XLK, 7.7 x 9.5 x 30.5 cm), the use of which shall reduce the risk of injury and discomfort to the trapped animal. For inventory and monitoring of small mammals in Bhutan, Sherman traps shall be used.

Sherman trap shall be placed on the transect lines (100 meters) at an interval of 10 meters, thereby setting 10 traps on each transect line. Therefore, 20 Sherman traps can be set in one strata or habitat type. Baits shall be used to attract the animals and to serve as food while caught in the trap. However, precaution should be taken so that the feed does not cause faulty trap. Colored ribbon (red, orange, pink and blue) can be tied on twigs and branches of shrubs for ease of locating of the traps. Basic procedure for setting Sherman trap is as follows;

- Check the trap for any holes—discard if the trap has been chewed through. Make sure the trap works properly.
- Find a favorable location for the trap within 2 m of a trap station
 - along downed logs, near trees, rocks, bushes, or woody debris
 - along a small mammal runway or near small burrow holes
- Place bait (apple, fish ball, peanut butter pack) and bedding material at the back of the trap, away from the treadle. Place a tiny bit of bait just outside trap entrance as well.
- Place the trap flat on the ground so it is stable (you may need to clear some ground by hand).
- Clear obstructions away from the trap entrance.
- Place a coverboard, tree branch or other woody debris over the trap for extra protection against weather and predator detection.
- Just before leaving the trap, check treadle sensitivity to make sure the trap door closes with a small tap on the trap.
- Place flagging near the trap (with station # written) for easy finding



Figure 4.10(A) Collapsible Sherman traps (America.bioweb.co) and (B) Modified mink trap (John Gurnell and Harry Pepper)

4.4.1.3.2.2 Collapsible Tomahawk trap (for squirrels, small carnivores, and large rats)

The traps are usually larger than Sherman traps (they actually come in different sizes) and are commonly used for species such as marten, red pandas, badgers, civets, mongoose, flying squirrels, etc. Two Tomahawk traps shall be set up, one at the starting and one at the end point of the transect line. Therefore, for each stratum, there should be four tomahawk traps. If larger-sized animals are captured, it may be necessary to administer anesthetics via injection before they can be handled.



Figure 4.11 Collapsible Tomahawk trap

4.4.1.3.2.3 Pitfall trap (for animal less than 10g)

Pitfall traps are used for live trapping smallest species, particularly the shrews. Small cans or buckets (~ 6 inches in diameter and 6.5-10 inches in height) are buried flush with the ground and a small amount of bait can be placed in the can to feed the animal before it is checked. Drift fences can be built near the can so that animals coming from any direction shall be funneled in to a can (Figure 4.12). Pitfall traps shall be placed a few meters from the Sherman traps selectively – the best locations would be up against a downed log or rock. Once the animal fall inside the pitfall trap, they cannot escape. The trapped animal can be simply transferred from the container to a handling bag for morphometric measurements and taxonomic identification. Followings are the basic procedures for setting up pit-fall trap.

- Make sure the pitfall trap has drainage holes so water doesn't accumulate if it rains.
- Find a favorable location for the trap within 2 m of a trap station.
- Dig a hole at the trap location. Place some rocks (for water drainage) in the bottom of the hole. Then place the pitfall trap in the hole so the rim is flush with the surrounding ground.
- Place bait, bedding, some plants and small woody debris (for shelter) in the bottom of the trap. But don't put so much that an animal can climb out.
- Set up drift fences (5-m long in each of 3 directions) to direct small mammals to the pitfall trap.
- Place flagging near the trap (with station # written) for easy finding

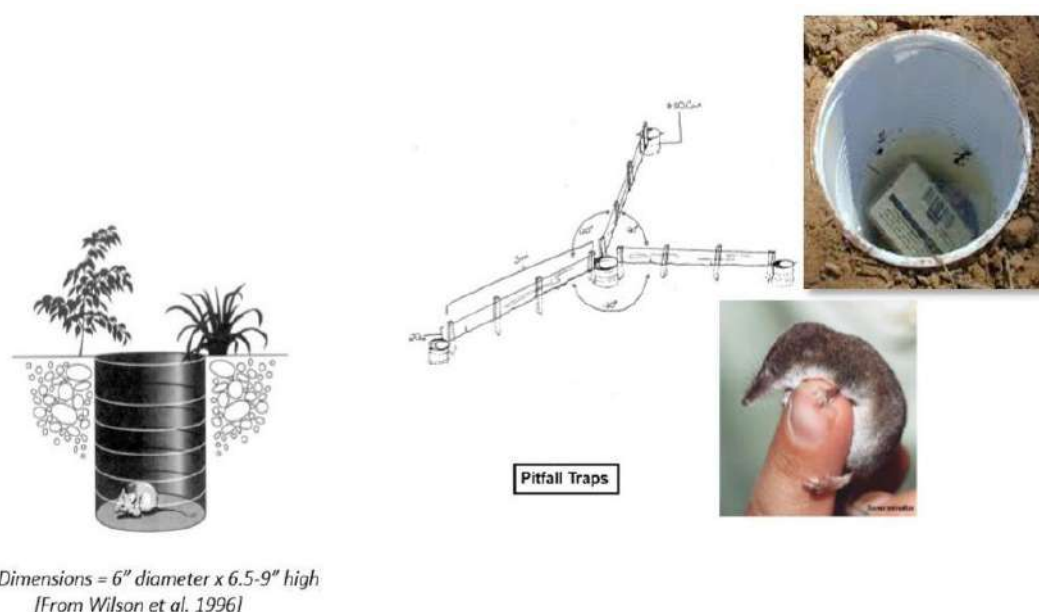


Figure 4.12 Pitfall trap layout with drift fence

4.4.1.3.2.4 Monitoring and re-baiting of traps

Ideally, trap lines are run for a period of 3-5 days (Hoffmann et al., 2010) to reduce stress on the animals. Traps are set before sunset and checked as early as possible on the following morning. All traps are then closed for the day, unless day trapping is planned. At sites where many shrews (esp. Soricinae) are expected, trap inspection at shorter intervals can prevent the animals from dying in live traps or being eaten by ants or predators in snap traps. It is recommended for daytime trapping at least for two days to check for diurnal species. Depending on weather conditions (e.g., heat) during the day, trap inspection at short intervals should be considered. Traps are baited on the first day and if required re-baited the following day.

Transects can be established on Monday morning, and the first check should be done on Monday night and at subsequent morning and evening sessions through Thursday morning and at the end traps are pulled out. Data can be organized and specimens prepared on Friday.

4.4.1.3.3 General Handling Procedures

Small mammals can be easily handled without anesthesia though if tissue samples are to be taken anesthesia should be used. Larger and carnivorous species like civets, mongoose are commonly anesthetized. The animal is transferred from the trap to a handling bag as follows:

- ✓ Open the door of the trap through the bag,
- ✓ Shaking the animal in to the bag.
- ✓ Weigh the animal in the bag using a Pesola spring scale and note in the data collection sheet
- ✓ Then by subtracting the weight of the bag you can obtain the animal's final weight.
- ✓ Open and grasp it through the bag on the nape of the animal neck, and hold it securely
- ✓ Determinations of species, sex, age, and pelt coloration for molting patterns can be made while handling the animal in this manner (Figure 4.13). If blood or ear plugs are to be obtained it is best to anesthetize the animal.



Figure 4.13 (A) Transferring an animal from trap to handling bag; (B) Weighing animal with Pesola spring ©Kuenzang Dorji

First hand keys to identify small mammals

- ✓ Shrews have long mobile noses, sharp insect-eating teeth and small eyes.
- ✓ Moles all live underground, have small or no ears, small or no eyes, and small or no tails.
- ✓ Voles are characterized by a stout body, small and rounded ears, short legs, relatively large eyes, and a tail that is shorter than the head and body

- ✓ Rodents are of all colors and sizes but all have gnawing teeth with a space behind them

4.4.1.3.3.1 Sexing small mammals

A. Females (does)

- Look for nipples
- Check distance between anus and reproductive organ if they are close together, it is probably a female.

Female mice are known as does. They have eight to twelve nipples to feed their litter until it is fully weaned at around four weeks. These nipples can sometimes be seen and are a good way to identify female mice since males do not have nipples. However, nipples are usually most visible in young mice or in does that have had a litter, and cannot always be seen through the mouse's fur. If the nipples are not obvious then you must rely on checking the mouse's genitals alone to sex it. A female mouse shall have a tear shaped vagina close to its anus, with little space in between the two.

B. Males (bucks)

- Look for testicles
- Look for the scrotum
- Check the distance between the anus and reproductive organ – if the distance is quite large you are probably looking at a male.

Male mice are called bucks. They do not have nipples, but just because you cannot see a mouse's nipples does not mean they are not there. If a buck is old enough to leave its mother (four weeks or older) then it shall probably have fairly obvious testicles though many wild rodent species are seasonal so testes are drawn inside the body during the non-reproductive period. Mice have large testicles in comparison to their body – each testicle is the size of a peanut minus the shell. These testicles shall 'drop' as the mouse matures into adolescence and can be seen as early as two and a half weeks in very early developers. Mice can retract their testicles into their body, so they may be there even though they are not totally obvious. The distance between the anus and the genitals of a male mouse is larger than it is in a female mouse. If you compare the two you shall see that while the female's anus and vagina appear almost joined, the male's reproductive organ is well spaced from the anus.

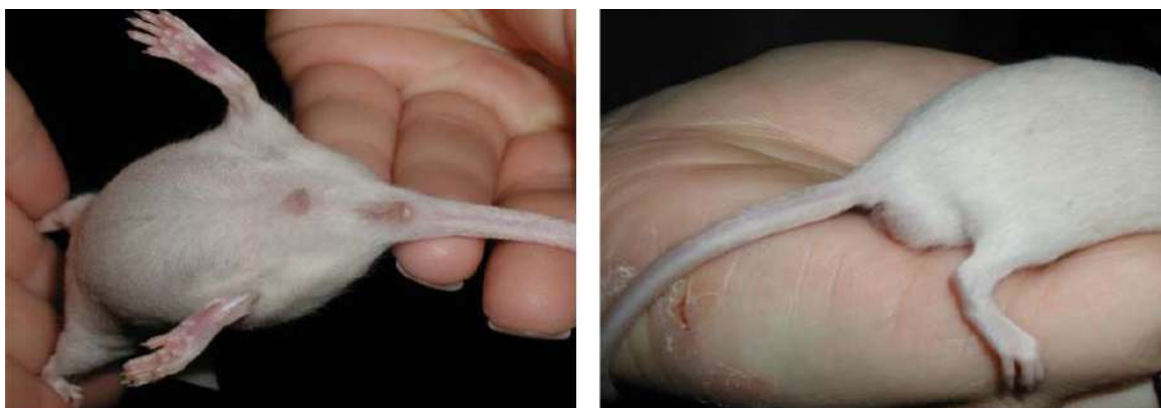


Figure 4.14 (A) Anogenital distance for buck and; (B) Descended testicle

Figure 4.15 shows additional pictures of 2 adult mice, one buck and one doe. You shall notice that there is a larger gap between the anus and penile shaft of the buck than that between the anus and vagina of the doe. The distance between the anus and genitals is called the "anogenital distance." You shall also notice that the female has a Vaginal Orifice, whereas the buck does not.



Figure 4.15 Ano-genital distance of buck and doe

4.4.1.3.4 Standard Body Measurement

Body proportion can be used as an index to determine an animal's age, health status, taxonomic distinction and relationship between population and sexual size dimorphism. The metrics described below are commonly used for most of the species:

4.4.1.3.4.1 Weight

Knowledge of an animal's body weight, though only a crude index of its overall condition, is one useful metric, when combined with body length, to assess an animal's condition. Such information is easily collected and there is generally a large, existing database for most species for comparison. Weights obviously are influenced by the animal's age, sex, and nutritional condition and can vary seasonally due to food availability or physiological changes (e.g., torpor in ursids). For smaller species, field weights can be obtained using spring scales (e.g., Pesola®) which are available in sizes for weights from a few grams (with an accuracy of 0.1 g) to 50 kg (with 500 g subdivisions).

4.4.1.3.4.2 Length

The measurement mentioned below are recorded to the nearest mm (possibly to the nearest cm for larger species) using vernier caliper. For longer body measurement, it is advisable to use cloth or flexible synthetic tape to follow the body contours and metal ruler for smaller measurement where rigidity is required.

- *Total length (TL)* - the animal is laid in a recumbent position on their back and the distance from tip of the nose to the distal end of tail vertebrae is measured. This method is more easily accomplished with smaller species (e.g., weasels); large species such as the African lion or bear species are more commonly laid on their ventral surface and a cloth or flexible synthetic tape drawn from the tip of the nose along the body's contours (between the eyes and along the midline of the vertebrae to the bony tip of the tail).
- *Body length (BL)* - measured from tip of the nose to base of the tail at notch of sacrum while lying in a recumbent position on their back.
- *Tail length (TaL)* - measured from base of the tail at the rump to tip of the last caudal vertebrae.
- *Hind foot length (HF)* - measured from end of the heel bone to tip of the longest digit plus the claw.
- *Ear length (E)* – measured from notch of the ear opening to the tip of the pinna (excluding any hairs).

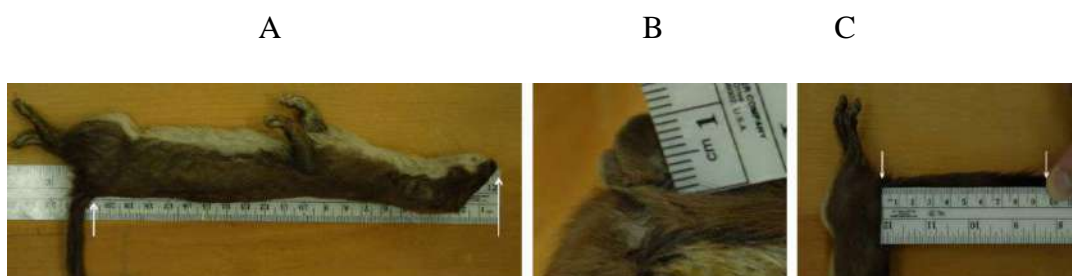


Figure 4.16 (A). Body length measurement; (B) Ear length measurement and; (C) Tail length measurement

Note: If you are not able to identify the species, photo can be sent to the experts with all morphometric measurements for identification. Photo should include dorsal, ventral and lateral view of an animal. Photo can be taken using "aquarium" with some artificially created micro-habitat. This provides animal natural feel and can capture original shape and size of an animal.

4.4.1.3.5 Tissue sample collection

Sample collection shall be done only if advised prior to the monitoring programme as proper storage facilities and expertise on sample analysis is prerequisite. If sample collection is required, the most desirable samples are tissue that includes muscle, tongue, skin (i.e., ear clip), blood, hair and bone. While collecting the sample, it is essential to avoid cross contamination between samples which can be done by washing the cutting instruments and hands (wear fresh latex gloves) between the handling of samples from different individuals and sterilize cutting instrument with a flame using lighter. For small mammals, small ear tissue biopsy shall be collected by ear-punch and stored in 95% ethanol or silica gel desiccant in tubes or twist-tie plastic bags. If ear punches cannot be obtained, 10-20 hairs (with follicles) should be collected and stored in coin envelopes.



4.4.1.3.6 Materials required

- | | |
|---|--------------------------------------|
| 1. Sherman live traps | 11. gloves |
| 2. Collapsible Tomahawk trap | 12. mask |
| 3. Cans/bucket for pitfall traps | 13. ear tag |
| 4. Ribbon | 14. ear punch |
| 5. cloth sack (handling bag) | 15. ruler |
| 6. permanent marker | 16. Zip lock |
| 7. track tubes | 17. GPS |
| 8. duct tape | 18. camera |
| 9. bait (grain, vegetables, meat or locally available fruits) | 19. Pesola scale (different weights) |
| 10. U-shaped wire hold downs | |

4.4.1.4 Bats Monitoring Protocol

4.4.1.4.1 Bats Monitoring Standards

4.4.1.4.1.1 Time of Year

- Sampling should be conducted in late March to April when it is time for maternity roost and from August to October when bats are active in feeding, flying and mating.
- The time of year or stage of the reproductive cycle influences sampling in several ways.
- During lactation, females must make at least one return trip to the maternity roost to nurse their young, before returning to foraging areas to feed (to meet their increased energy demands). This may give the impression of higher levels of bat activity than during other stages of the reproductive cycle, even though there may be no actual change in the number of bats present.
- A real increase in the number of bats present and correspondingly, in the levels of bat activity, shall occur when young of the year "fledge" and are recruited into the population.

4.4.1.4.1.2 Time of Day

- Bats are inactive during daylight hours, except in very rare circumstances (e.g., eclipses) and shall only be found in roost sites. For most species, several distinct periods of high activity can be recognized during the night. The first of these is during roost emergence, when the bats first leave the roost to forage. This usually occurs shortly after dusk. Activity by most species tends to decrease over the course of a night, but often a peak is seen around 24:00 to 01:00 hours, often followed by a final increase just before dawn as bats return to roost sites.

4.4.1.4.1.3 Environmental Conditions

- Environmental conditions also influence bat activity. The presence of precipitation, strong winds or temperatures below 10° C tend to cause a decrease in levels of bat activity. Therefore, no sampling should be done on nights with heavy precipitation or when the ambient temperature at sunset is below 10° C, as bat activity shall be low and unproductive sampling.
- Typically, sampling can also be unsuccessful before snow is gone and local lakes are free of ice.
- Increased levels of moonlight may tend to decrease capture success.
- Moderate to high winds may also influence capture success - blowing mist nets are less likely to capture bats.

4.4.1.4.1.4 Habitat Standards

- A minimum amount of habitat data must be collected for each survey type. The type and quantity of data collected shall depend on the scale of the survey, the nature of the focal species, and the objectives of the inventory.
- Accompanying data forms provide guidance to standard description of roosts- whether located in cliff, caves, trees, or buildings.
- Considering all these variables/conditions, sampling for bat monitoring is recommended from late March to April and from August to October, preferably during the dusk and dawn, and in weather conditions that are not too rainy or windy.

4.4.1.4.2 Sampling Design

Same grids as adopted for small terrestrial mammals should be used for bat monitoring, i.e., all monitoring works shall be done in the sampled wild biodiversity monitoring grids of 4x4 km. Within the sampled biodiversity monitoring grids, specific site for monitoring bat can be sampled taking into account different

habitat types. However, unlike other mammal species where survey can be conducted in any natural habitats, it is important to identify some prominent bat habitats such as caves and rocks, infrastructures like houses, bridges and tunnels, fruiting trees, water bodies, tree hollows, etc. for bat surveys to be more productive/successful. Capture (mist nets, harp traps, hand netting) and detection (ultrasonic bat detectors) should be employed simultaneously to determine presence/un-detected and relative abundance of bats.

4.4.1.4.3 Methods

Capture of bats allows identification of correct species, determination of age and sex, collection of mass and other mensural data, and an assessment of reproductive condition. However, this obviously requires some handling of and disturbance to the animal. All species or sexes are not equally catchable.

The two most common methods of capture involve the use of mist nets or harp traps, although several other methods (e.g., hand nets, funnels) have been used in the past. Many of these techniques require sampling at or in roost sites, and are not recommended because they tend to be disruptive to the bats and may cause them to abandon the roost. Conservation of bats and critical habitats, as well as minimization of disturbance must be considered for all potential sampling protocols.

4.4.1.4.3.1 Mist netting

Mist net (Figure 4.17) is commonly and widely used tool to capture bats. It is portable, cheaper and easier to handle in the field. It is considered the most efficient technique in field. Usually, the net is in black coloured and monofilament with 50 denier, 2 ply nylon and 28mm mesh size. Considering the topography and canopy coverage in the country, net length of 6m (18') and 12m (40') long and 2.1 m to 2.4 m height are recommended to be used. Generally, aluminium poles are used to support the mist net, however locally available poles such as bamboo and other natural materials could also be used.

Finding the right spot for putting up mist nets is crucial for successful bat capturing. In general, capture success is enhanced when nets are put at natural flyways *e.g.*, at a perpendicular angle to a forest edge or across forest trails.

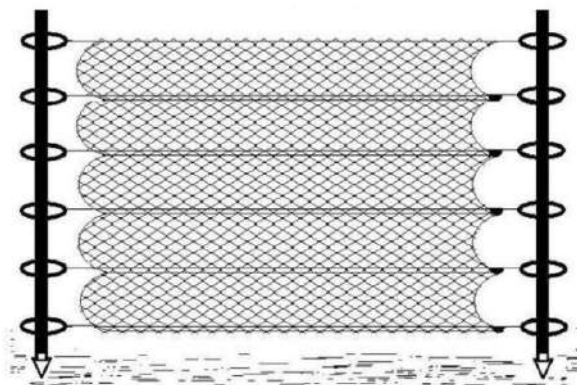


Figure 4.17 Setting up of a mist net

4.4.1.4.3.2 Harp trapping

Harp trap is additional tool to collect bats in the field. It helps the biologist to capture species that are never trapped with mist nets. The advantage of harp traps is that bats can be more easily removed from them thus lesser invasive to the species. In addition, harp trap can be used easily in small space of entrance and emergence. Usually, harp traps consist of 2 to 4 parallel rectangular metal frames (usually 2 m x 3 m) at distances of 4 to 6 cm that each carries a layer of vertically oriented monofilament fishing lines at distances of 2-3 cm. Distinct objects such as cave entrances, buildings, rocks, water holes, etc. presents good harp trapping and enhances capturing of bats.



Figure 4.18 Harp trap for capturing bats

Hand net is smaller in size and portable to carry in field. It is always better to use 2 ply nylon and 28 mm mesh size. The bigger size of throat we use, the more it can withstand the force of bats but the probability of detecting the net by bats is high. Hand nets are more efficient within closed space (inside caves and infrastructures). Also, it can be used in infrastructure corridors as well in forest corridors but in small scale.



Figure 4.19 (A) Hand netting (Hoop/scoop net) (B) Frequency broad band Detector

Detection involves sampling of bats either by visual or acoustic means. Unlike netting and trapping, acoustic methods do not involve handling and therefore disturbance is minimized. However, positive species identification is not always possible nor is an assessment of age, sex, or reproductive condition. Bats typically rely on vocalizations for communication and orientation when commuting or foraging. It is possible to eavesdrop on these vocalizations (i.e., echolocation calls) to detect the presence of bats, assess whether a bat is foraging or commuting, and potentially identify the species emitting the call. Petersson detector can be used to collect the array of species and its frequencies. The detector is portable and it doesn't need separate recording devices. Both Detectors (D and M) performs similarly. After identifying stopping points on the transect line, the surveyor can start recording for a given period of time.

Table 4.7 Data sheet for Bat Monitoring

| Bat capture data sheet | | | | | | | | | | | | | |
|------------------------------|-------------|--------------------|----|----------------|-----|-----------|-----|------------|----|-----|-----|-----|--------|
| Survey date: | | Survey start time: | | | | End time: | | | | | | | |
| Locality information Chiwog: | | | | Gewog: | | | | Dzongkhag: | | | | | |
| Latitude: | | Longitude: | | Elevation (m): | | | | Aspect: | | | | | |
| Habitat information: | | | | | | | | | | | | | |
| Field | Bat species | Sex | FA | BM | TIB | EL | BHL | TL | HF | WSP | HFL | ThL | Remark |
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| Recorded by: | | | | | | | | | | | | | |

4.4.1.4.4 Materials required

1. Mist nets, poles, and lines
2. Harp trap(s)
3. 'Hands-free' headlamp (e.g., Petzel) with a spare batteries, for each field person
4. Spotlight (optional)
5. Leather or cotton gloves
6. Cloth holding bags (for holding captured bats)
7. Pesola spring scale (50 g capacity)
8. Calipers
9. Thermometer
10. Identification key
11. Field note books
12. Compass
13. Camera with macro-lens and flash (to record voucher photos)
14. Bat detectors with fully charged rechargeable batteries
15. Spare rechargeable batteries
16. Microcassette recorder(s) for use with detectors(s)

4.4.1.4.5 Morphometric measurements

The standard measurements for bats include head-body length, tail length, hind foot length, ear length, forearm length, and body mass (Handley, 1988).

- **Body Mass** (BM) is recorded in grams with small spring-scales available in a variety of sizes from 10 g up to 2000 g (e.g., Pesola) and used according to the animals' size.
- **Head-Body Length** (HBL) of a bat is the distance between the back of the bat's pelvis and the tip of the snout

- **Tail Length (TL)** is the distance from the base of the pelvis to the tip of the tail.
- **Hind Foot Length (HFL)** is the distance from the base of the calcar or the calcaneum in bats lacking a calcar respectively to the tip of the longest toe. The foot is flattened on a ruler or Vernier calliper and the length is recorded to the nearest 1 mm.
- **Ear Length (EL)** is measured with a ruler placed gently in the notch at the base of the ear. The distance between the base and the tip of the pinna.
- **Tragus (T)** is the cutaneous projection at the opening of the external ear. It is measured between the base and the tip of tragus
- **Forearm Length (FA)** is the distance from the elbow to the wrist. To measure the forearm, the wing has to be folded. A ruler can be used, but a sliding calliper is more convenient to record
- **Tibia length (TIB)** is measured from the knee joint to the ankle of the Hind foot.
- **Thumb length** is a length of the first digit including metacarpal and phalanx excluding claw.
- **Wingspan (WSP)** is the maximum spread of the wing from tip to tip taken with wings fully stretched.

There are other morphometric measurements that are also taken for taxonomic studies which includes - Third metacarpal length (3mt), Fourth metacarpal length (4mt), Fifth metacarpal length (5mt).

Note: The taxonomy of Bats was most challenging part as Bats is one of the highly evolved mammals in the animal kingdom. To enhance the identification protocol, Bat Biologists have extended many laboratory works such as cranial measurements, Baculum measurement and molecular analysis.

4.4.1.4.6 Photography

High resolution and clear photography of Bats is one of the most important tools for identification in addition if surveyors do not have expertise to identify bats in the field. Some key features that are important to include in photographs are:

- Full view of bat
- Frontal view of bat.
- Lateral view of bats face, showing sella view, leaflets and other features
- Leaflets view
- Tail view
- Ear shape and Tragus view

4.4.1.4.7 Important keys identifying bat

Vespertilionidae

- Unmistaken long and forward facing ears, forearm length and shape of well-developed tragus (club, mushroom, slender or curved).
- Noseleaf is absent.
- Tube-shaped nostrils, thin and needle like tragus inside rounded ears.

Rhinolophidae

- Presence of distinct sella (blunt, rounded, sloping and pointed connecting process).
- Have complex noseleaf with erect posterior lancet and lower horizontal horseshoe surrounding the nostrils.
- Ears are usually pointed with well-developed antitragus.
- Tragus is absent

Megadermatidae

- Large and oval ears joined over the forehead by a membrane.
- Have distinctly bifid tragus
- Simple and erect nostrils help in confirming the species.
- Tail is absent

Hipposideridae

- Large size forearm and noseleaf with horizontal horseshoe surrounding the nostrils and associated leaflets.
- Sella and connecting process absent in Hipposideridae species.

Miniopteridae

- Doomed forehead and rhomboidal ears.
- Noseleaf is absent.
- Ears are separate from each other with well-developed tragus.

Pteropodidae

- Have large eyes and simple ears.
- Tail is usually absent or small.

4.4.1.4.8 Bat handling

Bat biologists/researchers have to handle bats in an appropriate way to allow for accurate identification of species and to avoid injuries, both to the animal as well as the handler. The captured bats should be removed carefully from nets/traps and kept in cloth bags until processing. It is also crucial to handle bats appropriately while taking external morphometric measurements. In addition, nets/traps should be checked every at least 15 to 20 minutes to avoid injuries/death of animals.

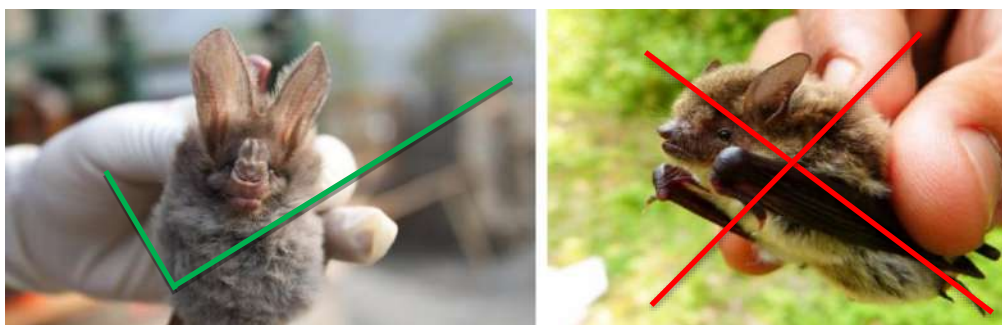


Figure 4.20 Bat handling techniques

4.4.1.4.9 Data Compilation, Storage, Analysis and Reporting

For each study area, the number of species captured or detected should be tabulated. For each species, sex, and reproductive class (if known) the following should be calculated:

- Number of bats caught per net-night or per hour (a net-night is equivalent to one six metre length of net set up for one night).
- Number of bats caught per night or hour of harp trapping.
- Number of bat passes/unit time.
- Number of feeding buzzes/unit time.

A monitoring report should be produced for the survey area (PA/DFO) based on the results from the monitoring programme. A copy of the tabulated data should be shared to the National Data Repository Centre of the Department and NCD for production of national reports and further storage of the data.

Table 4.8 Data sheet for Bat Monitoring

| | | | | | | | | | | | | | |
|------------------------------|-------------|--------------------|----|----------------|-----|--------|-----|-----------|----|------------|-----|-----|--------|
| Bat capture data sheet | | | | | | | | | | | | | |
| Survey date: | | Survey start time: | | | | | | End time: | | | | | |
| Locality information Chiwog: | | | | | | Gewog: | | | | Dzongkhag: | | | |
| Latitude: | | Longitude: | | Elevation (m): | | | | Aspect: | | | | | |
| Habitat information: | | | | | | | | | | | | | |
| Field | Bat species | Sex | FA | BM | TIB | EL | BHL | TL | HF | WSP | HFL | ThL | Remark |
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| Recorded by: | | | | | | | | | | | | | |

4.4.1.4.10 Ethics and Precautionary measures

Personnel

- All crew members should have up-to-date vaccinations against rabies and tetanus.
- The crew leader must be a biologist with experience in mist-netting and identifying local bat species.
- The crew leader must have previous experience of attaching light-tags before attempting this procedure.
- At least two crew members should be used for netting purpose.
- All personnel should thoroughly familiarize the Animal Capture and Handling manual before commencing with inventory survey that requires capture and/or handling.

Field Procedures

- During the day, all personnel should visit the study area in order to check out access, locate suitable areas for nets (trap stations), and set up equipment.
- Generate a habitat description of the study area
- Personnel should be aware of the various ecosystem distributions (i.e., biogeoclimatic zones), and the major (if any) land use practices in the project area.
- Landowners should be contacted for permission to sample on private land.
- At least two crew members are needed for mist netting and harp trapping of bats.
- Up to five nets can be set up and managed by the two people. A trap station (as specified in the accompanying data forms) may consist of more than one net.
- Environmental conditions (e.g., air temperature, cloud cover, wind, and precipitation) at sunset should be recorded.
- Nets and traps should be properly placed following net placement guidelines and should be optimized for capture success.

Safety precaution

Small mammals and bats are prime carrier of diverse potential diseases (Septiceamia plague, rickettsia, lassa fever, leptospirosis, tick born encephalitis, rat-bit fever, Hanta-virus, etc.) that can be harmful to public health security. It is important to use proper precaution measure (hand glove & mouth mask) from getting exposed to zoonotic pathogens and animal bites while handling the bats. Hand should be properly washed by Dettol and sanitizer right after the animal handling. It is important to disinfect and properly wash all the materials (like traps) by soaking in detergent water for an hour or less.

4.4.1.5 Bird Monitoring Protocol

4.4.1.5.1 Sampling Design

Bhutan is divided into 2424 grids of 4x4 km cluster plots used for the National Forest Inventory purpose. The grid (4x4 km) is also referred to as a sample 'Biodiversity Monitoring Grid' (BMG). Each BMG is assigned same numeric code as the NFI cluster plot. However, since the monitoring of biodiversity shall be a periodic event, monitoring shall be done in sampled BMGs in each PA and DFOs. The BMG is sub-divided to 16 1x1 km squares. The 1x1 km squares grid is called 'survey squares' and assigned survey squares (SS) codes (01 – 39,450). BMG and SS centroids are generated from the BMG and SS grids. The geo-coordinates of the centroids are used to geo-reference any other biodiversity, geophysical and climatic data (Figure 4.21).

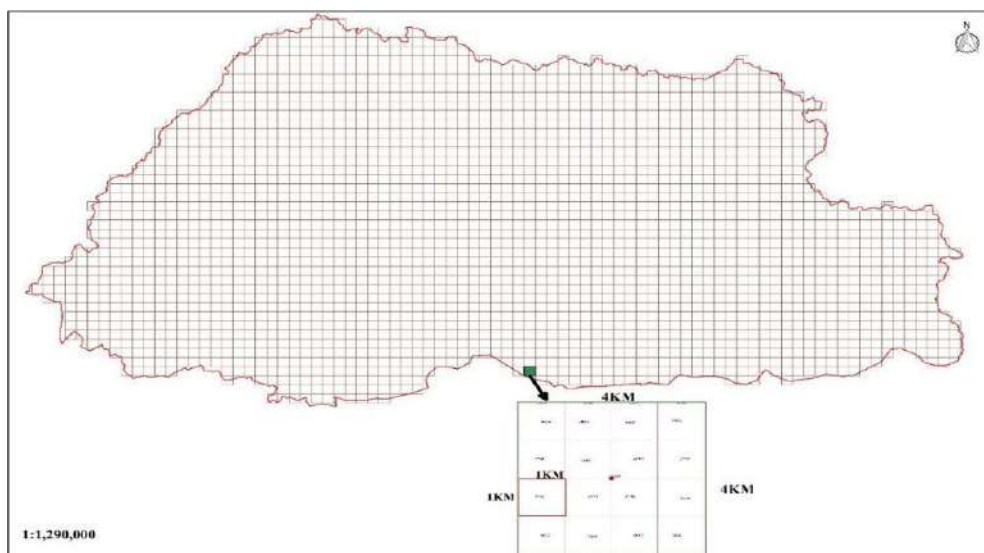


Figure 4.21 Survey design showing National Biodiversity Monitoring Grid (4x4 km) and Survey Squares

Monitoring surveys shall be carried out on different taxa in survey squares using the prescribed methods in the specific taxa monitoring protocol. For instance, to monitor bird species, layout or run permanent 1 km trail transect in the survey squares. Ensure to cover all representative habitats in the survey squares. Within the survey squares, make special search efforts to find breeding pairs and species of concerns. Ensure to survey at least 5 SS in each BMG. It is recommended that biodiversity monitoring grid code be used as a key reference in any numerical survey, inventory or research permit identification number.

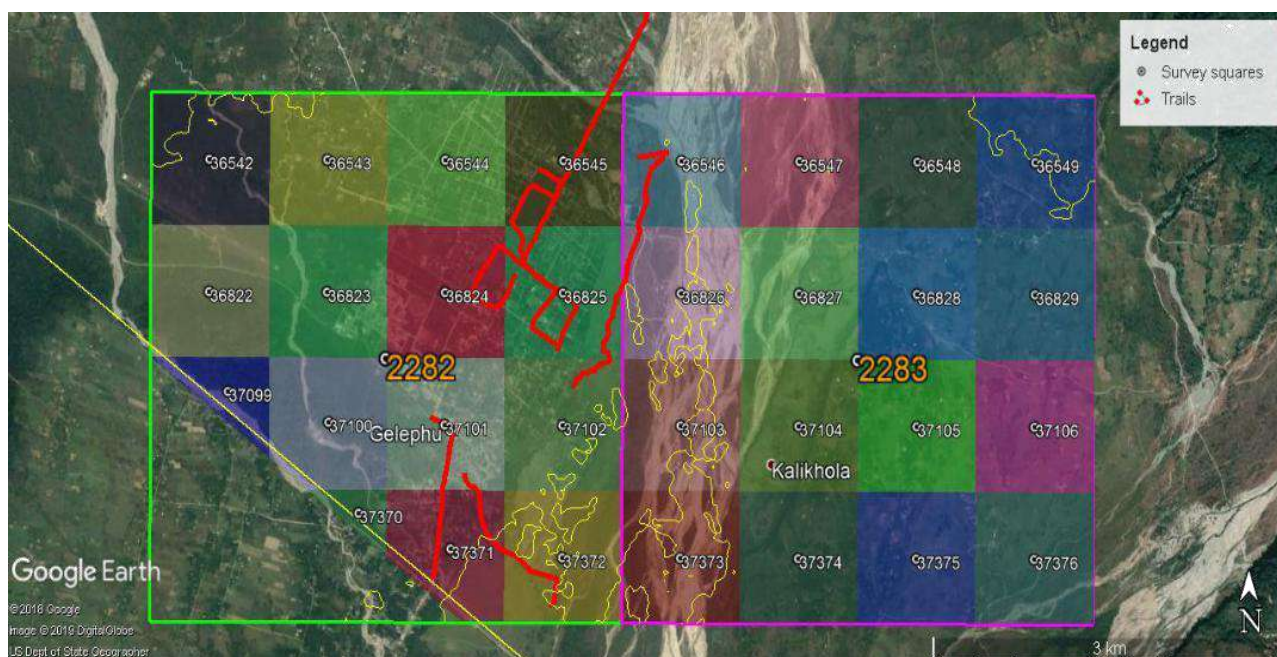


Figure 4.21 Two 4x4 km Biodiversity Monitoring Grids (with Green & Pink polygon outlines) falling on Gelephu Throm (2282) & Maokhola (2283) with 1x1 km Survey Squares and trail transects (Red Lines)

4.4.1.5.2 Methods

Organizing the monitoring survey

- Survey area: National biodiversity monitoring grid (4x4 km) shall be allocated to the management of respective PAs and DFOs by NCD.
- Assigning the survey squares: The PA and DFO management should allocate and assign BMG to their respective Park Ranges/Range Offices.
- Monitoring team & support group: The Range Office shall constitute monitoring team and support group within the range. The NCD, PA and DFOs, any other relevant agencies and Taxa Leaders shall form and provide national level support.
- Regional monitoring coordinators: The PA and DFO managements shall appoint a monitoring coordinator in their park or division respective to coordinate monitoring activity.
- Training frontline forestry officials to impart taxonomic skills to enable smooth implementation of monitoring.
- Incorporate in Individual Work Plan (IWP): Biodiversity monitoring activity be incorporated in Annual Performance Agreement (APA) and IWP.
- Recruiting & training volunteer observers: Advertise, recruit and train volunteer observers or citizen scientists to conduct bird monitoring in the BMG of their choice. Sign a letter of agreement between the regional coordinators and volunteers to conduct monitoring surveys.

Survey Methods

Different species require different survey methods.

- Common species: Trail transect or any survey method shall adequately gather data on common species. MacKinnon Listing can be followed for this purpose.
- Rare species: Trail transect combined with special search effort (combing or flushing) in their habitat enable to gather enough data on rare species. For instance, Wood Snipe which is rare as well as cryptic species shall need special search or acoustic survey methods.

- c) Colonial species: Counting of huge colonial species is difficult, therefore colonies can be counted. For example, Nepal House Martin colonies between Chendebji and Mangde Zam.
- d) Nocturnal species: Species which are active during the dusk should be adequately surveyed using night vision binoculars, and listening to the bird calls

Data Collection: Trail Transect

In the ‘survey squares’, layout 1km trail transect. In case, the survey square has more than one habitat type, run as many 1km trail transects as possible. A trail transect involves walking along an existing trail (footpath, animal track, and roads) and recording birds on either side of the observer. The distance a bird is seen or heard from the transect line is normally recorded as an absolute measure, perpendicular to the trail transect line with the laser range finder.



Figure 4.22 Observing birds along the trail transect and measuring perpendicular distance from the trail transect line to the bird sighting using laser range finder

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The data collection should be done as prescribed the data collection form prescribed in Table 4.9.

Table 4.9 Bhutan Bird Monitoring Data Form

| Grid Code | Sub-grid Code | Transect ID | Dzongkhag | Gewog | Chiwog | Park/TD | Range | Beat | | | |
|-------------------|---------------|-------------|-----------|---------|--------|------------------------|----------|---------|------|--|--|
| | | | | | | | | | | | |
| Date (YYYY-MM-DD) | | Location | | Weather | | | Northing | Easting | | | |
| | | | | | | Start: | | | | | |
| Surveyors | | | | End: | | | | | | | |
| 1. | | 2. | | | 3. | | | 4. | | | |
| SPECIES | | COUNT | | | | Distance Band (meters) | | | | | |
| | | M | F | Juv | Un | DIST(m) | Hrs | Alt(m) | Habt | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
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Grid & Sub-grid Codes: use pre-assigned numeric code on map, **Transect ID:** alphabetical & numeric combo, **Dzongkhag; Gewog; Chiwog:** use annex acronyms, **Park/TD; Range; Beat:** use annex acronyms, **S:** sunny, **OC:** overcast, **C:** cloudy, **SN:** snowy, **HS:** hailstone, **R:** rainy, **D:** drizzle, **ST:** still, **B:** breezy, **W:** windy, **SW:** Strong wind, **SM:** storm, **M:** male, **F:** female, **Juv:** juvenile, **Un:** no sexual dimorphism, **BrdC**[breeding code]:- **PsB:** possible breeding- pair, courtship, **PrB:** probable breeding, **BrC:** breeding confirmed- nest, egg, chick, poop sac, **Acty**[activity code]:- **FF:** forage/feed, **R:** perch/rest, **FL:** fly, **BS:** Bird Song, **Habt:** **SBLF:** subtropical broad leaf forest, **WBLF:** warm broadleaf forest, **CBLF:** cool broadleaf forest, **WL:** Wetlands

Box 4.1 Advisory Points

1. **Listen to Bird Songs:** Start to listen to bird songs of Bhutan to familiarize with calls and identify bird by songs.
2. **Study Guide Books:** Constantly study the field guide to the birds of Bhutan to assist easy identification of during the field observations.
3. **Constant Speed:** On each transect, walk along the transect at a fairly constant speed, looking on either side of the transect line and record all the birds sighted.
4. **Measure Distance:** For cluster birds consider the perpendicular distance at the center of the cluster from the trail transect line.
5. **Survey Team:** Compose bird survey team of THREE members (one data recorder & 2 observers). However, this composition is subject to vary from place to place.
6. **Data Recorder:** One data recorder shall be responsible for accurately and consistently recording the bird observations provided by two observers.
7. **Record Flying Birds:** If birds fly away as you are counting, record them from the point you first saw them.
8. **Detection:** All the birds on the trail (0m distance) are detected.
9. **Sighting Position:** More commonly, birds shall be flushed away from you, so keep an eye on the line of travel ahead of you and try to record the positions from which the birds are flushed.
10. **Bird onto Wings:** If birds are seen to take to the air, then these birds should be included in the count and an estimate of distance is made from the take-off point perpendicular to the line transect.
11. **Knowing Form:** Familiarize trail transect data form carefully and understand the parameters to be filled.
12. **Completely Fill:** Leaving the parameters empty shall create problem at the data analysis stage. Completely fill up all parameters mentioned in the form.

Breeding Bird Mapping in Survey Squares

Make a special search effort to find breeding pairs, nest, chicks or parents feeding fledglings to collect the breeding bird data in the SS. Also use cues such as adult birds carrying nesting materials, chick's poop sac, and adult birds carrying insects and worms in their beak. Collect GPS coordinates, nesting tree, number of egg, egg color, egg shape or chicks (if possible) and other geophysical data.

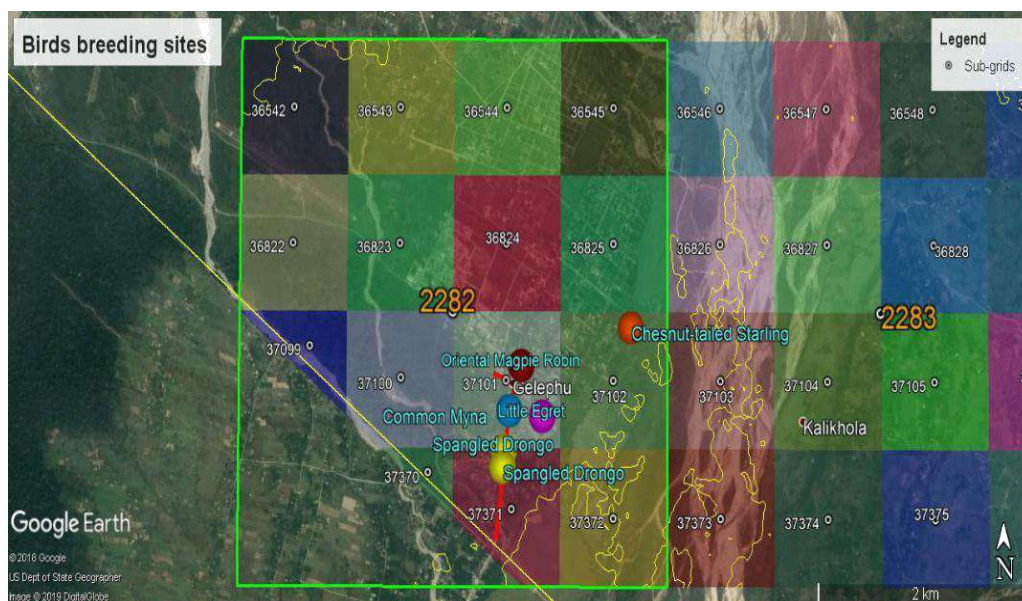


Figure 4.23 Breeding locations colour coded and labelled with species name

4.4.1.5.3 Determining the number of samples, length and positioning the transect

The best approach to monitor birds in Bhutan is to cover all the 2424 BMG by sampling 30% or 5 SS in each BMG. In the SS, layout 1km permanent trail transect or as many 1km trail transects equal to different habitats.

Data validation

- a. Validate individual records (weekly, annually, final)
- b. Review of territory mapping in km squares

Results

The first bird monitoring activity shall generate the first nationwide baseline data. From the baseline data, we can deduce species richness and current population status. It is anticipated to generate results beyond the following from subsequent bird monitoring data:

- a. Maps & altitude charts
- b. Species richness per square km
- c. Populations estimates
- d. Trends in species richness & population numbers.

Table 4.10 Breeding Bird Mapping Survey Data Form

| Grid Code | Sub-grid Code | Date (YYYY-MM-DD) | Dzongkhag | | Gewog | | Chiwog | Park/FD | Range | Beat |
|-----------|---------------|-------------------|-----------|---------------|-----------------------|--|--------|-------------|--------|------|
| | | | | | | | | | | |
| | | | | | | | | | | |
| SPECIES | | Northing | Easting | Nesting Habit | Host Tree (Live/Dead) | | Alt(m) | # Egg/Chick | Remark | |
| | | | | | | | | | | |
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Nesting Habit: **TR**- nest on tree, **TC**- nest in tree cavity, **SR**- nest on shrubs & bushes, **GS**- nest on grass, **OG**- nest on open ground, **UG**-nest underground, **BR**- nest in barns, **HS**- nest on human made structures.

4.4.1.5.4 MacKinnon Lists

MacKinnon List is the method that consists of listing all birds which are heard or seen in the chronological order of detection. This master list is then broken down into lists or samples of a pre-determined number of species; ten is often recommended. Each list thus provides a sample of the species community at the study site. The MacKinnon Lists method can then be used to derive abundance indices of individual species by calculating the proportion of samples in which each species occurs. This method can be followed if the purpose is for one-time rapid assessment of birds. Different listing can be done for different habitats, as prescribed in Table 4.11, Table 4.12 and Table 4.13. When longer time periods are spent in one spot or when resampling a given section of the study area, repeated counts of known territorial individuals should be avoided.

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Table 4.11 Datasheet for MacKinnon Listing in Broadleaf Forests

| Grid | ID: | Trans/Plot ID: | Date (YYYYMMDD): | | | | | | | Habitat: | | |
|-------------|------------|----------------|---------------------|---|---|------|-----------|-------|-------|----------------|---------|--------|
| Start Time: | | End Time: | Weather: | | | | | | | List: | | |
| GPS Start: | | | GPS End: | | | | | | | Surveyor: | | |
| | | | | | | | | | | | | |
| Sl. No | Time (Hrs) | Species | Cluster Size | | | | Altd. (m) | Evid. | Behv. | GPS Coordinate | | Remark |
| | | | M | F | J | USex | | | | Northing | Easting | |
| 1 | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | |

Habitat Type: SBLF: subtropical broad leaf forest, WBLF: warm broadleaf forest, CBLF: cool broadleaf forest, Remark: keep note of any special observations

CLUSTER SIZE: (M: male, F: female, J: juvenile, USex: Non dimorphic): Keep notes of threats (traps, snares, poaching): Hornbill nest trees, Altd.: altitude, Evid.: evidence (o: observed, c: call, f: feather, db: dead body, d: dropping), Behv.: behaviour (fd: feed, rt: rest, pn: preen, cs: courtship, fl: fly).

Table 4.12 Datasheet for MacKinnon Listing in Conifer Forests

| Grid ID: | | Trans/Plot ID: | | Date (YYYYMMDD): | | | | Habitat: | | |
|-------------|------------|----------------|--------------|---------------------|---|------|----------------|-----------|--|--|
| Start Time: | | End Time: | | Weather: | | | | List: | | |
| GPS Start: | | | | GPS End: | | | | Surveyor: | | |
| Sl No | Time (Hrs) | Species | Cluster Size | | | | GPS Coordinate | | | |
| | | | M | F | J | USex | | | | |
| 1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| 3 | | | | | | | | | | |
| 4 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |

Habitat Type: DTCF: dry temperate conifer forests (blue pine & spruce), MTCF: moist temperate conifer forest (hemlock, fir), SACF: subalpine conifer forest (juniper, rhodo & willow shrubs) DCF: dry chirpine forest, CLUSTER SIZE: (M: male, F: female, J: juvenile, USex: Non dimorphic): Keep notes of threats (traps, snares, poaching), Remark: keep note of any special observations. Altd.: altitude, Evid.: evidence (o: observed, c: call, f: feather, db: dead body, d: dropping), Behv.: behaviour (fd: feed, rt: rest, pn: preen, cs: courtship, fl: fly)

Table 4.13 Data form for MacKinnon Listing in Wetlands

| Grid ID: | | Trans/Plot ID: | | Date (YYYYMMDD): | | Habitat: | | | | | | |
|--------------------|------------|-----------------------|--------------|-------------------------|---|-----------------|-----------|-------|------|----------------|---------|---------|
| Start Time: | | End Time: | | Weather: | | List: | | | | | | |
| GPS Start: | | GPS End: | | Surveyor: | | | | | | | | |
| SI No | Time (Hrs) | Species | Cluster Size | | | | Aldd. (m) | Evid. | Beh. | GPS Coordinate | | Remarks |
| | | | M | F | J | USex | | | | Northing | Easting | |
| 2 | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | |

Habitat Type: AS: farmland & settlement, Wetlands (riverbeds, rivers, streams, lakes, marshes), AM: alpine meadows, OM: open meadows

CLUSTER SIZE: (M: male, F: female, J: juvenile, USex: Non dimorphic): Keep notes of threats (traps, snares, poaching), Remark: keep note of any special observations

Aldd.: altitude, Evid.: evidence (o: observed, c: call, f: feather, db: dead body, d: dropping), Behv.: behaviour (fd: feed, rt: rest, pn: preen, cs: courtship, fl: fly)

4.4.1.5.5 Materials Required

- Binoculars & Camera
- Laser Range Finder
- Altimeter/GPS Unit/Compass
- Topographic Map of the Survey Area
- Field Guide/Bird Songs
- Data Form/App
- Pencil/Ball Point Pen

4.4.1.5.6 Ethics

The following must be dully practiced while conducting bird watching or bird surveys.

1. **Maintain Privacy:** Take care not to disturb either the birds or their habitats or off end other people while you are bird watching: respect private property and the privacy of others. Don't disrupt the enjoyment that other people are getting from their own activities.
2. **Observe Silence:** Always be quiet. Birds have extremely acute hearing. Talk softly and as less as possible.
3. **Steady Motion:** Move carefully and regularly. Do not make sudden movements or point at a bird.
4. **Casual Approach:** Try to approach a bird casually as though you were not interested in it. If a bird feels it is the centre of attention, it invariably becomes alarmed and flies off.
5. **Avoid Flushing Birds:** Do not disturb birds hidden in the bush/foliage or especially near their nests. Be patient and wait to get better view. Never throw stones at the bird(s). Remember, welfare of the bird should always come first.
6. **Avoid Stress:** Avoid disturbing or stressing birds, especially breeding birds, which can be very susceptible to stress. They may abandon a nest with eggs or chicks if they are unduly disturbed. Similarly, don't harass them with excessive use of bird calls, and don't disturb a nest or handle eggs or chicks that you come across.

7. **No Littering:** Leave nothing but footprints: avoid damaging the natural environment. Leave it just as you found it so that others can enjoy it too. Take away garbage with you when you leave the place.
8. **Keep your good intentions to yourself:** Your intentions may be good, but it's often best not to interfere with birds that appear to be in distress. Baby birds on the ground can seem abandoned, but may be just out of the nest and learning how to fly. The parents are probably close by and they shall return when you have gone. Don't keep them waiting!
9. **Best Birding Hours:** Start bird watching in the early morning. Birds are most active in the first few hours of the day. They have another smaller peak of activity during an hour or two before dusk.
10. **Avoid Birding:** In general, birds don't like windy, wet or very hot weather. Therefore, bird watching shall be most successful on warm, sunny, still days.
11. **Avoid Colours:** Avoid wearing bright colored clothing that can be easily detected by birds.
12. **Over Play Playbacks:** Avoid excessive use of bird song playbacks. Do not play playbacks at very high volume especially around or breeding bird's territory.

4.4.1.5.7 Safety

1. Always go for bird surveys in group, with a minimum of two members.
2. Be aware of potentially dangerous wildlife – elephants, bear, tiger, snakes, etc.
3. Watch where you are walking. Having intensely engrossed into bird watching in air and trees, birdwatchers can easily lose track of immediate surroundings and bump into things or can trip over badly.
4. Prepare for the severe weather conditions, and beware of high-altitude sickness. Check weather forecast beforehand, carry rain gears, wear appropriate foot wear and long sleeves shirt and pants to cover your arms and legs to avoid bites from snake and insects.
5. Most species of birds are sensitive to disturbance during the breeding season; therefore, extreme caution should be taken while counting the nests or pairs. It is preferable to count the nest from a distance. A bare minimum time should be spent near a nesting colony. Most counts should be done in the morning or evening, and never during hot mid-day. Avoid going too near to the nests of raptors especially eagles.
6. Carry adequate consumption provisions (food & water), first aid medicine and energizers (chewing gums, sweets).

4.4.1.6 Monitoring Protocol for Fresh Water Fishes and Macroinvertebrates

Fresh water fish require a wide range of habitats to complete their life cycle. Widespread, good quality fish habitats increase the distribution and abundance of native fish. In Bhutan, freshwater, primarily of rivers and streams are estimated to be about 7,200 km, and they form the major habitat for the fishes. These streams and rivers connect the headwater at the glacial lakes with down streams, also connecting the cascading flow for aquatic organisms at various trophic levels.

Therefore, the freshwater fish habitats include:

- A. habitat zones (rivers, lakes, wetlands, creeks, swamps etc.) in the upper, middle and lower sections of a waterway
- B. microhabitats within each of these zones including banks, snags, rocks, channels, substrates, riffles, macrophytes (aquatic plants) and riparian vegetation.

4.4.1.6.1 Sampling design

Selection of appropriate sampling design depends on several factors such as the objectives, availability of gears, fund, geomorphology of the river and streams, time of sampling and human resources. Various types of probability and non-probability sampling methods can be used in the fish and freshwater macroinvertebrate

monitoring surveys. Stratified random sampling shall be used as it suits in a heterogeneous aquatic environment with undulating gradient.

Sampling shall be focused representing all eco-floristic zones and microhabitats for consistency in monitoring fishes and freshwater macroinvertebrate. The BMG of 4x4 km shall be over laid for identifying sample plots (Figure 4.24). The sampled BMG in each PA and DFO should be representative of all major habitat types (Refer datasheet) and at the sampled grids, sample site selection should cover all representative microhabitats (riffles, pools, runs, cascades and COPM) within the sampling reaches. These habitats should not be repetitively sampled in a particular effort stretch.

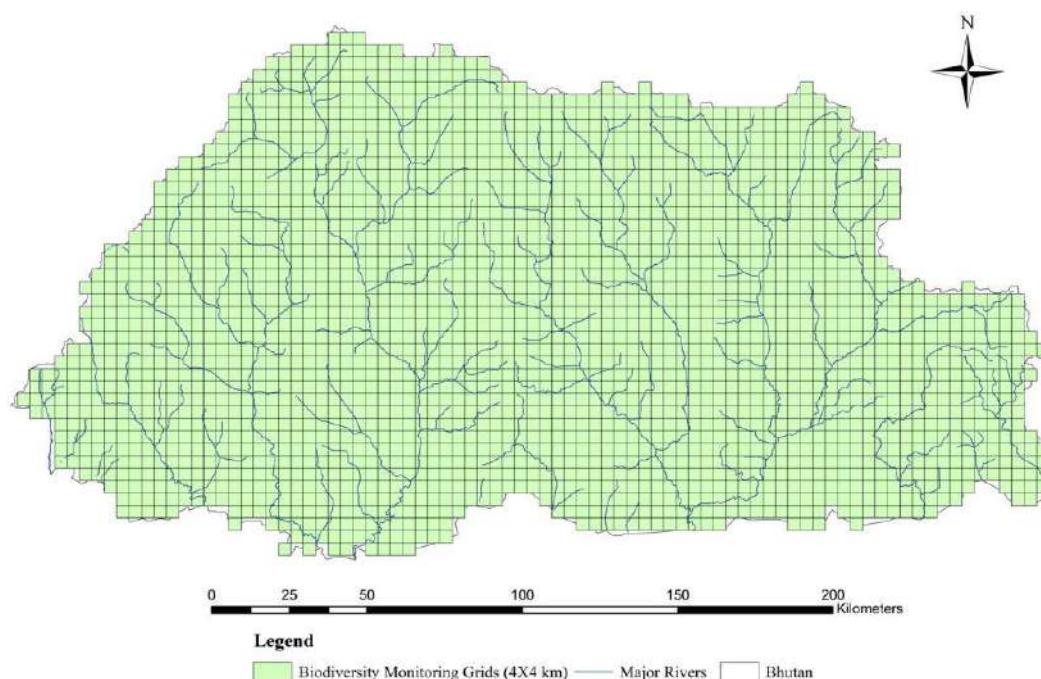


Figure 4.24 Map of Bhutan showing the Biodiversity Monitoring Grids laid and the Major Rivers of Bhutan

4.4.1.6.2 Sampling size for fish

Sampling size for fish can be determined by sampling efforts. Within the grid, a representative sampling site shall be selected for data collection. 10 samples for each habitat or stream reach shall be taken using appropriate fishing gears (Electro shocker/Cast net) to minimize error.

4.4.1.6.3 Sampling size for freshwater macroinvertebrate

Lotic ecosystem: Lotic ecosystem includes rivers and perennial streams. The length of the sampling stretch shall be 10 times the stream width. The width of stream shall be determined by taking a mean of stream width measured at three locations each measured 30 meters apart. There should be no major tributaries discharging into the stream at the sampling stretch and the site should be at least 100 meters away from the road or settlement. Within the sampling stretch, representative microhabitats must be identified to collect samples and specimens.

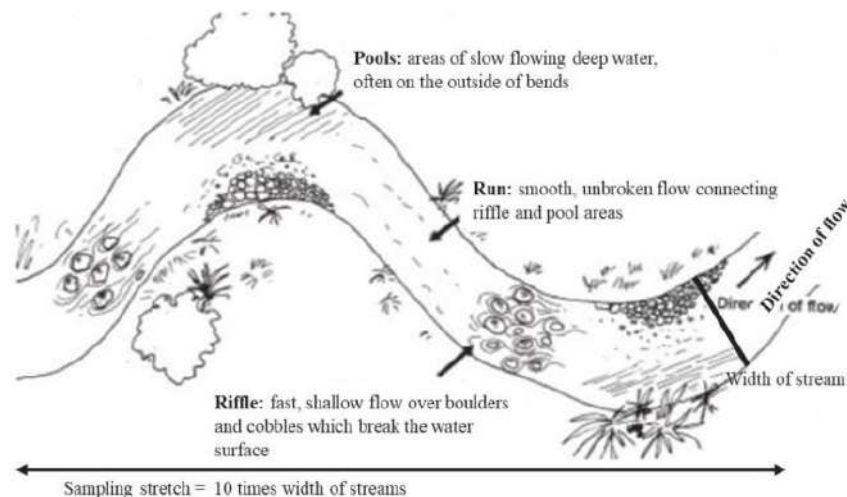


Figure 4.25 Different types of microhabitats and representative sampling stretch

Area of the sampling unit for sample collection corresponds to the size of the kick net (30 x 30cm). Collect only one replica from every sampling stretch.

Lentic ecosystem: Lentic ecosystem includes high altitude and low land lakes, reservoir, and perennial water holes. The sampling unit for lentic ecosystem, four sampling units must be assessed at the littoral zone. Laying of two sampling units shall be determined by the inlet and outlet of the lake, and the other two sampling units must be perpendicular to the inlet and outlet of the lentic ecosystem. However, in those lentic ecosystems, without outlet and inlet, sampling units must be laid based on the cardinal direction (East, West, North and South) at the littoral zone.

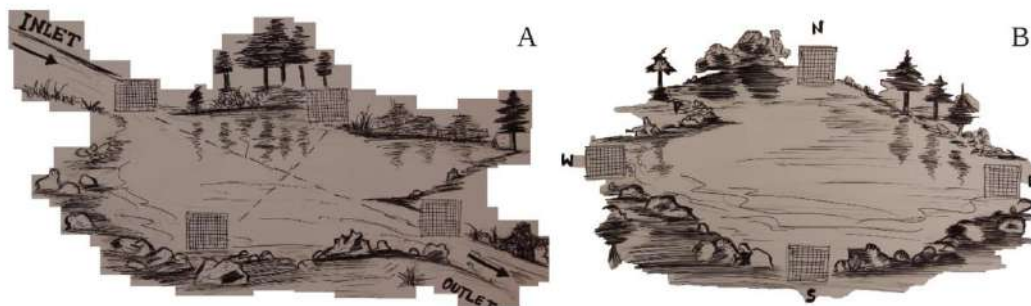


Figure 4.26 (A) Showing layout of sampling units on lentic ecosystem with inlet and outlet;

4.4.1.6.4 Methods for fish sampling

Many types of fishing methods are available and not all methods are feasible in Bhutanese river systems. Active gears for instance, electro-shocker and cast nets are generally used for the monitoring system. Electro-shocker is used in small water bodies while cast nets in rivers. To ensure that most migratory species are recorded, timing of survey is critical. Monitoring is preferred during spring season to get maximum diversity (March, April and May). Rainy season is not preferred as species are displaced by floods. Winter season is also not preferred as most species are inactive due to low temperature. Probabilities of catching migratory fishes are higher during monsoon. Sampling can be avoided during full moon phases as fish tend to become more restless. Data should be collected as per the prescribed form in Table 4.14.

Table 4.14 Datasheet for assessing and monitoring the fishes

| Fish Monitoring form | | | | | | | | | | | | |
|--|---------------------|---|---|-------------------|-------|------------------|----------------|---------------|---|----|----------------|---------|
| Grid No: | Plot ID: | | | | Date: | | Sampling Gear: | | | | | |
| Drainage: | | | | Start Time: | | *Stream Reach: | | | | | | |
| Stream/River: | | | | End Time: | | Vegetation Type: | | | | | | |
| Start | | | | End | | Substrate: | | | | | | |
| Latitude: | | | | Latitude: | | | | | | | | |
| Longitude: | | | | Longitude: | | | | | | | | |
| Altitude: | | | | Altitude: | | | | | | | | |
| Turbidity (): Clear; Slightly turbid; Turbid; Stained; | | | | | | | | | | | | |
| pH: | | | | Temp (°C): | | | | Conductivity: | | | | |
| TDS: | | | | Dissolved Oxygen: | | | | Salinity: | | | | |
| Collected by (team members): | | | | | | | | | | | | |
| Species | Sampling Effort No. | | | | | | | | | | Total Count | Remarks |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | |
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*Stream reaches: *Pool (Po)*, *Riffle (Rf)*, *Run (Rn)*, *Cascade (Cd)*.

For all the morphological measurement of the fish caught, measurement should be recorded as prescribed in Table 4.15.

Table 4.15 Datasheet measuring morphometric and fish release form

| Fish release form | | | | | | | |
|-------------------|-----------|----------------------|------------|-----------|--------------|----------------|---------|
| Species | Effort No | Standard Length (cm) | Weight (g) | Photo () | Specimen () | Health of fish | Remarks |
| | | | | | | | |
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4.4.1.6.4.1 Electro-shockers

Electro-shockers are efficient fish sampling gears. Along with the electro-shocker, two scoop nets for collection of fishes can be used. Recommended size of scoop mesh net eye is 0.5 x 0.5 cm.

Refrain repetition sampling in the same site to avoid stress and it could be fatal to fishes. Night efforts are proven to give better catch rate. However, particular gear shown in Figure 4.28 is not efficient in big river and recommended for streams only. (CAUTION: electro-shocker using dynamo or car battery could be fatal).



Figure 4.27 Electrofishing in streams and rivers

4.4.1.6.4.2 Cast nets

Cast nets are popular fishing gears (Figure 4.28), but the catch rate and species caught shall differ with mesh size, skill of fishermen and the time of sampling. Cast net is an effective tool while sampling in big river. For uniformity, a cast net with 6 feet, weighing 3-3.5 kg with 0.8x0.8 cm eye is recommended. However, it is not effective for many small benthic and cryptic species such as the *Amblyceps* spp. and *Schistura* spp.



Figure 4.28 A cast net used for fishing in streams and rivers

4.4.1.6.5 Methods for freshwater macroinvertebrate sampling

Usually, the best sampling season for freshwater is during the spring and for *streams and rivers*, it is during autumn seasons (Shah *et al.* 2011). These seasons correspond to the post-monsoon and pre-monsoon season in Bhutan. Sampling should be avoided during or shortly after floods or drying of the stream reach. The fresh water macro-invertebrates should be collected within a 1x1m plots in the four geographic cardinal directions of the lentic ecosystems 3 m away from the litho-aqua interphase into the lake/pond. On the free-flowing stream emerging from the marsh, survey should be conducted along the sampling stretch that is 10 times the width of the stream. Systematically, approach the microhabitats from downstream and proceed towards upstream, the next subsequent sampling microhabitats. This is being practiced to avoid recapture of taxa from the previously disturbed microhabitats if followed otherwise. Place the kick net perpendicular to flow of water current on the identified sampling units. Gently pick the boulders and cobbles over 5 cm and rub the organism from the stone to the net. Disturb the stream substrate with hand or leg and collect freshwater invertebrates into the net. Remove the net in a forward scooping direction and place the collected materials in the bucket. Rinse the net thoroughly with water over the bucket. If the samples collected are turbid, dilute by adding more clean water. Identify and sort sample specimens into different groups in the ice-cube trays. Count individuals with the same morphotypes and tally in the datasheet. Take photographs for all the taxa collected from the sampling unit. Collect specimens along with tagged specimen code in the vials (70% ethanol) for those taxa not identified in the field. Release all those taxa back into the stream other than specimens collected for lab assessment. All the information must be filled in the datasheet systematically covering all the attributes in the form (Table 4.16).

Forest and Nature Conservation Code of Best Management Practices of Bhutan

Table 4.16 Datasheet for sampling freshwater macroinvertebrates and measuring the physicochemical properties

[illegible]

Note: Microhabitat includes Po (Pools), Rf (riffles), Cd (cascade), Rn (run) and COPM (Coarse organic particulate matter) **Habitat types:** AL (Agriculture land), GL (grassland), SM (settlements) BF (broadleaved forest), MC (mixed conifer), CF (Conifer forest), SB (shrubs/bushes)

4.4.1.6.6 Physicochemical properties of freshwater

Physicochemical measurement must be taken prior to sample collection at the site. All parameters shall be measured once from every sampling unit for freshwater macroinvertebrates (Table 4.16), whereas for fish sampling, physicochemical properties shall be measured once in the beginning and once at the end of the sampling stretch. Prior measurements are usually conducted to acquire the natural properties of water. Remember to calibrate the multiparameter before taking the field measurement to avoid an error. If stored for a longer duration after the calibration, re-calibration is necessary for accurate reading.

4.4.1.6.7 Equipment and Materials

Following are list of equipment but not limited to, for conducting the freshwater fish and macroinvertebrate monitoring. Beside the given list, microscopes for identification of specimens at the lab and workplace camp shall be useful for validating the taxa names.

- electro-shocker,
- scoop nets,
- cast net,
- multiparameter,
- dissolved oxygen meter,
- turbidity meter,
- mini aquarium for photography,
- GPS unit,
- tag guns (voucher specimens),
- tag gun codes,
- micro-tubes,
- spring balance,
- digital caliper,
- digital high megapixel camera,
- kick net (mesh size 500 µm;
- kick net size 30 cm X 30 cm),
- measuring tape
- guide books.
- boots,
- buckets,
- formalin,
- ethanol,
- specimen jars (different sizes),
- ice-cube trays,
- pipette, bucket,
- bowls,
- vials,
- petri dish,
- hand lens,
- dissection kits,
- live jacket,
- hand gloves,
- sanitizer/soap,
- knife,
- label card,

4.4.1.6.8 Other taxa observation at the site

There are other groups of organisms in the freshwater ecosystem which helps in maintaining the continuous energy flow through a chain of trophic levels. This includes mammals, birds, rodents, herpetofauna, tortoise, and other living organisms which together provide important ecosystem services. All taxa observed at the sampling sites must be recorded in the data sheet (Table 4.17).

Table 4.17 Datasheet for associated taxa

[illegible]

4.4.1.6.9 ETHICS AND SAFETY

4.4.1.6.9.1 Ethics

Any researcher (national or foreigner collaborating with Bhutanese) who is wishing to conduct any kind of research must avail research clearance from the Department. Specimens used for research, education and experiment must be treated with ethical consideration. A researcher, technical staff or student must be properly trained and competent. Specimens and metadata collected should be deposited at a recognized data repository center within the country.

4.4.1.6.9.2 Safety

Researchers are responsible and must comply with occupational health and safety regulations to prevent personnel from physical and biological hazards. Researchers should be aware of the potential zoonotic risks. During the field work, crew members must be cautious and responsible for their personal safety. Formulation of preservatives and handling of electric shocker must be done only by the trained professionals.

4.4.1.7 Herpetofauna Monitoring Protocol

4.4.1.7.1 Methods

There are several methods to survey and monitor herpetofauna species. The most prominent ones according to Graeter et al. (2007) are;

- i) Pitfall Traps
- ii) Funnel Trapping, cover boards (artificial retreats)
- iii) Systematic searches
- iv) Photo identification
- v) Visual Encounter Surveys

Different methods are used for different species depending on the ecology, behavior, character of the species and types of habitats namely., wetlands, streams, forests, settlements, etc. Considering terrain, the best methods applicable for Bhutan is **Visual Encounter Surveys (VES)** for majority of species. It is cheap, easily implementable and efficient for range of habitats (Manley et al., 2004). Further, VES causes minimal habitat site disturbance, avoid animal mortality and can be easily applied in terrestrial and aquatic habitats.

For PA and DFOs, their jurisdictional boundaries could serve as the primary sampling unit. However, considering the size of the PA and DFOs, the concerned offices can identify potential herping areas so that VES or systematic search can be applied. For easy monitoring, the PA and DFOs must locate and identify water bodies (lentic or lotic), forest marshes, paddy fields where a good number of species of herpetofauna usually feed and breed. Every field office can have a set of identified herpetofauna habitat such as:

- a) Lotic river system
- b) Lentic water bodies
- c) Forest Marshes
- d) Paddy Fields
- e) Other categories (villages, towns, Dzongs, monasteries, etc.)

After testing these methods and collecting enough and efficient baseline data move to next step of using cover boards, minnow traps, nets, etc. For long term monitoring purposes, changes in species composition and numbers in wetlands, forests, road and river sides, countryside, etc., can be thoroughly monitored over a time period in pre identified habitats. Once the monitoring work commences, we can understand the type of habitat the species occupy and that's when assessing them would not be difficult. However, at the moment, due to

lack of information, we need to look at easier ways to assess the species and start recording them for conservation, management or exploitation purposes. Otherwise, in the effort of achieving the goal of conserving the species, it is possible that wrong information could be disseminated.

Every PA and DFO already has some information on locations which are potential home to herpetofauna species. For example, there are records of turtle species up to Gulabi Top under Zhemgang Division which means that we do not have to focus much on monitoring testudines in areas above Gulabi Top. Otherwise, if the monitoring is to be considered for “as and when staff visit field” in any part of the area under any PA or DFOs, Smart tools in smart phones currently used by field offices in Bhutan is recommended. Data collection formats are designed and species encountered can now be entered in the phones and computers of the field officials that can be submitted further for analysis, interpretation and conservation monitoring. These methods must be field tested and if proven good, must be used for monitoring species throughout the year. Smart data scheme used for patrolling can be used for conventional way of collecting, reporting and interpreting data for the long-term conservation of species.

4.4.1.7.2 Sampling Design

There are many sampling designs as described below but not a single method can be said as the best method. Therefore, combining methods to supplement one another is recommended.

4.4.1.7.2.1 Cover-Board Arrays (CB)

Long-term placement of metal or wooden “boards” in fixed arrays in selected terrestrial monitoring sites, provides species, frequency, occupancy, age, size and sex data.

4.4.1.7.2.2 PVC-pipe Tree Samplers (PVC)

A passive sampling method suitable for tracking adult tree frogs in forested habitats. It provides species, frequency, occupancy, and other population characteristics.

4.4.1.7.2.3 Funnel Traps (FT)

Short-term samplers deployed in arrays in shallow water to collect aquatic amphibians. Provides occupancy, species, frequency and developmental data on larval and aquatic adult amphibians.

4.4.1.7.2.4 Mark-Recapture (MR)

MR is used to track individuals through space and time (growth, longevity, fate, movement, population size, habitat use, and reproductive assessment). Useful for yellow tortoise and keel box turtles including the *Pangshura* species.

4.4.1.7.2.5 Visual Encounter Surveys (VES)

Time or area limited technique where observers walk transects and observe individuals and their position relative to the transect path. VES provides occupancy, density, species richness, location and frequency for surface-active species.

Besides the above-mentioned procedures, in most of the cases, the following survey techniques are used for any type of information collection including scientific research for specific objectives or other purposes.

A. Time-constrained Searches (TCS)

Time-constrained searches (TCS) encompass probing the identified habitats for amphibians and reptiles with collection of species that come across by hand (Bury and Raphael 1983, Campbell and Christman, 1982). Each search has time limit as well as number of same crew members. TCS is most useful to understand presence or absence of species that shall give baseline data on the types of microhabitats occupied by individual species.

However, TCS is not so good for population estimation since it is a plotless technique. Same extent of potential habitat tends to be searched in each habitat while habitat suitability may be different for same type of study areas. Thus, in some TCS results, it is likely that the poor habitat areas may yield better result (example number of species) than those habitat-rich areas while the population size in actual sense may be quite different. However, TCS is best for collecting base line information (than plot searches) since surveyors are free to scour over a large area where more species of herpetofauna are found. TCS technique is best employed when several study areas need to be surveyed in a short time, very relevant to the current monitoring system being practiced.

B. Surveys of Coarse Woody Debris

In Coarse Woody Debris (CWD) survey, the fallen or standing woods are searched for animals. CWD works much like TCS but to understand the population of species, the quantum of CWD must be known. The main disadvantage of CWD however is that density or population estimates apply only to one feature of the habitat. Animals that use other microhabitats like nearby rocky soils, downed wood and other may be missed in CWD surveys. Thus, this method is excellent only for those species which may use CWDs as their only habitat. CWDs may not be very relevant in Bhutan, since not many species that have been recorded so far are not CWD lovers.

C. Pitfall Trapping

Pitfall trapping is a flexible technique that can be used to achieve several objectives; for example, drift fences with pitfall traps have been used to encircle specialized habitats such as amphibian breeding ponds (Gibbons and Semlitsch 1981, Shoop 1968, Storm and Pimentel 1954). Pitfall technique can also be used for complete enumeration of breeding populations and has been employed widely for surveys of amphibian and reptile diversity and abundance in different habitat types (Bury and Corn 1987; Campbell and Christman 1982; Friend 1984; Jones 1981, 1986; Raphael 1984; Vogt and Hine 1982; Szaro, 1988). The main drawback of pitfall trapping is that trapability differs widely among species (Bury and Corn 1987, Campbell and Christman 1982, Gibbons and Semlitsch 1981). A survey of all species of herpetofauna in an area therefore requires more than one technique.

Pitfall trapping provides data on the presence or absence of species, and because the trapping effort can be quantified and standardized across study areas, relative abundances can be calculated. Estimates of actual population size may be possible, though probably only for abundant species. Pitfalls can be used as live traps if checked frequently, and mark and recapture techniques may also be used. If pitfalls are used as a removal method to estimate density, then the area being trapped must be known. This is extremely difficult to determine for most herpetofauna and is not recommended at this stage although it is possible. Pitfall trapping can also be useful for investigating seasonal activity patterns. Traps can be operated continuously, so that variation in activity due to weather can be detected (Bury and Corn 1987). Pitfall traps shall be permanent structures, so long-term monitoring can be accomplished by operating the same trap array or grid periodically over several years. Trapping has unknown effects, however, on population structure due to the removal of resident individuals.

4.4.1.7.3 Experimental Design of this Protocol

The design for this protocol is explained below.

4.4.1.7.3.1 Time-Constrained Searches

This technique is a quick survey method requiring few restrictions on the approach. Ideally, three points need to be considered:

- i) Collection should be done away from forest edges;

- ii) Aquatic habitats, such as breeding ponds or creeks should be avoided as these are covered by a separate protocol; and
- iii) Collection should cover as much of the stand as possible. There are two ways to accomplish this last point. One way is to devote enough time to the search to be able to collect across the entire study area. The second is to restrict the search to a fairly small area (for example, a circle with a radius of 25 m) and restrict the amount of time spent in collecting data. The number of smaller areas that can be searched in each study area depends on the amount of time devoted to the TCS. About 6 or 8 staff hours of collection time must be sufficient; few additional species may be detected by collecting for longer than 8 hours. If 1 hour is spent in each of the subsamples, then six to eight areas can be searched in each study area.

However, for Bhutan, since we are at the nascent stage for such information collection, it is recommended to use this method on wetlands, forest edges and any other habitat as identified by the field offices.

4.4.1.7.3.2 Surveys of Coarse Woody Debris

This technique is somewhat more complicated than TCS in that it involves systematically searching a predetermined number of logs in each study area. Several questions must be addressed when a study is designed, including how many logs to sample, how to apportion the sample among the different decay states of downed wood, and how to select the logs sampled. The application of this technique is recommended only for a species of caudata where this method is best used for.

4.4.1.7.3.3 Pitfall Trapping

Planning to set up pitfall trap mainly involves selecting an appropriate trap design. Two different pitfall designs (Figure 4.29) can be used. One, an arrays of pitfall traps with aluminum drift fences (Bury & Corn, 1987) and secondly grids of single pitfall traps without fences. There were quantitative and qualitative differences in the yield of each technique that must be considered in planning a project.

The choice of whether to install arrays or grids ultimately depends on the needs of the study. Arrays are superior for catching reptiles, but reptiles may not be abundant in forest habitats or of interest to the goals of a study. Arrays can provide large sample sizes in relatively short periods.

Grids remove fewer animals than arrays and are more suitable for long-term monitoring. Both techniques are effective for catching small mammals as well as amphibians. Arrays may be placed in pairs or single and may be placed at more than one location within a stand (Figure 4.29). Three or four single arrays scattered throughout the stand may better assess the variation within study areas, but this approach requires significantly more time for checking the traps in each area. Cost may decide whether to install arrays or grids. Grids are costly due to cost of materials. Grids take only about one-half the effort to install as the arrays. When personnel costs are high, this can result in a large difference in cost between the two methods. The cost involved in checking the traps is similar and depends mainly on the number of stands and the travel time between them.

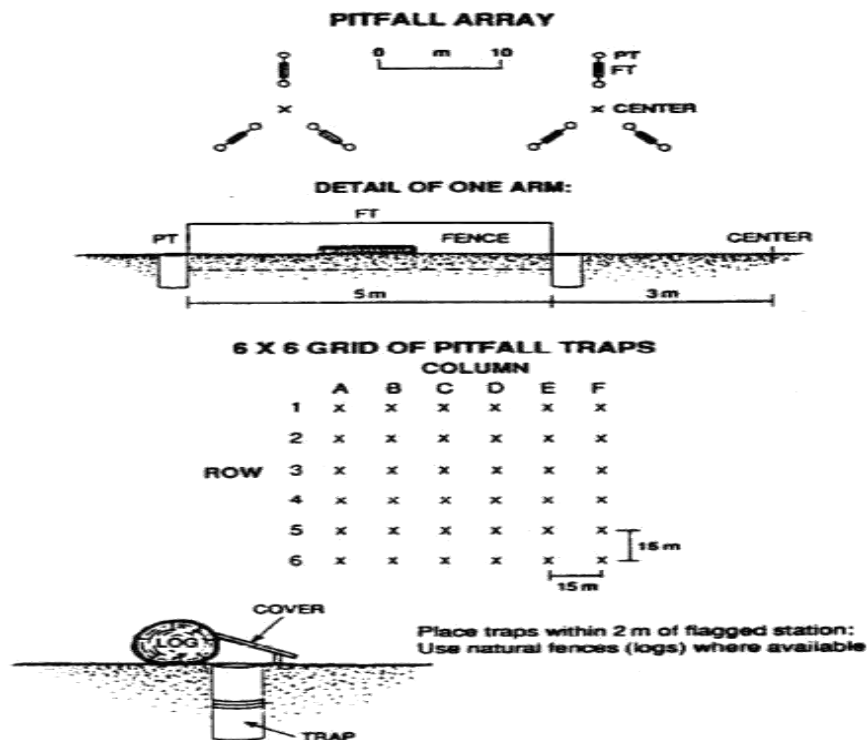


Figure 4.29 Designs for arrangements of pitfall traps either with or without drift fences. PT = pitfall trap, FT = funnel trap. (Diagram adapted from Corn and Bury 1990)

4.4.1.7.4 Crew Sizes

Optimal crew sizes depend on the technique being used. Time-constrained searches and surveys of CWD use the same collecting techniques, and three to four persons are suitable for both. In both crews, one person is the data recorder, and the remaining people do the collecting. A 6-staff-hour TCS, done with a two-person crew plus a recorder who does not collect, requires 3 hours, plus the time for breaks. For pitfall trapping, a large crew is generally necessary to install traps, but only one or two people are needed to check the traps once they are open. Installation of either arrays or grids is relatively fast with a crew of six. Crews of this size can install two arrays or grids per day. Two people can check a grid of 36 traps in an hour or less. Several sites can be checked in one day, depending on the travel time between study areas.

4.4.1.7.5 Time Frame and Weather

Hand collecting (TCS and surveys of CWD) should be done when amphibians are most likely to be active; that is, in the rain. If there are several study areas, then the primary consideration is that the weather be as consistent as possible throughout the collecting period. Activity of amphibians is highly dependent on weather, and comparisons between areas of collection under radically different weather conditions may not be valid. Collecting therefore should begin as early as possible in spring or as late as possible in fall, but still avoiding lengthy periods of cold and snow. Collecting should not be done in heavy snow; light snowfall in a period of wet weather probably shall not seriously affect amphibian activity. Two TCS can usually be done in one day, but one survey of CWD requires most of a day. It is possible, but not recommended, to split a survey between two days. Pitfall trapping has more flexibility, because all traps are open at the same time thereby reducing variability among study areas due to weather. The best season for operating pitfalls depends on the animals being trapped. For amphibians, spring and fall are again the periods of highest activity and shall result in the largest catch. If reptiles are being sampled, then early summer is the best time to open pitfall traps. Pitfall installation can be done at any time, but data (Bury & Corn 1987) suggest that pitfalls should be in the ground at least 1 month before trapping begins.

4.4.1.7.6 Operating Guidelines

In time-constrained searches, determine the number of 1-staff-hour searches that can be done in the amount of time allotted to each study area. On a topographic map or aerial photo of the study area, distribute the 1-hour searches for maximum coverage of the study area. The crew should enter each TCS with a map of the study area that shows the approximate location of each 1-hour search and the path to follow between searches, with compass headings and approximate distances. Each 1-hour search should be confined to an area with a radius of 25 m, and the center of each 1-hour search should be at least 75 m from any forest edge. Each TCS should survey as much habitat as possible within each study area. Move from one object to the next after a few minutes. A maximum of 10 minutes per object should suffice. Assuming a crew of two collectors and one recorder, each staff hour of search takes 30 minutes of actual time. When an animal is found, time is spent by the collector in assisting the recorder. The recorder should keep track of this time, and the total amount of data recording time is added to the end of the search, so that 1 full hour of collecting is achieved. This becomes more important in searches yielding many animals, because data recording shall require more time.

4.4.1.7.6.1 Surveys of CWD

The techniques involved here are more precise than those used in TCS. Logs are chosen by a systematic sampling scheme. Specifically, sample one log out of a certain number of logs encountered. In most habitats, choose every third log that comes along the survey covering a large proportion of the study area. Then, the log selected is divided into subsamples based on the decay state of the log. For example, we can compress the standard five-point decay classification into three categories:

Category A-decay classes 1 and 2, Category B-decay class 3, and Category C-decay classes 4 and 5. Sample 10 logs in each category (every 3rd log encountered in each category) for a total of 30 in each study area. Plot a path through the study area that shall cover a large portion of the area but shall not intersect itself. For each decay category, choose a random number from one to three. Begin following the designated path. At every downed log, determine the decay category and whether the log should be sampled. The recorder keeps a running tally of the number of logs encountered in each category. Each category of log accumulates at its own pace, and whether a log is sampled depends on the number of logs encountered in that decay category. The decision may be, for example, to sample every second category-A log, every third category-B log, and every first category-C log. When a log is selected, measure the total dimensions that shall help while analyzing the data. However, we do not describe here as to how that's done since we are on the process of collecting initial data only. Determine the tree species, if possible, and the slope and aspect of the site where the log occurs. Search the log for a maximum of 20 staff minutes. Carefully remove any bark and tear into the decayed wood layer by layer. If the entire log cannot be sampled within the time limit, search a portion of the log as completely as possible. This is very important, because densities of species that occupy logs are based on the volume of wood actually searched.

4.4.1.7.6.2 Collecting tips

If ever we apply CWD, we have several pointers for more effective collecting for both TCS and surveys of CWD. Tools needed for both techniques include potato rakes and crowbars. It is necessary to purchase high-quality potato rakes; the less expensive ones cannot withstand extensive use. Crowbars are handy for peeling bark and breaking up the less-decayed logs.

Large logs and bark piles adjacent to these or large, well-decayed snags are the most productive sites for TCS. Other habitats should not be ignored during TCS, however. Moderate-sized debris (10 cm or more in diameter) on the forest floor should be turned over; often two people are needed to roll logs. In general, avoid raking through leaf litter or turning very small objects, but search piles of bark, slash, or mounds, because these often-house amphibians. Rocks or boulders, if present, should be turned. Exercise caution when turning rocks on

steep slopes. Be alert; searches often occur on rainy days when visibility is poor, especially under closed canopies. Salamanders can flee rapidly down crevice, so grab them by cupping your hand on top of them. Frogs are elusive, and to catch them you may need the cooperation of two or three people to surround the quarry. Collectors should scrutinize the area under turned objects. Salamanders often freeze and most are cryptically colored.

4.4.1.7.6.3 Some species have special traits

House lizards are commonly found, and they rarely move once exposed. They are easily captured but must be picked up carefully or else they shall autotomize (spontaneously amputate) their tail. Newts are slow moving but possess a highly toxic skin poison. This poison is released only if the animal is under attack but may show up during rough handling (for example, if the newt is hit by a rake tine). All terrestrial salamanders have some toxic secretions, but they rarely exude these substances when being handled. At least one hand should be bare to capture animals; gloves are usually too awkward for collecting agile species.

4.4.1.7.6.4 Snakes might be encountered during searches

Venomous snakes occur at low, especially around rock outcrops and fields. It is recommended not to collect venomous snakes. Other snakes or lizards can be grabbed or, if fleeing, stepped on gently. Reptiles should be sluggish in cool, wet weather.

Habitat destruction can be minimized by returning cover items to their original positions. Roll small logs and rocks back and replace large pieces of bark slabs. Rake decayed logs back together and replace as much bark as possible. Some habitat destruction is unavoidable, but the organic material remains, and at least a portion of the log-soil interface can be restored by careful replacement of disturbed objects.

4.4.1.7.6.5 Installation of pitfalls

Place pitfall arrays and grids in spots representative of the study area. If single arrays are to be placed around the study area, the locations should be preselected from maps or aerial photos. The array or grid location should be at least 75 m from any forest edges (the farther, the better). For arrays, establish the center point of the first array at random. If a pair of arrays is used, measure 25 m from this point in a random direction for the center of the second array. For a grid, select one corner at random for the location of the grid. The grid is then laid out by using handheld compasses and 15-m tapes or measured ropes (necessary in dense brush). Installation of grids is generally fast with a six-person crew; four people lay out the grid, and two people begin installing traps. Two-person teams are best for grid layout. One person pulls the tape or rope until stopped by the second person, who remains at the previous station. Flag the new point and continue.

Pitfalls are constructed by fastening the open ends of two number 10 tin cans together with duct tape and then cutting the bottom out of one end (Figure 4.30). Traps are installed flush with the ground and have a plastic collar inserted at the top. This collar functions to keep animals from crawling out of the trap and is constructed by cutting the bottom out of 1-lb plastic margarine tub. When it is not used for trapping, the traps should be closed; use the plastic lids from the margarine tubs. In grids, place the trap within 2 m of the station flag. If possible, place the trap next to a cover object, such as a rock or downed log. Traps next to logs should be placed on the downhill side of the log. The hole for the trap is dug most easily with a posthole digger, which creates a hole with the correct diameter. A tile spade can also be used. Traps have an additional optional wood cover. When the trap is open, the cover is suspended above the opening. This functions in part as a rain cover and partly to attract animals.

If an array design is being used, drift fences are constructed from 50-cm-tall aluminum valley roofing metal. This comes in 15.2-m rolls, which should be cut into 5-m sections before it is taken to the study area. Then place fences pointing away from the center of the array at equal 120° angle intervals. The interior end of each

fence begins 3 m from the center of the array (Figure 4.29). There are many other possible arrangements for placing pitfall arrays; see figures in Campbell & Christman (1982), Jones (1981, 1986), and Vogt & Hine (1982).

Use a mattock or hoe to dig a trench 20 cm deep and 5 m long, stand the fence into the trench, and back fill with soil. Occasionally an axe is needed to cut large roots. Tamp down the loose dirt so that the fence is self-supporting (stakes are not necessary for these relatively short fences), and smoothen the dirt alongside the fence to create a runway. Move small obstacles (twigs, rocks) away from the fence. Traps are placed at the ends of the fence so that no gaps occur between the fence and the rim of the trap.

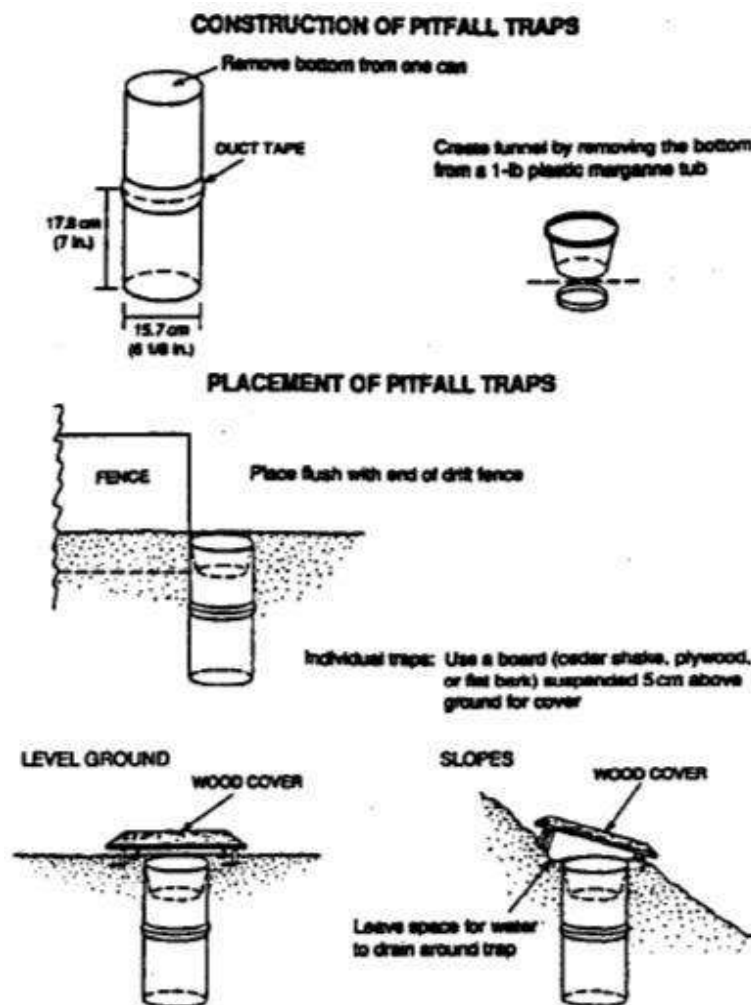


Figure 4.30 Construction and placement of a pitfall trap. (Diagram adopted from Corn and Bury 1990).

There are two important safety rules to follow when installing arrays. First, always wear gloves to handle the aluminum. The sharp edges can inflict serious cuts on unprotected hands. Second, exercise extreme caution in wet weather. The tools quickly become coated with slick mud, and a mattock or axe flying out of someone's hands can cause serious injury.

Funnel traps shall need to be constructed if reptiles are targets of the study (Jones, 1986; Vogt & Hine 1982). Funnel traps are constructed from window screen, which comes in rolls of 76 cm wide. Cut a 90 cm long piece and staple the ends together along the cut edge. Fold back the stapled edge so that you have a tube with 25 cm in diameter by 76 cm long. Construct funnels by rolling square pieces of screen into a cone and stapling. Fold back the edge and attach to the tube. One end is fastened permanently with staples, and paper clips are used at

the other end so that animals may be easily removed. Funnel traps are placed midway on both sides of each drift fence. Shape the trap and fill in with dirt so that no gap occurs between the fence and the trap. Shade the trap by placing loose bark or litter over the trap.

4.4.1.7.6 Pitfall Operation

Operating pitfall traps is a simple task. Techniques do not differ between arrays and grids. The primary decision is how frequently the traps should be checked. Check the traps every other day, if possible, but if there are a large number of study areas, then traps may have to be checked less frequently (3-5 days). Intervals of more than 5 days between checks should be avoided. Checking traps more frequently produces better specimens, particularly among the mammals that can be caught. If the number of study sites is such that all traps cannot be opened on the same day, care must be taken that all traps are closed in the same order they were opened in. This ensures the same trapping effort for each area.

Each time a trap is checked, remove debris that has fallen into the trap, and bail out excess water. A small amount of water should be placed in traps when they are opened, but in wet weather, most traps will accumulate more water than is desired. It has previously been recommended that water be placed in pitfall traps (Raphael & Barrett, 1981; Williams & Braun, 1983), (FRMD, 2017; Hoffmann et al., 2010) (FRMD, 2017; Hoffmann et al., 2010) and this is probably the quickest, most inhumane way to kill small mammals. Current guidelines for using pitfall traps to kill trap small mammals (American Society of Mammologists, 1987) specify drowning as the only acceptable method. But drowning is a slow and inhumane way to kill amphibians, and it has been prohibited in the current guidelines for field methods for herps. A generally acceptable compromise between these apparently incompatible recommendations is to keep a small amount of water (2 to 5 cm) in traps and check them frequently. Small mammals, particularly shrews, shall become hypothermic and drown in this amount of water, but most amphibians should be able to survive.

All animals trapped in pitfalls are to be taken to the laboratory for processing. Separate mammals, live herps, and dead herps, but otherwise place all animals from the same trap in one plastic bag. Carry a field notebook with waterproof paper to record the number of individuals, species, and trap number of all animals caught. This record is important and should become a permanent part of the data set. It provides critical information during the initial processing of specimens and is a valuable reference for the questions that inevitably arise even after the data have been processed. Record the study area, date, and trap number in pencil on a small piece of waterproof paper and place in each bag of specimens. Bag all the specimens from a single study area together in a large plastic bag. Keep the specimens in a cooler with reusable ice containers while in the field. On returning to the lab, place dead specimens in a freezer and live herps in a cool space.

4.4.1.7.7 Identification

Accurate identification of specimens in the field is critical for TCS and surveys of CWD. Field identification is less important for pitfalls, because all specimens are examined later in the laboratory. The field notes listing the specimens caught in each trap are more valuable, however, if they are accurate.

To increase accuracy, it is helpful for team members to examine series of specimens at a museum before field work begins. An additional field practice session is recommended to catch animals alive and to practice field identification. Most forms have distinct shapes or colors, but some species present problems. Most people have difficulty ranid frogs (*Rana* spp.) and juvenile salamanders. Northeast Indian literatures may be referred for identification of herps.

4.4.1.7.7.1 Disposition of Specimens

All animals captured in pitfall traps are routinely euthanized and preserved (special consideration need to be given to species scheduled as per the Forest and Nature Conservation Acts and Rules of Bhutan). Specimens

from TCS or CWD surveys may be treated in the same manner, or they may be released after the surveys near points where they were captured. If specimens are released, then positive identification is absolutely necessary (see above). Also, if animals are released, a representative series of voucher specimens should be retained from each study area and preserved. Capturing animals and retaining specimens requires valid scientific collecting permits from the appropriate agencies, and arrangements should be made before the study begins to deposit the specimens in an appropriate museum.

Process all specimens from a given survey, or all specimens collected from a pitfall site on a given day, together. This shall provide for the most accurate record keeping, and it helps in solving the mystery of the occasional unlabeled specimen. Thaw any frozen specimens, and kill the live ones. Be sure to keep the label identifying the specimen closely associated with each specimen. Kill by relaxing amphibians in a dilute solution of Chloretone and by injecting reptiles with aqueous sodium pentobarbital. Chloretone is a saturated solution of hydrous chlorobutanol in 95 percent ethanol. An effective dilution is 2 ml per 570 ml of water. Sodium pentobarbital (Nembutol is one trade name) is a restricted drug and may be difficult to obtain. Reptiles may also be killed by injecting 95 percent ethanol into the heart region.

Dead animals is then weighed and measured. Tie a numbered tag to the right hind leg, and preserve in formalin. Create a low-percent solution of buffered formalin by diluting commercial formalin to 10 percent and adding 4 g of baking soda or sodium carbonate per 400 ml of solution. Amphibians that appeared dead may begin to move when placed in the formalin. These should immediately be rinsed in water and returned to the Chloretone until dead. Amphibians and lizards should be laid out ventral side down in a shallow pan with a tight-fitting lid; for example, a plastic freezer container. Line the bottom of the pan with commercial paper towels (household towels have “dimples” that become imprinted on the skins of the animals), and pour a small amount of formalin into the pan. Snakes should be folded into an oblong coil with the head on the inside. The coil should be short enough to fit in the storage jars. Reptiles also must have formalin injected into the body cavity, limbs, and tail. Do not inject so much that a balloon like specimen is created. If injection is not possible, then the body cavity, limbs, and tail must be slit to allow the formalin to enter the body. Body cavities of large animals should also be slit for thorough preservation. Pisani (1973) provides a thorough discussion of preservation techniques. Let the specimens fix in the formalin for at least 24 hours, then store in 50 percent isopropyl alcohol.

If specimens are released, then reasonably accurate measures of snout-vent and total lengths can still be made. Place the animal in a plastic bag and restrain it against the bottom of the bag. When the animal is quiet and relatively straight, measure to the nearest millimeter with a ruler. Mass can also be measured in the field with spring scales available in forestry supply catalogs.

Besides herpetofauna, the investigator should be aware that many small mammals are also captured in pitfall traps. If a study is planned that uses pitfall traps, provision should be made for preserving the mammals as well.

4.4.1.7.8 Field Methods

Ideally, sampling sites which could be subjected to a fixed number of hours per visit and number of times per day, week, months, etc. is recommended. However, at the whole country scenario of considerably similar climatic condition, seasonal visit of habitat (Table 4.18) by the field officials of concerned PA and DFOs is recommended/prescribed. For easy data collection, entry and analysis, it is recommended to synchronize use of SMART patrolling phones for patrolling purposes in the field offices.

Forest and Nature Conservation Code of Best Management Practices of Bhutan

Table 4.18 Recommended season for visiting habitats under different field offices.

| Sl. | Name of Office | | Timing | |
|-----------------|---|-------|--------|---------|
| No. | | From | | To |
| Southern Bhutan | | | | |
| 1 | Samtse Divisional Forest Office | March | | October |
| 2 | Sarpang Divisional Forest Office | March | | October |
| 3 | Royal Manas National | March | | October |
| 4 | Phibsoo Wildlife Sanctuary | March | | October |
| 5 | Jigme Singye Wangchuk National Park | March | | October |
| Eastern Bhutan | | | | |
| 6 | Samdrup Jongkhar Divisional Forest Office | March | | October |
| 7 | Jomotshangkha Wildlife Sanctuary | March | | October |
| 8 | Sakteng Wildlife Sanctuary | April | | August |
| 9 | Bumdeling Wildlife Sanctuary | April | | August |
| 10 | Pemagatshel Divisional Forest Office | March | | October |
| 11 | Trashigang Divisional Forest Office | April | | August |
| 12 | Mongar Divisional Forest Office | April | | August |
| Central Bhutan | | | | |
| 13 | Bumthang Divisional Forest Office | May | | July |
| 14 | Phrumsengla National Park | April | | August |
| | | | | |
| 15 | Wangchuk Centennial National Park | May | | July |
| 16 | Zhemgang Divisional Forest Office | March | | October |
| 17 | Tsirang Divisional Forest Office | March | | October |
| 18 | Dagana Divisional Forest Office | March | | October |
| 19 | Gedu Divisional Forest Office | March | | October |
| Western Bhutan | | | | |
| 20 | Paro Divisional Forest Office | May | | July |
| 21 | Wangdue Divisional Forest Office | March | | October |
| 22 | Thimphu Divisional Forest Office | May | | July |
| 23 | Jigme Dorji National Park | May | | July |
| 24 | Jigme Khesar Strict Nature Reserve | May | | July |

For an in-depth data collection, the field offices should already have a list of potential habitats where the animals of this taxon are available. Having identified the habitats with fixed sizes (areas), the following VES protocol can be applied.

1. Every sampling site must be visited and at least scoured for 4 hrs per visit (VES). The 4-hour timeframe can be completed in one hour by 4 technicians, in two hours by two technicians, etc.
2. Middle of April and June (spring) and middle of June and August (summer) are considered the most appropriate time to visit sites (two visits each). Another two visits again in middle of August and October (just before winter) are appropriate to find the animals. A total of 6 visits in a year is necessary.
3. Interval of two weeks must be maintained between all site visits. To get hold of many target (amphibians and reptiles) species, the technicians must scour the best places within the recommended sites (areas suitable for these animals). For instance, rocky and logged areas that can be overturned must be given more attention than others that do not have cover. Ensure not to miss the species present in wetlands, by

checking up to a depth of at least half a meter (50 cm). Egg masses, larvae, and amplexed frogs must not be missed as well.

4. Surveying wetland areas isn't difficult since it can be done by simply walking along the edge of the water body. In wet meadows, walk in zigzag manner.
 - a) Two surveyors can walk in opposite directions around a water body, ending the survey when they meet. If water is too deep to walk through, technicians stay on the edge of the water body. The entire wet meadow area should be searched.
 - b) For streams, one technician surveys each side (a 500 m stretch, moving upstream from the starting point), simultaneously. It is expected that surveyors shall spend approximately 15 minutes per 100 m of transect, stopping the stopwatch when extra time is needed for species ID or to move around obstacles (Manley et al. 2004).
 - c) Searches are conducted using long-handled dipnets, and overturning logs and rocks.
5. For each observation, record the time, the amount of time that has elapsed from the start of the search, species, detection type (visual, auditory, sign), age class (adult, sub-adult, juvenile), and substrate type (rock, log, bare ground, etc.).
6. In addition, animals that the surveyors are capable of capturing should be measured (snout to vent and total length), assigned to sex and status. We can keep animals found dead on the road or anywhere nearby in the survey sites as voucher specimen. Place these animals in a plastic bag, label the bag with the date, location and species, and freeze until transport to either the identified office or another designated facility. Bags should be kept on ice when transporting. For living captures, photo documentation should be made of each new species for a property, including common species. Use Table 4.18 to record all the data. To record data of all herpetofauna species use Table 4.19, mainly for general purpose.

When resources are available, following protocol can be implemented with the help of man-made animal luring techniques. Many species of herpetofauna like snakes and lizards look for cover for protection from predators and/or thermoregulatory advantages (Lettink, 2007a) and we can use coverboards (Corn 1994; Bennett et al. 2003) to entice them as artificial retreats (Webb & Shine 2000; Souter et al. 2004). Normally 1 m² sheet which is also at least 1 cm thick can be used by spreading across the habitat at fixed distances. For example, place as many as six coverboard in six direction at 200 meters distance apart from one another from the center of the sample plot. Animals can be collected from cover boards and data gathered.

For the convenience of data collection, it is recommended to use SMART phone-based data collection package developed by the herpetofauna working group. A detailed process has been established in the package which has already been installed in the phones of some of the working group members.

1. **Nocturnal surveys** – Conduct at least one additional search at night to detect those species most active at night. Use

2. Table 4.20 to record the data.

Nocturnal Auditory Amphibian Counts

To supplement VES, visit to all sample plots for at least one night each during each 3 seasons is must. General anuran survey method is applied in this situation with fixed area as it falls inside the sample plot. It is simply done as follows;

- a) The surveyor reaches water bodies within the sampling plot, at night, and listen at each wetland or water bodies for at least 5 minutes.
- b) Whatever is heard shall be noted for each species and *index ranking* of 1, 2, 3 shall be given for the number of individuals heard. The meaning of ranking is explained as follows:
 - i. A ranking of 1 is equal to being able to count the number of individuals, there should be space between the calls.
 - ii. A ranking of 2 is equal to being able to distinguish individuals but there should be overlap between the calls.
 - iii. A ranking of 3 would mean that it is a full chorus of calling, with constant, continuously overlapping sounds.

Table 4.19 Amphibian and Reptile VES

| Date: OBS:BMG Reference: LOCALITY Start GPS: Latitude.....Longitude.....End GPS: Latitude: Longitude: Start Temp (C): End Temp (C): Cloud: Rain: WIND SPEED: Start Time: End Time..... Area corresponds to the Grid Location and locality being surveyed. Each map should have wetlands numbered. If the area being searched or where an animal is encountered is not marked on the map, record NM in this column. Wind speed codes: 0=no movement; 1=calm, smoke drifts; 2=light, feel on face, leaf rustle; 3=gentle, leaves in constant motion, flags extend; 4=moderate, dust and paper rises; 5=fast, small trees sawy, crested wavelets on water. Det. Type = Detection type: v=visual; c=capture; a=auditory; s=sign; Sub. = substrate type: R=rock; L=log; W=Water; V=vegetation; X=litter. Age: A=adult; M=metamorph; L=tadpole; E=egg mass. Sex:M/F/U. Status: G=gravid; S=swollen testes; otherwise leave this column blank. | | | | | | | | | | | |
|--|------|---------|-----------|-----|------|--------------|-----|-----|-----|--------|--------|
| GPS Location | Time | Species | Det. Type | Sub | Mark | Total Length | SVL | Age | Sex | Status | Others |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

Table 4.20 Nocturnal Frog call Datasheet

Date: OBS:BMG Reference: LOCALITY

Start GPS: Latitude.....Longitude.....End GPS: Latitude:
Longitude:

Start Temp (C): End Temp (C): Cloud:
.....

Rain: WIND SPEED: Start Time: End
Time.....

Area corresponds to the GIS map of Location being surveyed. Each map should have wetlands numbered. If the area being searched or where an animal is encountered is not marked on the map, record NM in this column. Wind speed codes: 0=no movement; 1=calm, smoke drifts; 2=light, feel on face, leaf rustle; 3=gentle, leaves in constant motion, flags extend; 4=moderate, dust and paper rises; 5=fast, small trees sawy, crested wavelets on water. Calling index: 1=Individuals can be counted; 2=overlap in calls; 3=full chorus, continuous and overlapping.

| GPS Location | Time | Dry/Wet | Water Temperature | Species | Calling Index |
|--------------|------|---------|-------------------|---------|---------------|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Preferably, nocturnal auditory amphibian counts must be conducted for minimum of two times (three times during the spring, mid-April through mid-June) and (mid-June through to mid-July) seasons. Each site must be monitored at least once in April, once between May and June and once between June and July. If budget, time and other resources are available additional visits to the sample plots are always important for a comprehensive data gathering. In Bhutanese conditions, it is always possible to make visits since service delivery activities are less in springs and summers.

3. Extend the survey time – In habitats with many species of amphibians and reptiles, it may be necessary to increase the amount of time each crew spends looking for animals, but the data need to be recorded such that the first 4 hours (2 for each technician) can be extracted for comparisons to other areas.

Additional Methods for Special Locations

The subsequent methods are supplementary techniques which may be executed at certain sites in addition to the main methods described above. These are mostly used in areas where there are known populations of target species or when additional fund becomes available for a prearranged area. However, the basic core protocol must still be followed to allow for comparison of all sites.

A. Marking Reptiles

Use nail polish dots to mark snakes and lizards while shell notching can be used to mark turtles. Notches can be created using a 3-sided file. By marking 1 to 3 marginal scutes, over hundreds of animals can be given unique marks. Once these marks have all been assigned to individuals, further marks using the scutes labeled D, E, F, G, R, S, T, and U can be designed (Figure 4.31).

Figure 4.31 A sample Marking Code for Testudines (Adopted from Corn and Bury 1990).

| | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| AB | BC | CH | HI | IJ | JK | KL | LM | MN | NO | OP | PQ | QV | VW | WX |
| AC | BH | CI | HJ | IK | JL | KM | LN | MO | NP | OQ | PV | QW | VX | |
| AH | BI | CJ | HK | IL | JM | KN | LO | MP | NQ | OV | PW | QX | | |
| AI | BJ | CK | HL | IM | JN | KO | LP | MQ | NV | OW | PX | | | |
| AJ | BK | CL | HM | IN | JO | KP | LQ | MV | NW | OX | | | | |
| AK | BL | CM | HN | IO | JP | KQ | LV | MW | NX | | | | | |
| AL | BM | CN | HO | IP | JQ | KV | LW | MX | | | | | | |
| AM | BN | CO | HP | IQ | JV | KW | LX | | | | | | | |
| AN | BO | CP | HQ | IV | JW | KX | | | | | | | | |
| AO | BP | CQ | HV | IW | JX | | | | | | | | | |
| AP | BQ | CV | HW | IX | | | | | | | | | | |
| AQ | BV | CW | HX | | | | | | | | | | | |
| AV | BW | CX | | | | | | | | | | | | |
| AW | BX | | | | | | | | | | | | | |
| AX | | | | | | | | | | | | | | |

Table 4.21 Turtle, minnow, and all species trap data sheet

| Date: OBS:BMG:LOCALITY: Start GPS: Latitude.....Longitude.....End GPS: Latitude: Longitude: Start Temp (C): End Temp (C): % Cloud: Rain: WIND SPEED: Start Time: End Time..... | | | | | | | | |
|--|-----------|--------|---------|-------------|---------------|--------|---------|----------|
| GPS Location | Trap type | Trap # | Species | Common name | Number caught | Mark ? | Measure | Comments |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

B. Marking Amphibians

Mark amphibians by toe-clipping, something which is very cheap and doable. Otherwise, use Visual Implant Elastomer (VIE). The frequency of visit to the site must be high if amphibians are marked. In normal conditions, amphibian marking is not recommended because they are one group of animals who surface only for a short amount of time (meaning the window of capturable time is very limited). Newts, that are found only in Punakha, Wangdue Phodrang and Dagana districts can be however marked if we can monitor them at least once a year.

4.4.1.7.9 Habitat and plant species composition data collection

It is assumed that data collected from the center of the sample plots shall adequately describe the terrestrial component of the area. Nevertheless, supplementary quantitative measurements are anticipated from wetlands investigated as part of the VES and trapping strategy. That practice consists of evidences on data from various strata such as major river, stream, creek, impoundment, lake, etc. The sampling plot may be classified as a Lake, wet grassland or wetland in Bhutanese nomenclature for paddy fields which serves as home to many species of amphibians.

If so, the primary habitat measurements would be acquired. Aquatic characteristics for additional wetlands besides paddy fields which are considered as major habitats (rivers and lakes like creeks, streams, ponds, etc.) which are surveyed for amphibians and reptiles, should also be measured. In addition, measurement data should be determined from GIS coverages in the lab prior to field work. Measurements include number of roads and other impacted soils adjacent to the water body, including numbers of water bodies. These information need to be verified on the ground.

4.4.1.7.10 Herpetofauna Photo Vouchering

The purpose of photo vouchering is to provide evidence that a particular species occurs in a given area. This is necessary to ensure confidence in reported records and to ensure that the sightings are accurate. For some species, photo records may not be adequate for vouchers. Under said situations, a voucher specimen may be needed. Bhutan's amphibians are distinct enough from each other, which can be vouchered with high quality photography. It is recommended that if vouchering of these species is needed, a recording be made of their calls. It should be possible to document all of Bhutan's herpetofauna with photographs if the objective is only to document the occurrence of a species at a given site. The Photo vouchering shall be done following the guidelines below;

1. Include a scale in the photo (or at least some of the photos of the same individual) such as a ruler, coin, pencil, or human hand.
2. Photograph animal as soon as possible after the capture – some amphibians can change color when placed into containers.
3. It may be easier or necessary to place a frog or salamander into a Ziploc baggie. This shall help immobilize the animal. The photo can be made through the clear plastic of the baggie. Be sure to include a small amount of water in the baggie so the amphibian does not desiccate and do NOT leave the animal in the baggie for more than a few minutes at the most.
4. A whole-body shot should be taken of each individual to be photo vouchered. Photo should be taken at a dorsal side (looking at the back of the individual). In addition to this photo, several additional photos from different angles shall be needed depending on the species.
5. Most field guides describe the characteristics of samples that can be seen (or absent) from each of the photo angles. If the field guide lists a defining characteristic that is not accounted for in the lists for each group of animals mentioned below, please also photograph the presence or absence of such characteristics.

Salamanders

All salamander species should have an additional photo taken which clearly shows the whole body from a dorsolateral angle. For 4 of the 5 species, clear, high-definition photos from those 2 angles should be sufficient for identification.

Anurans

Anuran include two groups of hopping species, the frogs and the toads. They share similar physical appearance but are very different in characters and habits. The skins, the habit and even habitat differ. Thus, photography can be used to identify toads and frogs.

i. Frogs

The following list of 6 additional photos (different photo angle a-f) should be taken to voucher the Ranid species. Rana of unknown species or those found outside of their known range should also have photos taken from all of the following six angles:

- a. Dorsal showing the full extent of the dorsolateral ridges
- b. Dorsolateral
- c. Head - dorsal
- d. Head - lateral
- e. Toe webbing
- f. Ventral or belly

ii. Treefrogs

The following list of additional photos should be taken to voucher treefrog species listed by each angle. Treefrog species have toe-pads. If you are unsure of which treefrog species is in hand, please take photos of all the following angles:

- a. Back of thigh
- b. Dorsolateral
- c. Head - dorsal
- d. Toe webbing

Remember that the only way to distinguish between some species is call. If it is necessary to voucher these species from a particular site, a recording of their calls must be made

iii. Toads

The following list of additional photos should be taken for each of Bhutan's 4 toad species in order to voucher the species presence for a given site.

- a. Head - dorsal
- b. Dorsolateral
- c. Number of warts occurring per spot (the photo should be a close-up of several spots where the number of warts can be clearly counted)
- d. Ventral

iv. Spadefoot toad

There is only one species of spadefoot toad known to occur in Bhutan as of now. In addition to the lateral photo for this species, additional photos showing the eyes and/or the spade on the back foot would clearly voucher this species.

Snakes

The two groups of snakes, venomous and non-venomous have unique physical appearance that can be differentiated using photo vouchers. The scale sizes and the colours vary between many of them.

i. Nonvenomous Snakes

For all nonvenomous snakes, a dorsolateral photo should be taken in addition to that of the lateral angle. It is also suggested to photograph both the ventral side and the anal plate of many of the species in Bhutan. These 4 photos should be sufficient to document the majority of the nonvenomous species with a few exceptions.

- a. Additional dorsolateral photo, close enough to be able to count the rows of scales with striping above the ventral scales
- b. Head - dorsal
- c. Head - lateral
- d. Photograph showing the keeled or lack of keeled scales.

ii. Venomous snakes

It is not recommended to handle a venomous snake without the proper training on the appropriate handling techniques. Take the best photo possible without endangering yourself. The dorsal pattern on Bhutan's 4 venomous snakes is distinct enough to allow identification. This picture can be taken without touching the animal. Remember to keep an appropriate distance from the snake at all times.

Lizards

Bhutan has 28 lizards. Photographs of the dorsolateral angle should be taken of each of them in addition to the dorsal photo. In addition, the slender glass lizard (*Ophisaurus* species) should be photographed from the lateral angle, and the skink species should be documented from the lateral side of the head, specifically focusing on the ear area, and the lateral side of the tail.

Turtles

All turtles should have photographs of the dorsolateral side and the ventral side (also known as the plastron in turtles) taken in addition to the dorsal photograph. Other suggested photos include:

- a. Head - dorsal
- b. Head - lateral
- c. Leading (neck) edge of carapace
- d. Nostrils

4.4.1.7.11 Data Analysis

The collection of basic information should allow the production of a simple species list for each site. The data must also be used to estimate the proportion of points occupied using programs such as MARK or PRESENCE. Also, to determine the proportion of areas occupied, the nocturnal auditory call data collected can also be analyzed using program MARK or PRESENCE. The species list can be used to calculate basic diversity indices. Depending on the numbers of animals recaptured, the data may also be used to estimate population size, although they may give biased information.

4.4.1.7.12 Materials Required

For a complete and near perfect monitoring, good equipment is necessary. Some important field equipment includes.

A. Materials needed for handling snakes

| ITEM | NUMBER |
|--|---------------------------------|
| Camera (with flash light) | Based on number of crew members |
| Snake Hook/Tongs | Based on number of crew members |
| Torches (Night vision) | Based on number of crew members |
| Snake boots | Based on number of crew members |
| Snake tubes for handling venomous snakes | Based on number of crew members |
| Protection clothes | Based on number of crew members |
| First aid kits | One set per crew |

B. Other materials required

| ITEM | NUMBER |
|---|------------------------------|
| Kestrel temperature and wind gauge | 1+ |
| Water thermometer and pH meter | 1+ |
| Pair leather gloves (for large snake captures) | 1+ |
| Hand spades or rake | Based on no. of crew members |
| Field guides and Anuran call tape for reference | One set per team |
| Hand lens | 1+ |
| Stop watches | 1+ |
| Pair hip waders | Based on no. of crew members |
| Coverboards | Based on design of survey |
| Minnow traps | As required |
| Frye nets | 1+ |
| Hoop traps for turtles | Based on number of crew |
| Voice recorders for acoustic study | 1 per crew |
| Nail polish | Sufficient |
| 3-edged file | As required |
| Cuticle scissors, and/or Visual Implant Elastomer | Sufficient |
| Coded Wire Tag | As required |
| Passive Integrated Transponder Standard field kit | As required |
| Clip board | Many |
| Pencils | As required |
| Sharpie markers | As required |
| Hand sanitizer | As required |
| Plastic Ziplock Baggies | Many |

C. Materials Needed for TCS or Surveys of CWD

| ITEM | NUMBER |
|--|---------------|
| Potato rakes (a backup rake is not a bad idea) | 2 |
| Crowbar | 1 |
| Stopwatch | 1 |
| Clipboard | 1 |
| Thermometer | Several |
| Plastic bags | 2+ |
| Cloth bags or pillowcases | 1 |
| Pencils | 1 |
| Compass | 1 |
| Clinometer | 1 |
| Short (15 cm) plastic ruler | 1 |
| Long (30 cm) plastic ruler | 1 |
| 10-m measuring tape | 1 |

D. Materials Needed for Pitfall Installation and Operation

| ITEM | NUMBER |
|--|---------------------|
| Posthole digger (1/person) | 1+ |
| 15-m tape or measured nylon rope | 2+ |
| Plastic flagging (1 roll/pair of people) | 1+ |
| Waterproof ink marker (1/person) | 1+ |
| Number 10 tin cans | 72/grid or 24/array |
| 1-lb margarine tubs | 36/grid or 12/array |
| Wood covers | 36/grid or 12/array |
| Waterproof notebook and paper (1/person) | 1+ |
| 6- by 10-inch plastic bags | Many |
| 12- by 16-inch plastic bags | Many |
| Plastic cup or long handled spoon (1/person) | 1+ |
| Small cooler with reusable refrigerant | 1+ |

4.4.1.7.13 Ethics and Safety**4.4.1.7.13.1 Ethics**

Everything concerning animal survey and collection has ethics and etiquettes. Therefore, the following preconditions must be observed while conducting surveys.

- Collect the animals but in a humanely way.
- Preserve specimens without making the specimen look odd.
- Euthanize the animal instead of killing it.

4.4.1.7.13.2 Safety

Conducting any survey involves risks when it comes to herpetofauna monitoring. We do have venomous snakes although we have a smaller number of species. Some species can be fatal if precautions are not taken. Therefore, safety must be always given a priority before starting any surveys.

Venomous Snakes

The first rule to search for herpetofauna species that use covers for thermal regulation and their safety is to never put your hands on any such types of covers (coverboards, rocks, or any other substrate coverings) without first overturning them to see what's there underneath. There could be animals that you need not mark (which means you need not handle) or those that could potentially harm you. Instead, see for possibilities to photograph the animal by including the dorsal surface of the species for studying the sample by using photographic-pattern-recognition software. We do have such techniques but we lack facilities. However, we can always seek help of photo identification experts.

If you have to mark any venomous snakes using passive integrated transponder (PIT tags) use snake tongs, sticks or tubes to handle them. Use Rubbermaid containers to place the species by using tongs or sticks and then entice the animal into the snake tubes. Make sure the animal is not able to scrunch backwards from inside the tube before grabbing the snake for measurement at the open end of the tube. Then measure or mark the animal once it is immobilized. To carry out this exercise, one needs to be trained. Otherwise, this can be fatal. Untrained! Stay away from this work. You can but take photograph from a safe distance without disturbing it, if it is possible.

4.4.1.7.13.3 Hygiene

Numerous amphibian species, mostly toads, are proficient with producing an irritant from their skin. Rubbing eyes, face or eating post handling an amphibian without washing hands can be potentially harmful because amphibian secretion in your eyes or face can burn you. Medical attention may be required if washing does not help.

Ensure you do not carry infectious fungus and virus from one survey site to another site (between the wetlands or any sites). Dry whatever you have used during the first sampling wetland for few days (3-4 days) and then only use for another wetland sampling. This can help stop spread of diseases amongst the plots and wetlands. Or rinse, bleach and dry all the equipment used in one sample area if you don't have much time.

4.4.1.7.14 *Data quality and management - VES can be difficult to rate for quality*

Scrutiny of information or data collected shall not divulge missed detections or misidentifications. Misidentifications could be cross checked by either the use of digital cameras, or by the field supervisor working intermittently with each surveyor. According to Manley et al. (2004), rotating crew members can lessen observer bias since the site shall be visited by more than one crew. Assumptions can be reduced as they keep changing their sites. Reviewing of all the recorded photographs must be done by at least 2 additional technicians who may have good idea. At the end of each trapping day, field crew pairs should review data sheets to ensure that all information are present. At the end of the week or the survey period of every sample areas, the field crew leader should review the data sheets for identification, escape & mortality rate, and legibility.

Target Species

The list of target species (Table 4.22 and Table 4.23) represents the species of conservation concern as chosen by the taxa working group. Distribution maps of these species must be made before monitoring them. Papers on status of herpetofauna of Bhutan (Wangyal, 2011; Wangyal, 2012; Wangyal 2013; Wangyal, 2014;

Wangyal and Gurung 2012a; Wangyal and Gurung 2012b; Wangyal and Das, 201 , Bauer and Günther, 1992; Das et al., 2014; Das and Palden, 2000; Deuti, 2010; Koirala et al., 2016; Palden, 2003) and others can be used to locate the species as they have lists of species with information details of habitat.

Table 4.22 Target amphibian species

| Common Name | Scientific Name | Habitat |
|---------------------------|--------------------------------|--------------------------------|
| Blue-eyed spade-foot toad | <i>Leptobrachium bompu</i> | Clean rivers, streams |
| Himalayan newt | <i>Tylototriton verrucosus</i> | Ponds, paddy fields, etc. |
| Liebig's Mountain Frog | <i>Nanorana liebegii</i> | Mountain streams |
| Bhutan Cat-eyed Toad | <i>Scutiger bhutanensis</i> | Alpine areas |
| Indian Balloon Frog | <i>Upperodon globulosus</i> | Shallow wetlands & streams |
| Bird Shit Frog | <i>Theloderma asperum</i> | Near human habits in low lands |
| Annadalli's Frog | <i>Raorches annadalii</i> | Near human habitations |
| Common Tree Frog | <i>Polypedates maculatus</i> | Paddy fields |
| Sikkimese Caecilian | <i>Ichthyophis sikkimensis</i> | Warm moist soils |
| Garo Hills Frog | <i>Philautus garo</i> | Central Bhutan Forests |

Table 4.23 Target reptile species

| Common Name | Scientific Name | Habitat |
|-------------------------|---------------------------------|------------------------------------|
| Yellow Tortoise | <i>Endotestudo elongata</i> | Sub-tropical forests and plains |
| Tricarinate Hill Turtle | <i>Melanochelys tricarinata</i> | Sub-tropical forests, river plains |
| Box Keel Turtle | <i>Cuora mouhotii</i> | Sub-tropical forests, river plains |
| Black Pond Turtle | <i>Melanochelys trijuga</i> | Sub-tropical forests, river plains |
| Stream Turtle | <i>Cyclemys gemeli</i> | Sub-tropical forests, river plains |
| Bhutan Lizard | <i>Calotes bhutanensis</i> | Forest openings |
| Bhutan Keel Skink | <i>Eutropis quadratolobus</i> | River banks |
| Water Monitor Lizard | <i>Varanus bengalensis</i> | River banks |
| Tokay Gecko | <i>Gecko gecko</i> | Close to human habitats |
| King | <i>Ophiophagus hannah</i> | Anywhere |
| Russel's Viper | <i>Daboa russellii</i> | Sub-tropics forests |
| Monocellate Cobra | <i>Naja kauothia</i> | Everywhere |
| Python | <i>Python bevittatus</i> | Sub-tropic forests |

4.4.1.8 Insect Monitoring Protocol

4.4.1.8.1 Transect design and layout

As a part of monitoring and detecting change in population and diversity, it is obligatory to have the sampling done in the same site and using the same method to have a comparable result. For monitoring of insect diversity, in the sampled biodiversity monitoring grid, 300-meter trail transect shall be laid out in the field and insect of the five orders (Lepidoptera, Hymenoptera, Coleoptera, Orthoptera, Odonata) shall be collected. Along the 300 meters transect of 5 m wide, only those insects that are encountered within the 5 meter width of the transect shall be collected. The layout of the transect in the field shall be determined by the terrain and individual judgment has to be used while laying it out for the first monitoring exercise. Thereafter, once the transect location and direction has been determined, the position of the transect shall be recorded permanently for successive monitoring exercises. More than one such transects can be laid in each monitoring grid.

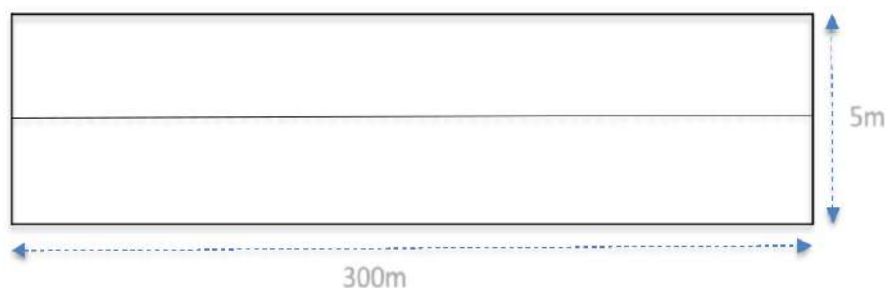


Figure 4.32 Transect dimension and layout

4.4.1.8.2 Survey Method

Under this Protocol, minimum of two individuals are required during the survey. Once the transect plot is laid out or identified, team members shall move at the same pace from the starting point and should not spend more than 30 minutes in completing the transect survey. Additional 30 minutes shall be spent in sorting out the samples, entering the data in the form, labelling the samples and preserving the samples for future DNA analysis. One of the team member shall use an aerial sweep net to capture the flying insects whereas the other team member shall search the forest floor for any insects, he can also use a beating tray to collect insect that are resting on the bushes. Each of the team member shall carry a killing jar for different insect orders and as soon as a catch is made, it shall be euthanized using the Jar assigned for the particular insect order. Once the survey is completed, segregate the samples into species and assign a unique tag number even if the species is identified. The information should be entered into the data sheet. To save time, sorting of insect samples, entry of data in the prescribed form and labelling and preserving the insect samples should be done after the 30 minute transect. It is also important to note the start and end time of the survey and reflect it in the data sheet. The subsequent sections shall describe the materials required, collection method used for each group of insects, euthanization, relaxing, mounting, labelling, preservation and DNA sample collection.

| | | |
|--|-----------------------------------|-------------------------------------|
| (A) Insect Collection equipment | | |
| • Sweeping net (canvas) | • polystyrene board | • Hair brush |
| • Aerial sweep net | • lamp light (low UV bulb) | • Plastazote strip |
| • Beating tray | • White cloth | • Camphor or naphthalene ball |
| • Aspirator | • Torch | • Relaxing box |
| • Collection tubes | (B) Euthanizing reagent | • Labeling materials |
| • Euthanizing tubes and jars | • Ethyl acetate | (D) Identification materials |
| • GPS | • Pipette dropper | • Stereomicroscopes |
| • Hand lens – 10x | • Acetone | • Stacking microscopes |
| • Tight lid storage container | (C) Mounting materials | • Identification keys and books |
| • Tissue paper | • Pins (various sizes: 000–38 mm) | (E) Preservation materials |
| • Transparent paper envelope | • Mounting stage or pinning block | • Ethanol |
| • Binocular | • Mounting card (various sizes) | • Display boxes |
| • Cotton | • Spreading board | • White tray |
| • Silica gel | • Pinning forceps | • Cabinet |
| | • Water soluble glue | |

4.4.1.8.3 Collection Methods

There are many methods for collecting insects, most of which involves simple instrument and which can be easily done by beginners. For Bhutan, the idea of Insect Monitoring Protocol is to restrict the group of target insects and keep the collection method simple. The following sections describe the collection method that shall be applied in the field during monitoring exercises.

4.4.1.8.3.1 Coleoptera

Beetles are the group of insects that belong to the order Coleoptera. The term, ‘Coleoptera’ is derived from the Greek works (koleos), meaning ‘sheath’, and (pteron), meaning wing (Jones 2018). The Coleoptera, with about 33600 species, is the largest of all insect Orders constituting 173 families (Bouchard et al, 2017). Thus, hard forewing forms the most obvious distinctive feature to recognize beetle in the field. These wing-cases, usually are curved and mounded to cover the rear half or two-thirds of exoskeleton body completely and tightly. Often, beetles are easily identified from other insects and collected using simple tools and techniques. There are many methods used to collect different beetles depending on habit and habitat. The equipment described here is not exhaustive, only the most essential items that can cover collection from diverse range are described. Ground search and hand picking may also be done in addition to sweep net and beating tray methods.

Sweep net

It is the most essential tool to collect a diverse range of beetles. It is used to sweep through grasses, small shrubs and other low vegetation. Each sweep should be steady but not too fast and about 20-30 sweeps should be taken before emptying the net. Prolonged sweeping without emptying the net damages the specimens caught in the net.

Beating tray

It can be used to dislodge beetles from tree branches and other higher vegetation by sharp taps with a stout stick or vigorous shaking. It is used in the early or late in the day or in the cooler weather when insects are least active. Pale-colored umbrella, or just a white plastic or cotton sheet on the ground under the tree should suffice.



Figure 4.33(a) Sweep net and (b) Beating tray

4.4.1.8.3.2 Lepidoptera

Butterflies and moths are differentiated by the antennae, butterflies have clubbed antennae and are found during the day, while the moths' antennae are not clubbed and are nocturnal and few species are also found during dawn and dusk. Butterflies and moths share common characteristics as they all have their wings and body covered with microscopic scales. Butterflies are on average larger and more colorful than moths and can further be separated from the moths by the club-like shape of their antennae. The butterflies and moths are widely

distributed and found in diverse habitats such as grasslands, agricultural fields, conifer forests, broadleaved forest and scrubland.

Sweep net

Butterflies can be scanned with the naked eye during the day and collected with sweep netting. The net bag should be long enough to fold over the frame to prevent any active butterflies taking flights. Sweep net can be used to collect butterflies through plants, moist areas, and other areas where butterflies are basking or resting or even during the flight.

Light trap

Moths can be found on the walls of buildings, near forests, grasslands, especially at spots which are lit at night. Most moths and few nocturnal beetles, bees, wasp, grasshopper can be collected by setting simple light trap- clean white sheets against the chargeable LED light. The best place to set up the light trap is where the light is visible from the surrounding forest. Best collection night is when there is no interference of the moon light and when the weather is warm with slightly cloudy sky.



Figure 4.34(a) Aerial sweep net (b) Light trap

4.4.1.8.3.3 Hymenoptera

Hymenoptera refers to the winged insects derived from an ancient Greek word (pteron) for wing and (hymen) for membrane and also for god of marriage. Thus, the key characteristic of this order is that the hind wings are connected to the fore wings (married wings) by a series of hooks in flight. Hymenoptera is a large order of insects, comprising the sawflies, wasps, bees, and ants with over 150,000 living species. Females typically have a special ovipositor which is often modified into a stinger. It can be found in all types of terrestrial habitat and relatively easy to find on the blooms, old houses and river banks. Collection of hymenoptera involves various methods such as sweep netting, bait trap, fine netting, aspirating, beating and yellow pan. However, sweep netting, shall be used for monitoring as it is robust, easy and less time consuming.

Sweep net

Bees and wasps are generally collected with a sweep net. The net should be light, long and foldable for easy handling and dull in color to avoid easy detection by insects. Bright color sweep net should be avoided since insects are sensitive to bright colors. The collector should approach perched insect with slow motion as fast-moving objects are easily detected by bees and wasps due to flickering effects. Sweeping should be precise, swift and the collected insect should immediately be euthanized in the euthanizing tube containing ethyl acetate. Euthanized specimens should then be transferred to clean tubes for transfer to the laboratory.

4.4.1.8.3.4 Odonata

Dragonflies and damselflies are easily recognized by their four wings, each with a nodus and a dense network of veins, and long slender abdomen. Often, they are differentiated by following morphological characteristics (Table 4.24):

Table 4.24 Morphological characteristics

| True Dragonflies (Anisoptera) | Damselflies (Zygoptera) |
|--|---|
| Body build heavy | Body build light |
| Forewings and hindwings of different shapes and broad, never stalked | Forewings and hindwings similar in shape, mostly narrow and often stalked |
| Eyes touching (except in club-tails, family Gomphidae). | Eyes well apart |

In the Anisozygoptera, the eyes are separate and they resemble true dragonflies (especially Gomphidae) in their body shape. However, their wings are stalked and are of approximately the same shape (as damselflies).

Most dragonflies and damselflies species prefer warm climate and high diversity can be found below 2000 m.a.s.l. Dragonflies and damselflies spent most of their life in water as larvae. In most species their adult life spans only a few weeks to a few months.

Sweep net

Specimen are best caught by large sweeping net with a diameter of about 0.5m with a handle of 1.5 m. Hold it gently by its four wings and take close-up photographs to recording live colors. It is always advisable to carry a small hand lens in the field, to enable examination of small structures that are needed to confirm identifications.

4.4.1.8.4 Orthoptera

Grasshoppers are the largest super family of the Orthoptera suborder Caelifera with 11 families. Grasshopper is a medium to large sized terrestrial insect. It is found cosmopolitan all over the world. Grasshoppers are best known for their ability to jump incredible heights and distances. Grasshoppers are of ecological importance for recycling of plant matter, since they are mostly defoliators of decaying plant and moss.

Sweep net

The standard sweeping net (15-inch diameter) fitted with a nylon netting bag and short handle (2 feet) is suitable for catching grasshopper. Sweep the net quickly through vegetation a number of times (5-10) in rapid succession. After taking a sweep sample, grab the net about halfway up the bag to trap any collected insects in the bottom part of the net.

4.4.1.8.5 Specimen Photograph

Taking photographs is recommended during the field works and also at the insect repository or at the museum. For some insects, it is possible to identify through photographs and in addition, photo documentation is vital for research and monitoring. Thus, having a photo options during field data collection is an added advantage. For instance, a data form in a mobile app consisting of a photo upload option would ease museum and data curators in management. Standard photography techniques should be followed while taking pictures in the museum collections. Digitization of insect collections and maintaining a separate database for photos are recommended. However, digitization may involve high resolution cameras and its equipment.

4.4.1.8.6 Euthanization

4.4.1.8.6.1 Hymenoptera, Orthoptera, Coleoptera (small)

The specimens should be euthanized in the euthanizing tube using the ethyl acetate as standard euthanizing chemical. Ethyl acetate should be soaked in shredded tissue paper or cotton to avoid fast evaporation, and cone shaped paper placed on the soaked cotton, to avoid soaking of specimen. The specimen especially hairy bees should not be soaked in ethyl acetate. The specimen should be given enough time for ethyl acetate to take effect and care should be taken not to take out half dead insect out of the euthanizing jar (few hours for larger specimens). Pinning should be done only to the completely dead specimen to avoid pinning of live insects. Specimen may be euthanized and stored for 12 hours before pinning to relax the muscles.

4.4.1.8.6.2 Odonata

The specimens should be placed in a paper envelope with wings folded, preferably one made of the transparent ‘glassine’ paper sold by entomological suppliers and stamp dealers. Specimens should be left alive in paper envelope for at least six hours to allow them to void their gut contents. Remove specimens from the envelope and immerse them in acetone after which most specimens die in 10 to 20 seconds (any labelling should be written in pencils acetone dissolves most inks). The acetone should be in an airtight, flat-bottomed plastic container such as used for food storage. Dragonflies must never be euthanized by pinching, as is commonly done with butterflies. Once the insect is dead, it should be left in the acetone for 8-12 hours. This removes fat, aiding color preservation and making the specimen less attractive to pests. The enveloped specimen may then be deposited in the repository centre.

4.4.1.8.6.3 Lepidoptera and Coleoptera (large)

The specimens should be euthanized in larger and air-tight euthanizing jar preloaded with tissue paper or cotton soaked in ethyl acetate. Add a layer of thick filter paper above it to avoid shocking of the specimens. Ensure to put the air-tight lid immediately. Once the specimen is euthanized, it may be transferred to the container before mounting. Specimens should be pinned or mounted immediately after 12 hours. Beetles may be immediately transferred in 70% ethanol containing collection tube with proper label for prolonged preservation and DNA extraction. Large butterflies can be euthanized by pinching the thorax between thumb and forefinger, and for further euthanizing, specimen may be placed in the euthanizing jar.

4.4.1.8.7 Relaxing

By the time specimens are back to the station, specimens might be stiff making spreading and mounting difficult, often common with already dead specimens. The specimens have to be relaxed by floating on warm water (e.g., beetles, bees and wasp) and moistening the specimens in between the folds of tissue paper (e.g., butterflies, moths, dragon flies and damselflies) in the air tied container. Specimens euthanized in less than 24 hours, can be mounted or pinned without needing to relax. If perfectly relaxed using the methods, ensure to dry it before mounting or pinning

4.4.1.8.8 Mounting

Specimens to be mounted/pinned should be preferably relaxed if dried or hardened. Small and medium sized specimens (e.g., beetles, bees, and wasps) are card mounted. After dissection, specimens should be sufficiently cleaned and placed on its dorsal surface with downward pressure on the glued mounting card. Larger specimens should be pinned. Beetles are pinned through the right elytron at a point toward the base and about one-third elytral width from the suture. Bees, wasps, butterflies, moths and grasshopper are pinned on the right side of the thorax midline and halfway up the pin. One should take great care when pushing the pin through the ventral surface. Pin gently and slowly and check the position of the pinpoint as soon as it pierces through. Flexible

forceps and pins should be used to tease and spread-out wings (e.g., bees, wasps, butterflies, and moths), legs, antennae and mouthparts. If required, position and general structure of the specimens should be maintained with the aid of pins. Dissected genital parts should be mounted along with it or in a separate card using water soluble glue.

4.4.1.8.9 Labelling

As soon as the specimens are collected, the specimen should be labeled with *Plot Id* and species *ID* that correspond to the survey data form. Once it is mounted/pinned, the specimen should be well labeled with all the essential locality data with the following information (Figure 4.35): [1] country, [2] location, often the nearest town or village, [3] geographic coordinates, [4] altitude, [5] collection date, [6] collectors and [7] brief description of habitat (vegetation type or micro-habitat).

If these do not fit on a single label a second label should be used. Identification label or determination labels can be added separately and should generally include [1] Family, [2] the scientific name, [3] identifier and [4] the year of identification.



Figure 4.37 Mounted beetles



Figure 4.35 Labelled insect on display and the contents of the label

4.4.1.8.10 Preservation

A simple method to preserve the specimens is to prepare them as dried specimens and stored in a well concealed box under dry and dark conditions with proper labels. Often collections are attacked by a variety of insect pests. Vigilance and precautionary measures must be rigorously enforced. Vigilance includes making at least a quarterly visual examination of each box or drawer and field specimens (alcohol collection) for the sign of pest infestation and need of replacement of preservatives. Camphor is used as a natural insecticide in the drawers and 70-80% of ethanol to preserve the specimens in container.



Figure 4.38 Preservation of specimen in repository

4.4.1.8.11 Identification

The voucher specimens should be compared using various literature keys, monographs and specimens in the National Invertebrate Museum at National Biodiversity Centre. Identified specimens along with voucher specimens should be preserved in national repository centre and duplicates maintained at NCD, NBC, NPPC, UWICER, RUB and other relevant institutions.

4.4.1.8.12 DNA sample collection in Insects

DNA samples can be collected for all insect orders in a quality vial. The same *species tagID* as reflected in the insect monitoring data form can be used to tag the specimen with note “DNA sample collected” in the remark column of the insect monitoring data form.

For all the insect groups, the legs are usually preferred because their removal does not affect the general aspect of the specimen. A single leg (or 2) or a leg fragment (2 to 3 mm long) is sufficient for DNA extraction.

4.4.1.8.13 Ethics and Safety

4.4.1.8.13.1 Ethics

1. No more than specimens strictly required for a specific purpose should be captured or ethically euthanized.
2. Do as little damage to the habitat as possible.
3. The catch in a trap (e.g., light trap) should be released after being examined, except for any specimens that must be euthanized for voucher purposes or for ecological or other scientific study.
4. If a trap used for scientific purposes is found to be repeatedly catching rare or local species unnecessarily it should be re-sited.
5. When coleopterists (or others) work on dead wood or bark, they should leave a substantial proportion untouched in the locality. Where practicable, detached bark and worked material should be replaced.
6. Overturned stones and logs should be gently replaced in their original positions unless very deeply embedded.

7. Specimen should not be collected from the hive of bees or wasps or poke the hives, since they are aggressive in nature and their sting is lethal in some case.

4.4.1.8.13.2 Safety

1. Wear a hat and light-colored clothing (so ticks can be easily spotted), including long-sleeved shirts and long pants tucked into boots or socks.
2. Use insect repellent for greater protection.
3. Wash and dry work clothes using the “hot” settings to euthanize any ticks present.
4. Workers with a history of severe allergic reactions to insect bites or stings should carry an epinephrine auto injector
5. Seek immediate medical attention if a sting causes severe chest pain, nausea, severe sweating, loss of breath, serious swelling, or slurred speech.
6. Chemicals like ethyl acetate, naphthalene ball, paradichlorobenzene (PDCB) crystals, thymol or phenol are toxic in nature and should be handled with care.

4.4.1.9 Flora Monitoring Protocol

4.4.1.9.1 Sampling Design

Monitoring of flora shall be confined in the BMG of 4x4 km. There are a total of 2424 BMG spread across the whole country, corresponding to 2424 cluster plots of the NFI. For flora monitoring in each field office, the BMG shall be sampled and all monitoring shall be done in the sampled grids, following the protocol described in this document.

- In the sampled grid of 4 x 4 km, two plots of 20m x 20m shall be established as far as possible along altitudinal gradient not less than 0.5km apart.
- Ensure the team enters 200-300m inside the grid.
- Plots shall not be established within 200m from vehicular roads and 100m from the footpath
- Establish vegetation plot inside the grid representing the major forest types of the particular area
- Use SW Maps for navigating to the grid.

4.4.1.9.2 Method

4.4.1.9.2.1 Tree & shrub plot establishment procedure

Option 1:

Fixed area plot size of 20m x 20m is established by using the nylon ropes and wooden pegs. The 4 nylon ropes of 20m each are used with a knot made on all the ropes at 10m to mark the centre of the quadrature. The nylon ropes are pulled towards the 4 cardinal directions from the center of the plot and marked at 10m with wooden peg corresponding with the knot. These wooden pegs corresponding with the knot are the midpoint of each side of the quadrature plot. From the midpoint, the two ends of the nylon ropes are further pulled to two respective cardinal directions (north-south and east-west) perpendicular to the centre of the plot to find the corners of the plot. The process is repeated with all the remaining nylon ropes to find the four corners of the quadrature plot and finally, the traverse of all the nylon ropes are closed eventually forming 20m x 20m quadrature plot.

Option 2:

Fixed area plot size of 20m x 20m is established for the enumeration of trees and shrubs. The establishment of the plot begins from the center of the plot and extends towards each side. This method is based on the Pythagoras theorem wherein the field personnel measures the hypotenuse to get the sides. By doing so, it

minimizes errors and ensures that a more accurate square shaped plot is generated as compared to other conventional methods.

Following steps can be followed to layout the 20mx20m plot under this option (Figure 4.39).

- i. Starting from the center, setup an azimuth and walk 14.14 meters diagonally towards A.
- ii. Then 90° right to A, move 14.14 meters towards B from the center
- iii. Then 90° right to B, move 14.14 meters towards C from the center
- iv. Then 90° right to C, move 14.14 meters towards D from the center
- v. Together, these becomes the four sides of the plot and should measure exactly 20x20 m. Mark the points A, B, C, and D and install wooded/iron pegs.
- vi. Now secure the four pegs with 20-meter nylon ropes

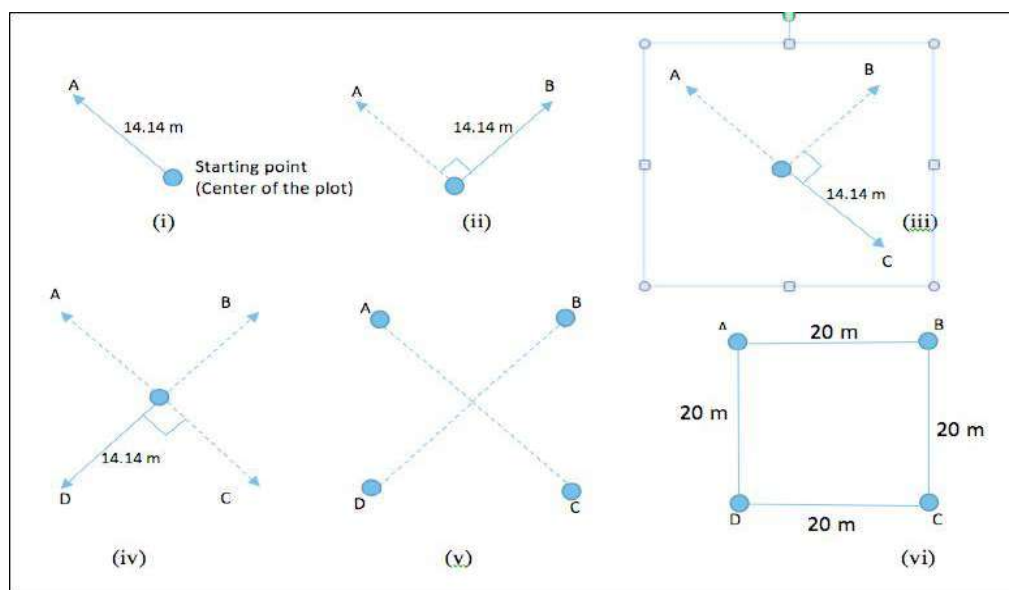


Figure 4.39 Schematic diagram showing the process of laying 20m x 20m plot

Cautionary notes:

- To save time, it is advisable to keep 4 numbers each of 14.14 and 20-meter nylon ropes ready.
- Ensure that the measurements are correct, avoid too much tension or sagging of rope.
- Avoid trampling and destruction of plants while setting up the plot.
- Use slope correction table while establishing the plot in the absence of hypsometer.

4.4.1.9.2.2 Tree & shrub data collection procedure

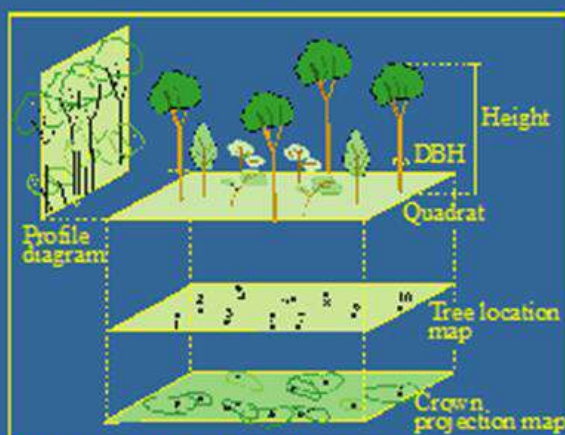
Record the plot id, both trees and shrubs species on the same data form as in Table 4.25. Collect the voucher specimen incase the species is unidentified

1. Start measurement from the North direction (clockwise) till completion
2. Always measure the DBH from uphill and avoid sagging, twisting, buttressed, etc.
3. Measure the DBH of all the individual species > 1.3m height using the diameter tape and hypsometer respectively
4. Record as “S” for sprout under the stem type column
5. Tag all species with number

Cautionary notes:

1. The growth form of the same species differs significantly, depending on what type of environmental condition they grow, although they belong to the same life-form group.
2. Consider forking above DBH as 2 trees.
3. Multiple stems emerging from the single root system is called "sprout" stem type and this should be considered as one tree, although the measurement should be done for all the sprouts. For calculating the species diversity only one main stem data is taken into consideration.
4. In case of the woody liana and climber species, only DBH is recorded, height/ length may not be possible.

Vegetation data collection profile



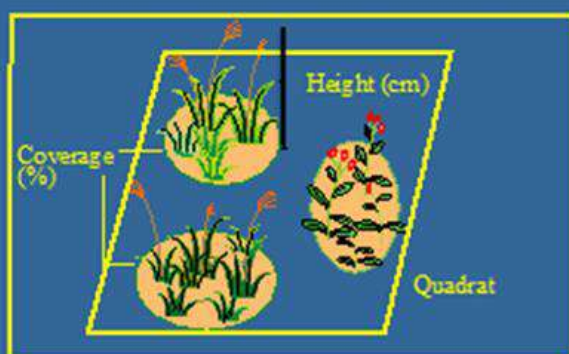
Tree plot 20 x 20m

Height → Height class distribution

DBH → DBH class distribution

Basal area (BA)

↓
= Dominance analysis
= Dominant species



Herb plot 2 x 2m nested inside tree plot

H → Maximum height (cm)

C → Coverage (%)

Volume (H*C)

↓
= Dominance analysis
= Dominant species

Figure 4.40 Vegetation profile showing the (A) Tree/shrub plot and (B) Herb plot measurement standard practice (Source: Wangda and Ohsawa 2006a)

Table 4.25 Data Form for recording Trees and Shrubs in the vegetation plot of 20m x 20 m.

| | | | | | |
|-------------------------------|--|-----------|--|--|--|
| Location: | | Grid No: | | | |
| Date: | | Plot No: | | | |
| Altitude (m): | | Plot Size | | | |
| Aspect (o): | | Recorder | | | |
| Inclination (o) : | | | | | |
| GPS Location: N | | E: | | | |
| Threshold: >1.3m, Ht= Height. | | | | | |

| Sp. No. | Species name | DBH | Ht. | Status | Stem type |
|---------|--------------|-----|-----|--------|-----------|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

4.4.1.9.2.3 Crown Cover

The readings of the crown cover % using the densiometer/fisheye lens (hemispherical photograph) of the crown cover is taken in all the 4 quadrants of 10x10m, later the readings are averaged and recorded as one reading for 20m x 20m plot.

4.4.1.9.2.4 Procedure for establishing ground regeneration plot

Ground flora is known to be especially sensitive to changes in environmental conditions and provide valuable information about the impact of chronic stresses on the forest ecosystem. The dynamics of ground flora vary from season to season. Ground vegetation plot size of 2x2m quadrat is established inside the tree and shrub plot of 20x20 m.

4.4.1.9.2.5 Procedure for ground vegetation (herbs) data collection

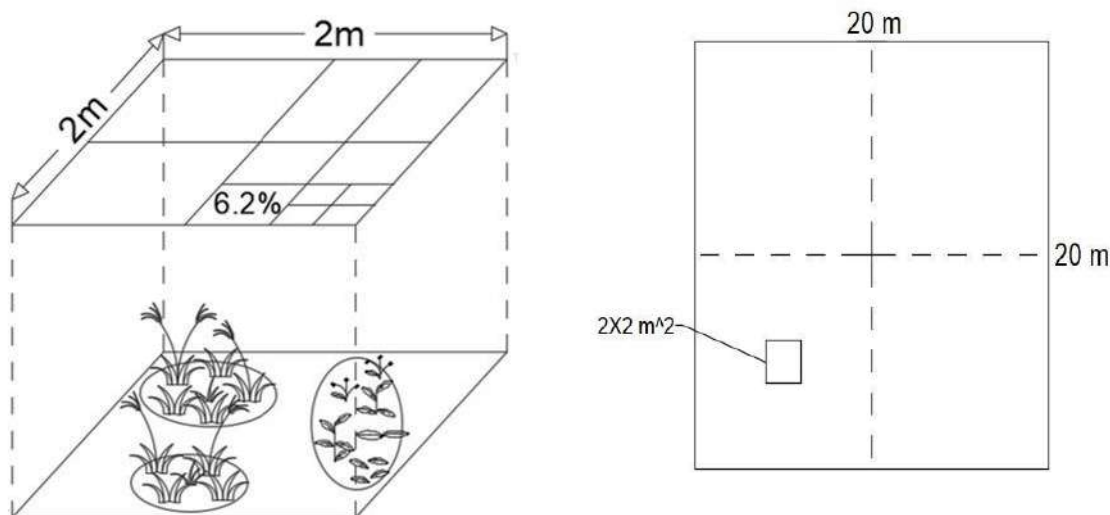


Figure 4.41 2m x 2m quadrat plot with grid to measure the cover % of each species (A) and the location of the herb plot in one of the quadrants (B)

1. Inside the 2m x 2m plot, record the plot id and species details as shown in the data form in Table 4.26
2. Measure height of the tallest species using the 5m-fiber glass tape.
3. Estimate and record the Area of Occupancy (AOO) of each species inside the quadrat in % (IUCN, 2001)
4. Collect the voucher specimen of the unidentified species (refer Cautionary for specimen collection)

Cautionary note:

1. Avoid trampling of herbaceous species, sapling and seedlings by the survey team members. Therefore, first collect the data of the ground vegetation as soon as the tree & shrub plot is established.
2. The height of the scrambling or leaning herbaceous species is measured from the tip perpendicular to the ground surface rather than measuring the height of the leaning species from the base to the tip of the plant.
3. Always collect the voucher specimen from outside the plot

Table 4.26 Data form for recording ground vegetation (herbs) in the plot of 2m x 2 m

| Location: | | Grid No: | | |
|----------------------------------|---------|----------------|-------|---------|
| Date: | | Plot No: | | |
| Altitude (m): | | Sub-plot No: | | |
| Aspect (°): | | Sub-Plot Size: | | |
| Inclination (°): | | Recorder: | | |
| Aspect: | | | | |
| Threshold: Tallest Ht, Ht=Height | | | | |
| Sp. No. | Species | Ht. (cm) | C (%) | Remarks |
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4.4.1.9.2.6 Recording of regeneration inside the herb plot

Regeneration is measured inside the same herb plot. In order to observe the regeneration types, seedlings are counted to find out the regeneration density. The height is measured for all species and the species name is recorded as usual.

Step wise

1. Record the plot Id first
2. Enumerate species details as shown in the form (Table 4.27).
3. Measure height of each species using the 5m-fiber glass tape
4. Record the age of each species

Cautionary note:

1. In order to avoid trampling of regeneration by the survey team members, it is mandatory to collect the data of regeneration first, after the quadrat for tree & shrub plot is already established.
2. Seedling of tree species should not be messed up with the herbaceous species. Seedlings of 45 cm height and above can be counted as regeneration.
3. Count the inter nodes to estimate the age and for conifers count the whorl of the branches. During each year of growth, the seedling produces a whorl of branches out from the stem. To get an estimate of the seedling's age, we can count those whorls up the stem, and if the whorls have broken off, we can count the little scars that remained

4.4.1.9.2.7 Epiphyte data collection procedure

- Cautionary note:**

- #### 4.4.1.9.3 Procedure for plant identification and collection of herbarium specimen

The following sections should not be taken as a guideline for identification of species but provides some clue for observation (Cope *et al.* 2012).

4.4.1.9.3.1 Observe the flowering plants

- Observe the habit type, (herb, shrub or tree) size of the plant and note the habitat as it might give important clue to differentiate between certain species.
- Carefully examine the morphological characteristics of the species such as color of sepal and petal, number of flowers, number of pistils and stamens, ovary position, symmetry, structure and arrangement of leaves, etc.
- Obtain the clue by observing the fruit, seed type, bark and secondary metabolites present in the species.
- Make a blaze to the tree especially in the subtropical forest and observe the change in color of the blaze after a while.
- Examine the root type and size of the grasses and bamboos

Table 4.28 Data form for recording epiphytes in the vegetation plot

| Data Form for recording epiphytes in the vegetation plot | | | |
|--|---------|---|---------|
| Location: Date: Altitude (m): Inclination (°): Aspect (°): | | Grid No: Plot No: Plot Size: Recorder: | |
| Sl/No. | Species | No. | Remarks |
| | | | |
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4.4.1.9.3.2 Observe ferns and their allies

- Examine the fern size, habit, habitat, structure, size, and arrangement of the fronds (leaves of ferns). It may be simple, pinnate, palmate, whorled, etc.
- Observe the color and texture of the stipe, presence of hairs, scales or glands on the base of the stipe and the stalk of the leaf is known as the stipe.
- Observe the position, size, shape and arrangement of spores. One of the characteristics of fern is the arrangement and position of spores (Sori).

4.4.1.9.3.3 Observe the bryophytes

- Check if the plant is thalloid (flat or blade-like), leafy or prostrate branched.
- Observe the size, arrangement of leaves and margins entire, lobed or unlobed and other important characters.
- Observe the shape, size of the capsules and spores of the mature species upright or nodding.
- Check for rhizoids (hair-like structures) and scales. However, this may require dissecting microscope.

Cautionary notes:

1. Carry the Guidebooks and references up to the camp site and identify the species whenever possible
2. Verify the species using known voucher specimens (digital or voucher herbarium specimen). At times, it may entail dissection in the laboratory using high-powered lens and microscope to determine the shape, color and measurement of specific characteristics for correct identification.
3. Learn and know the important family characteristics of each plant group, terminologies and then validate using Flora of Bhutan and other guidebooks.
4. Understand the diagnostic characteristics usually described with two or more comparative statements for family, genera and species taxa.

4.4.1.9.4 Procedure for collection of voucher specimen

Voucher specimens are critical for authenticating the identification of a taxon and also to track the nomenclature change. If there are no specimen, the determination history cannot be traced or checked. Specimen can prevent mistakes in species identification from the particular sampling site. It is important to have a good and fertile specimen for correct determination of the species. Comparing specimen shall lead to discovery of new species and also helps in verifying same common name. Correct identification of species is absolutely critical to monitor the species over time. Specimen serve as a tool for identifying locations of a taxon and any disagreement among surveyors as to whether a taxon occurs at a given site can often be quickly resolved using a well-documented specimen as indisputable evidence. Specimens deposited over time form a valuable database that can be used for additional research. The purpose of the specimen is beyond taxonomical repositories, researchers now recognize their applicability for genetic, ecological, and environmental studies (Culley 2013).

The National Herbarium, Serbithang has collection of voucher specimen over 20,000 collections of Angiosperms, Gymnosperms, Pteridophytes and Bryophytes. To strengthen the identification skills, it is worthwhile to refer and study the voucher specimens before the commencement of the survey in the field.

4.4.1.9.4.1 Procedure for collection of Herbarium specimen

A. Taking field note:

1. Species name/Botanical name/common name/local name, Date, Locality, Habitat, Habit, other information.
2. Life form of the specimen must be recorded, that is: tree, shrub, herb, climber, woody lianas, etc.
3. Other specific unique characteristics of the species namely: the latex, spins, barks, odour, trunk etc., can be observed and recorded for faster identification for unidentified species.

B. Specimen collection:

1. Always collect the specimen from the mature plant and decide carefully which parts would most accurately represent the species.
2. Collect vegetative and the reproductive parts of the species (leaves, flowers, fruit, etc.).
3. Collect the adequate specimen enough for mounting and archiving (A3 size paper) in large polyurethane bags instantly in the field.

C. Pressing the specimen:

1. Fold the specimen carefully and place inside the whole bunch of old Indian newspaper used as blotter folder for drying under natural heat condition.

2. Always tag each specimen for cross-referencing with your field note before pressing.
3. Press the specimen using the plant press in such a way that any flowers or fruits are obvious for mounting on to the mounting sheet.

Cautionary notes:

1. Avoid collection of species known to be extremely rare (photographs vouchers can be used for identification).
2. Be aware of species like poison ivy, poison sumac and stinging nettle that may cause injury. Only collect them with proper protective gear.
3. It is easy to collect the whole parts of herbaceous plants by uprooting, but the specimen must be folded at desired folding points for pressing.
4. The frequency of changing the newspaper shall depend on the weather condition and the newspapers are changed when they are wet or when the specimen is getting moldy.
5. The life-form should not be misunderstood with the growth-form, the growth-form simply refers to the physiological adaptation of a species thereby changing the morphology of a species to its environment, whereas life-form is the structure of a mature plant on the basis of which it can be classified such as tree, and shrub.

4.4.1.9.5 Photographic record

Photographic evidence of all the species both identified and unidentified species has to be logged, the photographic record shall validate and supplement the species data recorded inside the plot. For some of the species, the photograph can capture the whole plant, the flowers, fruit, leaf, etc., other minor details can be observed in the voucher specimen for identification purpose. A good photography shall depict detailed information of the specimen for examination and identification.

1. Take close up photographs of flowers, fruit and leaves
2. Take unique morphological characteristics if there is any
3. Take photograph of whole plant, especially the small plants
4. Take photograph of the whole plot to capture the whole strata of vegetation and this kind of evidence shall be a wonderful testimony of plot information for monitoring over a longer period of time.

4.4.1.9.6 Data Compilation, Storage, Analysis and Reporting

4.4.1.9.6.1 Data sorting, storage and sharing

Once the data collection is completed in the field, all the filled datasheet should be converted into digital format, either through scanning or photography. Both material data and digital data should be securely saved. Digitalization is particularly important for saving the data in multiple copies, and to prevent degeneration of the data over time.

All the data should also be adequately processed in Microsoft excel or Microsoft access for analytical purposes. A copy of both raw data and processed data should be shared with the National Data Repository Centre of the Department and NCD.

4.4.1.9.6.2 Data Analysis and Reporting

After the data is compiled in the excel sheets, species richness (H'), dominance, cluster and multivariate are analyzed using any of the following statistical analysis software;

1. R Stat

2. SPSS (Social Science and others)
3. GenStat (Agriculture and others)
4. PC-ORD (Ecological analysis package)
5. Excel analysis (Focus)-Many Cases

However, the most commonly used software are Excel analysis and PC-ORD.

A. Excel analysis

Use Microsoft Excel functions to clean, sort and arrange the data

1. Prepare Height class and Diameter at Breast Height(DBH) Class

- Prepare Height class and Diameter at Breast Height (DBH) class using the function=CEILING(number, multiple), the number is the height/DBH of tree and the multiple is the height/DBH range
- Arrange and prepare Height and DBH class matrix manually

2. Calculate indices of a species diversity Shannon-Wiener index (H')

$$H' = - \sum_{i=1}^s \frac{n_i}{n} \log_2 \frac{n_i}{n} ; \text{ OR } H' = \sum_{i=1}^s -(P_i * \ln P_i) \quad (1)$$

1. Calculate the Basal Area (BA) using formula =PI()*DBH^2/4
2. Calculate Relative Basal Area % (RBA%) using formula =BA/total basal area (insert \$ sign between the letter and the number to fix the value*100)
3. Use the value of PI=PI/100
4. Calculate LogPI using this function=LN(PI/100)
5. Calculate PI*LogPI, sum of all PI*LogPI gives the (H')

3. Pivot Table Analysis

The function of a pivot table is to summarize the data (data reduction process), sort, reorganize, group, count, total or average data stored in a database. It allows its users to transform columns into rows and rows into columns. It allows grouping by any data field and they are very flexible.

1. Find and click on the Pivot table
2. Select the pivot table fields for summarizing the data
3. Click the field to summarize, then drag and drop to the appropriate fields, that is Row, Column and value

4. Dominance analysis

$$d = 1/N \{ \sum_{i \in T} (\chi_i - \chi')^2 + \sum_{j \in U} \chi_j^2 \} \quad (2)$$

Where χ_i is the actual percent share (relative basal area is adopted here) of the top species (T), i.e., in the top dominant in the one-dominant model, or the two top dominants in the two-dominant model and so on; χ' is the ideal percent share based on the model as mentioned above and χ_j is the percent share of the remaining species (U). N is the total number of species.

1. Calculate RBA% for 100% $= (RBA\% - 100)^2$ for the species number 1 and $= RBA\%^2$ from the species number 2 onwards
2. Calculate RBA% for 50% $= (RBA\% - 50)^2$ for the species number 1,2 and $= RBA\%^2$ from the species number 3 onwards
3. Calculate RBA% for 33.3% $= (RBA\% - 33.3)^2$ for the species number 1,2,3 and $= RBA\%^2$ from the species number 4 onwards
4. Repeat the same process for 25%, 20%, 16.6%, 14.3%, 12.5% respectively

B. PCORD

Steps to prepare the main matrix for Cluster analysis in PCORD

1. Arrange RBA% plot wise.
2. Custom sort RBA% from Largest to Smallest for all the plots.
3. Assign species code in each species name (PCORD does not recognize scientific name).
4. Transpose the species from Row to column and delete the scientific names.
5. Fill in the first column & first row with the number of plots and on the second column with the text as "Plot" (thumb rule).
6. Fill in the first column second row with the number of columns/species and on the second column with the text "Species" (thumb rule).
7. Fill in the variable type with capital letter "Q" in the second column third row till the end of the species (thumb rule).
8. Fill in the variable name in the second column fourth row with the species code.

Steps to do cluster analysis in PCORD

PCORD is a windows program for multivariate analysis of ecological data entered in spreadsheets. It emphasizes nonparametric tools, graphical representation, and randomization tests for analysis of community data. It offers many ordination and classification techniques not available in major statistical packages.

1. Open the PCORD and import the main matrix of the excel sheet.
2. Select the Excel Spreadsheet and file and then open.
3. Click "OK" in the pop up transformed Matrix.
4. Activate the matrix by clicking one of the menu buttons.
5. Click the button for the result txt syntax for the cluster cycle.
6. Click cluster analysis under the Groups menu.
7. Select the Sorensen (Bray-Curtis) for distance measure and Group Average for Group Linkage Method.
8. Type in the title of the result and the dendrogram results will be displayed in the Result txt syntax showing cluster cycle.
9. Click cluster dendrogram under the Graph menu for final result.

4.4.1.9.7 *Materials Required*

Many equipment is required for conducting the vegetation survey as prescribed in this protocol document.

- | | |
|-------------------------------|------------------------------|
| 1. Nylon rope 100m each plot | 10. Hypsometer |
| 2. Plant press | 11. Binocular |
| 3. Pruning secateurs | 12. Climbing gear |
| 4. Soil PH meter | 13. GPS |
| 5. Soil Moisture meter | 14. Clip board file |
| 6. Soil temperature meter | 15. TAB with reference books |
| 7. DBH tape | 16. Measuring tape |
| 8. Densiometer | 17. Clinometer & compass |
| 9. Stapler gun and number tag | 18. Field notebook |

4.4.1.9.8 *Ethics*

The survey and monitoring of plants should be aimed specifically towards achieving the objectives prescribed in this protocol and other objectives set out of priority. The enumerators and surveyors engaged in the monitoring programme shall, therefore, refrain from doing activities which deviates from those prescribed in the protocol.

Some of the key points of importance are as follows;

- a. Unless otherwise specified in the protocol, no plants/plant parts or flowers shall be collected either from inside or outside the plot.
- b. If the protocol prescribes collection, voucher specimens must be deposited in a public herbarium or other public collection providing access to deposited materials.

Box 4.3 Team formation and Logistics

Survey team should have thorough knowledge of survey protocol. The survey is not just one-time activity, but permanent plot has to be monitored and observed for changes taking place inside the plot. While monitoring the permanent plot, observational data is validated such as: weather, phenology, disturbance etc. For the initial survey a minimum of 5 persons including the team leader and a local guide and eventually 2 to 3 persons are enough to collect the data:

Data enumerator

The recorded data must be kept safe from damage and also check for errors before leaving the plot. As a mandatory requirement, no blank spaces in the form shall be left to avoid confusion to the person transferring data to the computer. The record must say something like "No ground vegetation, eroded soil, rocks, wood debris, gravel" instead of leaving blank spaces on the form.

Compass, clinometer and Hypsometer reading person

The person handling the Compass, Clinometer and Hypsometer should be able to take the reading precisely, such as, the height of the tree, slope % and the bearing. Inexperience person must be trained adequately to take the reading correctly. Instruments should be checked frequently; malfunctioning equipment must be replaced immediately and keep safely at all time.

DBH measuring person

There are certain techniques to take the measurement at DBH of the trees very efficiently, such skills are developed through frequent field surveys and this guideline should use the standard tree measurement techniques of forest inventories.

Tape and nylon rope handler

The person carrying the Measuring tape and the nylon rope takes order from the team leader to establish the plot and other members of team should help where ever necessary.

Local guide

The need for a local guide is so important during the survey, the guide can lead the foot trail safety and the voucher specimen is carried safely without any damage. In difficult terrain condition, two guides are necessary to assist the survey team members.

The minimal requirement of 5 persons may not suffice in the places infested with wild elephants and poachers. In such a situation, additional person with firearms can be deployed for the safety of the survey team.

4.4.1.10 Socio-Economic Survey

Social science can help natural resource managers to (1) identify and evaluate social as well as ecological trade-offs associated with different management options; (2) make decisions that are better for the environment and human well-being, given that social-ecological systems are integrated and influence one another; (3) make decisions that are more appropriate to a particular social-ecological setting; and (4) obtain information from a broad, scientifically-based sample of people to better anticipate variation in their interests, and in the effects of management decisions on human communities (Charnley et al., 2017). The conservation social sciences can provide unique and important contributions to society's understanding of the relationships between humans and nature and to improving conservation practice and outcomes (Bennett et al., 2017).

4.4.1.10.1 Data Collection Protocol

The socio-economic survey could be conducted once at the starting of planning period and during the midterm review as a process of monitoring and evaluation (5 years).

The sources of data required for the planning and monitoring from social perspective shall be relied on the primary data and secondary data collection. The process of obtaining the data is explained in detail below:

4.4.1.10.1.1 Primary data collection

Primary data collection shall be carried out in two main stages involving focus group discussion and followed by household survey. The focus group discussion shall be carried out using semi-structured Questionnaire with mainly open-ended questions, while household survey can be conducted using structured questionnaire that consists of both open and closed-ended questions. These two different sets of questionnaires aim to generate information about selected individual household while PRA helps to generate information about a village holistically (Sperienburg et al., 2002).

Focused group discussion

- The Focus Group Discussion (FGD) can be carried out at Village, Chiwog and Gewog level based on availability of resource, time and field condition. The selection of venue and meeting hall arrangement is crucial to enable conducive environment. Effective communication and interaction shall lead to high-quality results from the FGD. The focused group discussion shall be called once with minimum of 10 heads and comprising of minimum 30% of female participation. This shall be guided by the semi-structured questionnaire forms (Table 4.29).
- The duration can vary depending on the dynamics of the participants, but ideally an FGD takes between 60 to 90 minutes.
- At least two people are required to conduct it effectively. Responsibility can be identified between two surveyors as to take the task of ‘Facilitator’ and ‘Transcriptionist’ or ‘Notetaker’.
- The facilitator is recommended to speak local language to the participants (if possible) as to convey clear message and make them respond at best possible way.
- Transcriptionist should interrupt the session to clarify himself to keep the note as reported, discussed or agreed by the participants. Since questions in PRA are open-ended the follow-up questions to be asked is very important.
- Since response from different gender, age and economic background shall differ, facilitator should take control of dominant respondent or participant throughout the session to ensure that all participants are equally involved in the discussion.
- Use prompting questions to ensure active participation. Split the group to accommodate contrasting views and backgrounds to generate more discussion.
- Record all the information that were discussed. The entire discussion and all points raised should be recorded, because the process is based on open or guiding questions, to ensure nothing is missed or points taken out of context. Note-taking should be shared and, if possible, supplement with a voice recorder with prior permission

Table 4.29 Household Questionnaire Survey Form

Part B: PRA Form

1. Village information

| |
|---------------------------------------|
| Dzongkhag : |
| Gewog : |
| Chiwog |
| Village : |
| Location: Lat..... Long..... Alt..... |
| Vegetation type: |
| Interviewer : |
| Date: |

2. Details of Participants

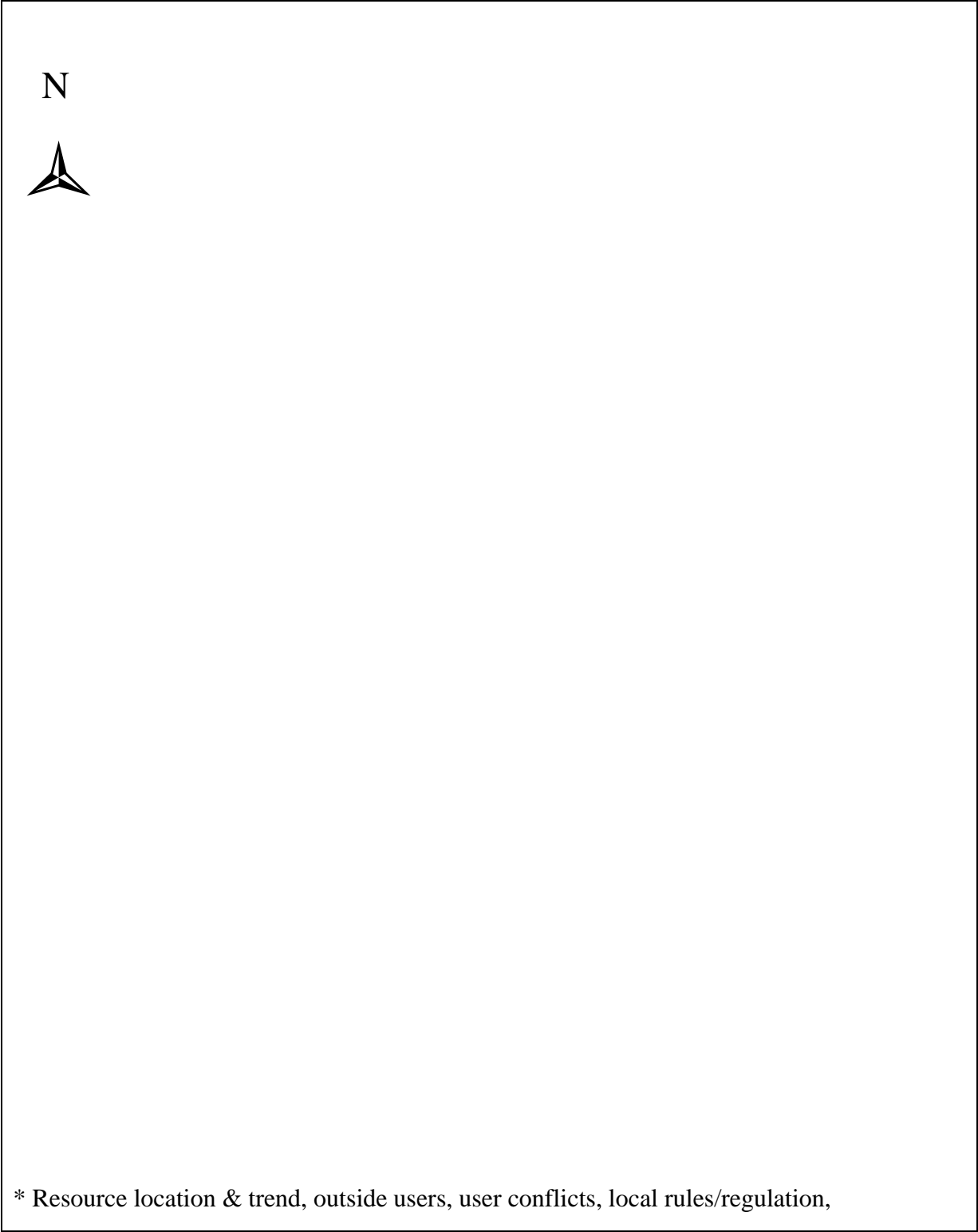
| Sl.no | Name | Age | Sex | Position in the family |
|-------|------|-----|-----|------------------------|
| 1. | | | | |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |
| 5. | | | | |
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| 11. | | | | |
| 12. | | | | |
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| 14. | | | | |
| 15. | | | | |

2020 (update)



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4. Resource mapping



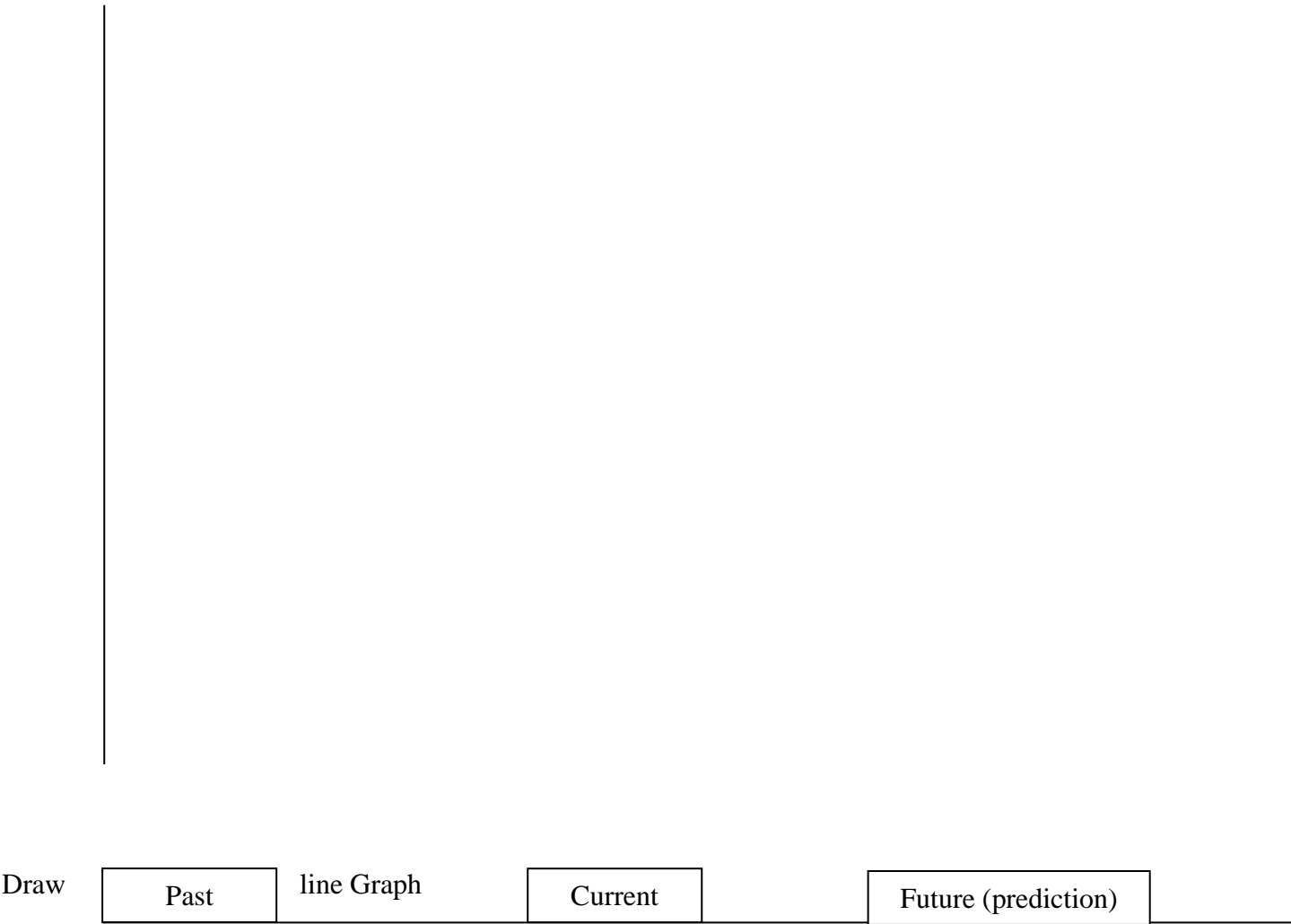
5. Seasonal Activities Calendar

| Activities | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Remarks |
|------------|------|------|------|------|------|------|------|------|-------|------|------|------|---------|
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6. Natural Resources harvesting calendar

| Resources | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Remarks |
|------------------|------|------|------|------|------|------|------|------|-------|------|------|------|---------|
| Timber | | | | | | | | | | | | | |
| Bamboo | | | | | | | | | | | | | |
| Cane | | | | | | | | | | | | | |
| Pipla | | | | | | | | | | | | | |
| Chirata | | | | | | | | | | | | | |
| Agroo | | | | | | | | | | | | | |
| Honey collection | | | | | | | | | | | | | |
| Cannabis | | | | | | | | | | | | | |
| Fishing | | | | | | | | | | | | | |
| Poaching | | | | | | | | | | | | | |
| Honey collection | | | | | | | | | | | | | |
| Others (Specify) | | | | | | | | | | | | | |

7. Natural Resources Trend Analysis



8. Matrix ranking for Natural Resources use

| | | | | | | | | | |
|--|--|--|--|--|--|--|--|--|--|
| Uses/species | | | | | | | | | |
| Timber | | | | | | | | | |
| Fuelwood | | | | | | | | | |
| Fodder | | | | | | | | | |
| Furniture | | | | | | | | | |
| Shinglep | | | | | | | | | |
| Medicine | | | | | | | | | |
| Flag poles | | | | | | | | | |
| Fencing post | | | | | | | | | |
| Traditional curving and handicraft | | | | | | | | | |

9. Pairwise ranking for timber species

| | | | | | | | | | |
|---------|---|---|---|---|---|---|---|--|--|
| Species | | | | | | | | | |
| | * | | | | | | | | |
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10. Box 4.4)

11. SWOT analysis on Environment and Conservation

| | |
|---------------|----------|
| Strength | Weakness |
| Opportunities | Threat |

12. Problem Tree Analysis and Ranking on Environment and Conservation

| |
|--------------------------|
| Problems |
| Root Causes |
| Possible solution |

Box 4.4 Stakeholder Analysis

Stakeholder Analysis

Stakeholder analysis is a technique to identify stakeholders and analysis of their needs, interests, and influence. It can be used as an evaluation and monitoring tool to assess how relationships and perceptions of relationships changed over time.

There are many stockholder analysis techniques and methods, however, in Bhutan stakeholder analysis and mapping using the Venn diagram is widely practiced while working with local communities considering the low literacy rate.

Resources Required

- A large piece of paper to hang up or lay flat on a table that the group can gather around
- Construction paper circles of various sizes (small, medium, large)
- Tape
- Markers or other writing utensils

How to do

1. Label and date your paper. Also helpful is assigning a note-taker to record any insights uncovered through the process.
2. List the organization whose stakeholders you are assessing (e.g., Gewog developmental program) by writing the organization name on one of the large circles and placing it in the middle of the paper.
3. Have the group identify stakeholders and partners. (You may already have a list that provides a good starting point.) Have the group decide how important each stakeholder is to your organization, choose a corresponding circle size (small = somewhat important; medium = important; large = critically important), and write the stakeholder's name on the circle.
4. Decide how close the current relationship is between the selected stakeholder and organization (e.g., Gewog). If the relationship is close, tape the circle very close to or touching

the organization. If the relationship is distant, tape the circle toward the edge of the paper, etc.

5. Assess each stakeholder this way, encouraging group members to write the names on the circles and post them. Disagreement about the importance of stakeholders is okay. Ask questions to understand why members feel the way they do.
6. You have now identified and created a stakeholder map. Have the group assess it as a whole.
 - Does anything strike the group?
 - Are any groups missing?
 - Are any relationship patterns surprising?
 - Does an existing partner have a strong relationship with a partner you would like to work more closely with?
 - Do any problems or opportunities present themselves?
 - Does the group lack a good relationship with any important stakeholders?

Sampling and Sample size

Determining adequate sample size of the total house population is very important to ensure that the survey result is statistically relevant. However, the sample size also has to be balanced with the available resources, namely., financial, human and time. Random sampling is used to ensure that the sample is representative of the study area/survey, thus avoiding bias in sampling and ensuring that each household within the sample frame has an equal chance of being sampled.

Gewog administrative boundary as sampling frame and total households in the Gewog should be considered as population. The sample size shall be determined using Yamane's (1967) method which is widely used and accepted in social science surveys.

Using the formula;

The sample allocation shall be proportionate to Chiwog household and household interviews shall be done randomly. The house numbers e.g. MA-12-268 of the sample households will be tabulated in excel and randomly selected for questionnaire survey.

| | |
|--|--|
| <p>Determining sample size using Yamane formula (Yamane, 1973)</p> $n = \frac{N}{1 + N * (e)^2}$ <p>n=Sample size N= Population size e=Margin of error (MoE), At 95 % confidence interval e= 0.05</p> <p>Example Let's assume that the population (Household) in Gewog is 2000. At 5 % MoE, the sample size would be:</p> $n = \frac{N}{1+N(e)^2} = \frac{2000}{1+2000*(0.05)^2} = 333 \text{ (Households)}$ | <p>Sample allocation</p> <p>The sample allocation should be proportionate to Chiwog household.</p> <p>Example</p> <ul style="list-style-type: none"> • If Chiwog 'A' has 1000 hh 1000/2000 * 333 = 166.5 (167 hh) • If Chiwog 'B' has 700 hh 700/2000 = 116.55 (117hh) • If 'Chiwog 'C' has 300 hh 300/2000 * 333 = 49.95 (50hh) |
|--|--|

List down the households in the Chiwog (with the name of the head of household) and deploy simple random sampling techniques to select household to be interview. Use whisk social gathering technique which is the

most convenient method in the field. Write down, on individual pieces of paper, the number of each household or representative group. Place the pieces of paper in a container, shake it and then pick out the required number at random. You can also use scientific calculator or excel program in the computer to generate random number which can be assigned to the list of households.

4.4.1.10.1.2 Household questionnaire survey (Face to Face interview)

The questionnaire for household survey should be pre-tested before conducting actual survey. The questionnaire shall be both closed and open-ended questions. The main aim of the survey is to collect specific qualitative and quantitative information from the representative households.

It can be conducted “face to face” preferably in local language. The surveyor or interviewer need to be very conscious throughout the interview in terms of keeping memo or notes for additional information that respondents provide through the session. The interviewer should follow the following norms:

- Meet with your interviewee and greet with a friendly smile and try to establish a relationship that makes him/her feel comfortable and relaxed. Pay attention to posture and body language.
- Describe the purpose and objectives of the survey and explain the rules on confidentiality.
- Establish ground rules. Explain that it is fine if he/she does not know the answer.
- Keep it short, check the time and, if a respondent becomes restless, change the subject. If he/she stop paying attention, stop or take a break if needed. Do not rush; be patient and calm, but serious. Be prepared to find alternative ways to ask the same question.
- Do not give direction to informant or suggest your own opinion as an answer.
- Be patient and give the respondent time to think.
- Respect the various views, regulations and traditional culture (e.g. a man may not be able to interview female respondent on his own).
- Drop a sensitive issue or put it aside for a second interview. Do not force the informant to answer.
- Let the respondent talk, and even slightly deviate from the question, but not for too long.
- Provide teaching aids, maps or drawings to help you explain an idea.
- Do not make any promises.
- Make sure to thank the informant. Advise respondent that you may need to come back or call for any missing information.

Table 4.30 Form for Household Questionnaire Survey

| Household Questionnaire Survey Form | | | | |
|--|-------------------|-----|--------------------------|--|
| <u>Part I: Interviewer details</u> | | | | |
| Name : | | | Designation: | |
| Office: | | | Contact No.: | |
| Email ID: | | | Date: | |
| Part II: Household information and Source of Income (Give details per household member) | | | | |
| 2.1 Respondent Detail | | | | |
| Dzongkhag: | | | Name of respondent: | |
| Gewog: | | | Village: | |
| Age/sex: M <input type="checkbox"/> F <input type="checkbox"/> | | | Cell Phone #: | |
| 2.2. Household member Information | | | | |
| | | | Status of HH member | |
| Sl.no. | Sex <i>M/F</i> | Age | In-Present*/Out-Absent** | Main occupation & responsibility in the family |
| | | | | |
| | | | | |
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**with the household (> 6 months/year at home)*

***Registered with HH but not living here (< 6 months/year absent)*

2.3. What are the main sources of income to the family? (Rank from 1-5 with 1 as the most important and 5 the least)

| Source | Rank |
|-------------------|------|
| Agriculture | |
| Livestock | |
| Horticulture crop | |
| NWFPs | |
| Tourism/Pottering | |
| Labour | |
| Employment | |
| Business | |
| Others (Specify) | |

2.3.1 Area of Household Expenses

| Particular | Estimated Amount (in Nu.) |
|---------------------------|---------------------------|
| School expenditure | |
| House hold expenses | |
| Rituals | |
| Constructions /Renovation | |
| Pilgrimage | |
| Leisure items | |
| Vehicles | |
| Farm Machineries | |
| Others (specify) | |

2.4. Type of land holdings

| Type: | cultivated/used by HH | fallow/unused | sharecropped / rented in | sharecropped / rented out |
|--------------------------------|--------------------------|---------------|-----------------------------|------------------------------|
| Chhuzhing, wetland | | | | |
| Kamzhing, dryland | | | | |
| Tsesha, kitchen garden/Khemsas | | | | |
| Orchard | | | | |
| Tsamdrog | | | | |
| Others: _ _ _ _ _ | | | | |

| | | | | |
|--|---|---|--|--|
| Part III: Agriculture Crops | | | | |
| 3.1 Type of Agriculture crop | | | | |
| <p>Which are the main crops grown by the household?</p> <p><i>☐ rank in ascending order in order of importance (1 being most important followed by 2, 3, etc.)</i></p> | <p>wetland rice</p> <p>upland rice</p> <p>maize</p> <p>millet</p> | <p>wheat</p> <p>barley</p> <p>mustard</p> <p>potato</p> | <p>radish/turnips</p> <p>bitter buckwht</p> <p>sweet buckwht</p> <p>Chilli</p> | <p>vegetables</p> <p>-----</p> <p>-----</p> <p>-----</p> |
| <p>Which are the cash crops grown?</p> <p><i>☐ rank in ascending order in order of importance (1 being most important followed by 2,3, etc.)</i></p> | <p>apple</p> <p>other temp. fruit</p> <p>cardamom</p> | <p>Orange</p> <p>other subtrop. fruit</p> <p>walnut</p> | <p>other nuts</p> <p>-----</p> <p>-----</p> | |
| <p>Does HH have other, special crop or livestock activities <i>☐ if yes, tick</i></p> | <p>☐ grow mushrooms ☐ keep silk worms ☐ keep bees</p> <p>☐ ----- ☐ ----- ☐ -----</p> | | | |
| <p>What are the main problems for Agriculture?</p> <p><i>☐ rank in ascending order in order of magnitude (1 being most problematic followed by 2,3, etc.)</i></p> | <p>☐ damage by wild animals</p> <p>☐ insufficient irrigation water ☐ insufficient labour ☐ bad road</p> <p>☐ insufficient funds to invest ☐ pests and diseases ☐ road/market far</p> <p>☐ other ----- ☐ insufficient land ☐ erosion</p> <p>☐ other ----- ☐ unreliable transport ☐ poor soil</p> | | | |

3.2 What is the annual income from Agriculture crops?

| Sl.# | Type of crops | Quantity (Unit) | Unit cost | Total amount | Remarks |
|------|---------------|--------------------|-----------|--------------|---------|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |

3.3 What are the main problems/constraints for Agriculture of the HH? (Rank from 1-5 with 1 as the most severe and 5 the least)

Problem/Constrain

Rank

☐ Damage by wild animals

☐ Poor accessibility

☐ Poor marketing

☐ Soil erosion

☐ Poor soil fertility

☐ Insufficient irrigation water

☐ Insufficient funds to invest

☐ shortage of labor

☐ Pests and diseases

☐ Insufficient land

Erratic Climate condition

Others (Specify)

Part IV: Livestock holding and importance

4.1. Type of Livestock holdings

| Livestock type | Total |
|---|-------|
| Yak | |
| Horse | |
| Cattle: Traditional/local breed Jersey breed Brown swiss breed Mithun breed Buffalo | |
| Bee keeping | |
| Fishery | |
| Goat | |
| Sheep | |
| Poultry | |
| Pigs | |
| Dog | |

4.2 What is the annual income from livestock?

| Livestock type | Item | Quantity | Unit | Rate/unit in Nu. | Total | Remarks If any.... |
|----------------|------------------------|----------|------|------------------|-------|--------------------|
| Yak | Milk | | | | | |
| | Cheese | | | | | |
| | Butter | | | | | |
| | Meat | | | | | |
| | Manure | | | | | |
| | Sale of live animal | | | | | |
| | Others..... | | | | | |
| Buffalo | Milk | | | | | |
| | Cheese | | | | | |
| | Butter | | | | | |
| | Meat | | | | | |
| | Manure | | | | | |
| | Sale of live animal | | | | | |
| | Others..... | | | | | |
| | Milk | | | | | |
| | Cheese | | | | | |
| | Butter | | | | | |
| Cattle | Meat | | | | | |
| | Manure | | | | | |
| | Sale of live animal | | | | | |
| | Others..... | | | | | |
| Horse | Transportation charges | | | | | |

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| | |
|---------|----------------------|
| Poultry | Sale of live animal |
| | Others |
| | Egg |
| | Meat |
| Pig | Sale of live animal |
| | Others |
| | Meat |
| | Manure |
| Goat | Sale of live animal |
| | Others |
| | Meat |
| Goat | Sale of live animals |
| | Other |
| Others | |

4.3. What is the importance of livestock to the household? Rank from 1-5 with 1 as the most important and 5 the least

| | Rank |
|-------------------------|------|
| Source of income | |
| Source of food | |
| Draught power | |
| Manure | |
| Means of transportation | |
| Others (Specify) | |

4.4. What are the main problems/constraints regarding livestock for the HH? Rank from 1-5 with 1 as the most important and 5 the least

| | | |
|--|---|--|
| <input type="checkbox"/> losses due to predators | <input type="checkbox"/> insufficient fodder | <input type="checkbox"/> diseases |
| <input type="checkbox"/> low milk yields | <input type="checkbox"/> insufficient grazing | <input type="checkbox"/> Parasites |
| <input type="checkbox"/> poor quality local breeds | <input type="checkbox"/> poor quality grazing | <input type="checkbox"/> other _ _ _ _ _ |
| <input type="checkbox"/> few extension visits | | |

Where does the household graze their livestock? *Please Tick*

| |
|----------------------------|
| Improved pasture |
| Open Forest |
| Abandon agriculture field |
| Tethered and Stall feeding |

Part V: Forest Resources use & People's outlook

5.1 Does he/she collect Forest resources?

Yes ☐ No ☐

If yes

5.2 What does he/she collect and income from forest resources?

| Resources | Qty. With scale/unite | | Rate per scale/unit | Annual income from sale | Distance from village to the collection site (Km or hr walk) | Trend (Increasing, Stable, Decreasing) | Remarks |
|---------------------------------|-----------------------|------|---------------------|-------------------------|--|--|---------|
| | Consumption | Sale | | | | | |
| Firewood | | | | | | | |
| Fodder | | | | | | | |
| Medicinal plants | | | | | | | |
| Mushrooms | | | | | | | |
| Incense | | | | | | | |
| Fern | | | | | | | |
| Thatch grass | | | | | | | |
| Canes | | | | | | | |
| Bamboo | | | | | | | |
| Fern/leaves for bedding | | | | | | | |
| Top soil/leaf moulds | | | | | | | |
| Cordyceps collection | | | | | | | |
| Agricultural tools | | | | | | | |
| Religious drums | | | | | | | |
| Wood burl/burr for <i>Dhapa</i> | | | | | | | |
| Others (specify) | | | | | | | |

Note: Annual income from sale can be calculated later

Trend: I=Increasing, S=Stable/Same, D=Decreasing

5.3 List five most preferred timber species for construction purposes?

- 1)
- 2)
- 3)
- 4)
- 5)

5.4 What are the threats to forest resources? Rank from 1-5 with 1 as the most severe and 5 the least

- 1)
- 2)
- 3)
- 4)
- 5)

Part VI: Wildlife Conservation

6.1 What animals and at what frequency do you sight wild animals in your areas and what is your feeling towards them? Also your views on the population trend

| Sl.no | Species | Frequency of sighting | Your feeling to Wildlife | Population trend | Reasons for increase or decrease (use additional sheet if space is not enough to write) |
|-------|---------|-----------------------|--------------------------|------------------|---|
| | | | | | |
| | | | | | |
| | | | | | |
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| | | | | | |

Frequency: A= Always, O=Occasionally. Feelings: L=Like, N=Neutral, D=Dislike

Population Trend: I=Increasing, S=Stable/Same, D=Decreasing

Part VII: Human-wildlife conflict

7.1 Did you get any of the following problems due to wildlife? Please tick in the appropriate cell

| Problem | Yes | No | Minor | Severe |
|----------------------|-----|----|-------|--------|
| Crop Damages | | | | |
| Livestock predation | | | | |
| Property damages | | | | |
| Disease transmission | | | | |
| Social Harassment | | | | |
| Others | | | | |

7.2 Has the household lost livestock to wild predators in the past three years? Tick appropriately

☐ Yes / ☐ No

| | | *Indicate code for the identification evidence of the predator for each case: s=animal seen, h=animal heard, p=pugmarks, t=type of killing, etc. | | | | | | |
|--------------------------|-------|---|-----|-----|-------------------------------|------|----------|-----------|
| Type of livestock killed | Breed | Date of Kill (month/year) | Age | Sex | Dist. from village (hr or km) | Cost | Predator | Evidence* |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

7.3. What are the root causes for Livestock depredation?

- 1.
- 2.
- 3.
- 4.
- 5.

7.4. What are the prevailing mitigation measures adopted? Rank from 1-5 with 1 as the most effective and 5 the least

| Action | Rank | Remarks |
|---|------|---------|
| Traditional Fencing (specify types in the remarks column) | | |
| Electric/Solar fencing | | |
| Guarding | | |
| Scarecrow | | |
| Trapping in field | | |
| Hunting in field | | |
| Endowment funds/insurance scheme | | |
| Others (specify)..... | | |

7.5. Do you have any other innovative ideas to curb livestock depredation?

- 1.
- 2.
- 3.
- 4.
- 5.

Do the wild animals depredate/damage the crop? ☐Yes /☐No

If Yes, indicate the crops and the order of magnitude for each animal spp.

| Crops | Animal species | Month | Qty (Kg, Drey, Sang etc..) | Local Rate per unit | Total Amount | Order of magnitude |
|-------|----------------|-------|----------------------------|---------------------|--------------|--------------------|
| | | | | | | |
| | | | | | | |
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What are the possible reasons for wild animals coming to field and damaging the crops?

- 1)
- 2)
- 3)
- 4)
- 5)

In your opinion what could be the solution for the conflict?

- 1)
- 2)
- 3)
- 4)
- 5)

7.9 Did the wild animals damage your properties in last three years? ☐ Yes ☐ No

If yes, indicate the properties damage by each animal

| Type of properties | Animal species | Month | Frequency (Once, Occasionally, frequently) | Specify the damage | Total loss in amount |
|--------------------|----------------|-------|--|--------------------|----------------------|
| | | | | | |
| | | | | | |
| | | | | | |
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| | | | | | |
| | | | | | |

Part VIII: Climate change and adaptation

Have you ever heard the term Climate Change? Yes ☐ No ☐

If yes, do you notice climate change in your village? Yes ☐ No ☐

If yes, can you please share your experience of climate change in your village? (for example: weather, climate, plant phenology cycle change, movement or migration of birds and animal)

Weather or climate pattern:

i) Rainfall pattern in last 10 years: Increase ☐ , decrease ☐ same ☐

ii) Temperature pattern in last 10 years: Increase ☐ , decrease ☐ same ☐

iii) Snow fall duration and intensity: more duration and more amount ☐ , more duration and less amount, ☐ less duration and more amount ☐

iv) Dry weather condition: Increase ☐ , decrease ☐ , same ☐

B. Plant phenology cycle change (flowering season, budding season, shifting in vegetation, invasive plants etc).

.....

.....

.....

C. Migratory birds or wild animals you have sighted or occurring in your village that was not present in the last 20 years or more. Please name them in local language or common English name.

.....

.....

.....

D. Birds or wild animals that have migrated out from your area? Please name them in local language or common English name.

.....

.....

.....

E. Is there any evidences of drying water sources in your locality?

☐ Yes ☐ No

If yes, Number of water source dried

F. How do you feel about the biodiversity and ecosystem of your community before 10 years and today?

Before

Today

Excellent Good Bad Reasons

Improved Stable Worst Reasons

2. How do you feel about the impact of climate change and vulnerability?

a. Yearly Increasing ☐ b. Yearly Decreasing ☐ c. Same as before ☐

3. What are the probable reasons for climate change in your opinion?

Natural (please describe)

.....

.....

Human (please describe)

.....

.....

.....

3. Have you ever experienced extreme weather events that affected your life in the last 10 years?

Yes ☐ No ☐

4. In what specific ways have this variability's/extreme climate affected your lives?

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| Nature of climate variability | Rank (1: most severe; 2,3,4....) | Impact on livelihood (Yes/No) | Impact on income (decrease or Increase) | Loss of properties / assets (Type) | Loss of lives (Yes/No) |
|--|-------------------------------------|----------------------------------|--|---------------------------------------|---------------------------|
| Drought | | | | | |
| Flood | | | | | |
| Landslide | | | | | |
| Soil erosion | | | | | |
| Hailstorm /wind | | | | | |
| Forest fire | | | | | |
| Early onset of rain | | | | | |
| delayed onset of rain | | | | | |
| Prolonged rain | | | | | |
| Scanty rain | | | | | |
| Pest and diseases (forests and agriculture crops and diseases for human) | | | | | |
| Others | | | | | |

5. Have you introduced new varieties of agriculture crops? If yes, why? Please give the reason

Reasons:

.....

.....

6. Which breeds of cattle is preferred by your community and why? Please give the reasons.

Reasons:

.....
.....

7. Do you consider it necessary to have adaptation strategies to cope with climate change impacts on livelihood of the society?

Yes ☐ No ☐ If yes, please suggest some strategies to cope with climate change.

1.....

2.....

3.....

4.4.1.10.2 Secondary data collection

In addition to the primary data collected at the Chiwog/Gewog level, a need to obtain secondary information about the survey area (Chiwog/Gewog) is important to get a better understanding on the household information and a wider view on different socio-economic well-being of the concerned village. As such, the secondary information required to be gathered at the central level includes the review of relevant scientific articles and journals, plan documents, policy and acts, and national reports. At Gewog/Chiwog level, related information to be collected includes records, Gewog statistics, Gewog plan documents, RNR documents, and other technical reports.

4.4.1.10.3 Data Processing and Analysis

Both quantitative and qualitative data collected from the field can be sorted for data entry in MS Excel Worksheet. It can be processed in PivotTable or SPSS (Statistical Package for Social Scientists) and any other widely used software and analytical tools. For qualitative data, non-parametric test, frequency distribution, and descriptive statistics may be performed as per need. Descriptive statistics may be applied to calculate the frequency, percentage, minimum value, maximum value, mean, standard deviation and standard error of different numerical and categorical data. To test the significance and relationships, statistical tool such as chi-square is recommended.

In order to derive the expected result out of Socio-economic Survey analysis, each part of the Household Questionnaire Survey and Participatory Rural Appraisal has a set of respective guiding hypothesis, outcome, and objectives.

4.4.1.10.3.1 Part A: Analysis of Household Survey

Household information and source of income

Hypothesis: Limited land holding may result to State Reserved Forest (SRF) land encroachment while lack of income source is suspected to resort to illegal trade of wildlife, timber or NWFPs. Less number of people living in the village or more people living outside the village as student, monk, employee, etc. is expected to exert minimal pressure to the forests in case of natural resource utilization.

Expected outcome: Structure of household composition (age, type of occupation and job responsibility in the family), land holding, source of household income and area of expenses is understood.

Objective: To determine household profile in terms of their resource (human, land and income) and area of expenses.

Agriculture farming

Hypothesis: A small land holding, low income generation from the sale of agriculture products may induce pressure on forest through NWFPs collection and poaching. Challenges in agriculture crop protection may entail to killing wild animals by farmers using lethal weapons. Constraints of inadequate irrigation water may lead to food crisis and subsequent impact on forest ultimately.

Expected outcome: Household agriculture farming and its associated problem, and income generation from the sale of agriculture products understood.

Objectives:

- i. To understand varieties of crops grown and annual income generated from the sale of agriculture products by a household;
- ii. To determine challenges/problems associated with agriculture farming and food security or grain-self-sufficiency of a household.

Livestock farming

Hypothesis: A household involved in rearing various types of livestock have better livelihood than those households which do not rearing cattle at all. On the other hand, breed type and mode of rearing of cattle type varies resulting in different quality of livestock products and impacts on forest. For example, local breed, mithun and yaks compared to Jersey and Brown Swiss are expected to induce more pressure on the forests and are more vulnerable to predators if they stray into forest areas. So, retaliatory killing of predators by herdsman for cattle loss is one main factor that can decimate or even wipe out predator population in the locality.

Expected outcome: Household livestock farming practices and its associated problem, and income generation from the sale of livestock products understood.

Objectives:

- i. To understand various types of livestock (cattle, horse, poultry, pig, etc.) reared and annual income generated from the sale of livestock products;
- ii. To determine mode of livestock rearing and their associated problem

Forest Resource use

Hypothesis: Maximum dependence on various forest resources by the household is assumed to impact adversely and exacerbate the conservation problems in the locality. Unregulated collection of forest products (e.g., NWFPs) could entail to local extinction at a faster rate.

Expected outcome: Household forestry resource use pattern and trend, and income generation from the sale of forest products understood.

Objectives:

- i. To understand the use of forest resources and its trend, and income generation from the sale of forest products;
- ii. To determine forestry associated challenges and their perception on resource availability.

Wildlife Conservation and people's outlook

Hypothesis: A few segments of local people's positive attitude in respect of conservation is appreciated and acknowledged by conservationists. On the other hand, some people's negative attitude and perceptions are never taken into account rationally. Therefore, frequent occurrence of wildlife species of high conservation value in the locality is more vulnerable in unavoidable situations with human encounters.

Expected outcome: People's attitude and perceptions about wildlife conservation understood.

Objective: To determine the attitude of people about wildlife conservation and their perception about the trend of wildlife occurrence in the locality.

Human-wildlife conflict

Hypothesis: Wild animals that are responsible for agriculture crop depredation and livestock predation are highly vulnerable to retaliatory killing by farmers. Crop protection measures prevailing in the locality are barely effective depending upon the wildlife species while migratory cattle are largely predated due to complacent herding practices.

Expected outcome: Human-wildlife conflict pattern and prevailing mitigation measure in the locality understood.

Objectives:

- i. To better understand driving factors and the area of human-wildlife conflict, and its pattern in the locality;
- iii. To determine the prevailing HWC measures and potential intervention measures.

Climate change and adaptation

Hypothesis: Local people are the better source for reporting climate change within some predetermined indicators. Interactions between farmers and wildlife have changed over the resource sharing and use pattern due to climate change impacts. People are already practicing resilient climate change adaptation measures especially in the area of agriculture and livestock farming practices.

Expected outcome: Knowledge on climate change impacts and resilient adaptation measures prevailing in the locality is enhanced

Objectives:

- i. To determine the climate change impacts (both adverse and benign) and its trend in the locality in a given time frame;
- ii. To understand the prevailing climate adaptation measures being practiced by the local people.

4.4.1.10.3.2PART B: PRA Analysis

Historical Timeline

Hypothesis: There is either overlap in the development and conservation activities by various agencies in the village or total negligence of the village in development planning with an assumption of being supported by some other agencies other than PA.

Expected outcome: Knowledge on chronology and duplication or negligence of all development, religious, social and conservation activities in the village is enhanced.

Objective: To understand the structure of development activities and conservation programs set up in the village.

Resource mapping

Hypothesis: Resource sharing between local people and outsiders in the locality leads to deterioration of natural resources at a faster rate and conflict rises thereof. In some villages, there are village norms (from religious and cultural perspectives) for sustainable resource utilization besides resource sharing regimes instituted by the DoFPS.

Expected outcome: Areas of various forest resource collections (by the local people and outsiders), degradation/deterioration threats to natural resource and application of existing local norms understood.

Objectives:

- i. To determine utilization and area of collection of various forest products.
- ii. To understand threats to resources, resource sharing strategy and its associated conflict management in the locality.

Seasonal Calendar Activities

Hypothesis: Local people's farming season is often interrupted by development activities/planning which affect them. Collection of forest resources (NWFPs) is occurring inconsistently beyond the provisions of standing rules.

Expected outcome: Knowledge on farming and seasonal off-farm activities prevailing in the locality is enhanced.

Objective: To understand seasonal agriculture and livestock farming activity patterns, and seasonal off-farm activity (including forestry, culture, religious, etc.).

Ranking for natural resources

Hypothesis: Legitimate rights of local people for collection of timber and NWFPs are being respected and forestry personnel assume that their demand is fulfilled. But, in reality local people's desire for better species for some genuine reason always remains unfulfilled.

Expected outcome: Relative significance and utilization of forest resources understood.

Objective: To better understand the importance, priority, and utilization of particular resources (timber and NWFPs) for the local people.

Stakeholder Analysis

Hypothesis: There exists overlap in supporting the development and conservation activities by various agencies in the village or total negligence of the village in development planning with an assumption of being supported by some agencies other than field office

Expected outcome: Institutions or agencies involved in the development planning and funding the activities or program in the locality realized.

Objective: To identify stakeholders involved in planning and funding development activities in different fields (health, education, etc.) other than the RNR sector.

Strength, Weakness, Opportunity, Threats (SWOT) Analysis

Hypothesis: Local people are considered as threats from the perspective of resource sharing and encounter with wildlife, by many people including some conservation agencies. Local people's attitude and behavior in terms of biodiversity conservation are assumed rather negatively without carrying out in-depth situational analysis.

Expected outcome: Four dynamic variables (SWOT) – strength, weakness, opportunity, and threats of community on conservation assessed.

Objective: To determine strength, weakness, opportunity, and threats of local people from the angle of biodiversity conservation.

Problem Tree Analysis

Hypothesis: Everyone sees different types of problems and look at them differently as an individual. In the case of HWC, conservationists and farmers have different perspectives. Knowledge on driving factors and their interconnectedness to an identified problem of a particular place and specific time is never looked at seriously by both the parties (conservationist and farmer).

Expected outcome: The main driving and underlying factors of specific wildlife associated problems encountered by the local community identified.

Objective: To better understand driving parameters and interconnectedness to an identified problem (e.g. Crop depredation by wild pig) occurring in a particular place and specific time.

Information on wild animals

Hypothesis: Different segments of people have their own perception about wildlife occupancy and their distribution. Local people reason out that stringent conservation policy has resulted in the increase in wildlife population which live nearby agriculture field or forest edge. On the other hand, conservationists assert that fragmentation of natural habitat of wild animals due to infrastructure development is one significant cause for displacement of wildlife from forest to nearby agriculture fields.

Expected outcome: Knowledge on occurrence of wild animals and its frequency of sightings in the locality enhanced.

Objective: To understand wild animal occurrence and rate of sightings by people in the vicinity of villages.

Ecotourism potential and governance

Hypothesis: Some villages in PAs already have community-based ecotourism and governance regime in place. But most of the villages do not have established community-based ecotourism activity other than occasional visit by tourists.

Expected outcome: Governance of existing-community based ecotourism and benefit sharing understood, and potential community-based ecotourism identified.

Objectives:

- i. To better understand the management regime or governance of community-based ecotourism and its benefit sharing modalities.
- ii. To determine potential area of community-based ecotourism from the perspective of natural, cultural and social values.

Household information and source of income

Hypothesis: Limited land holding may result to State Reserved Forest land encroachment while lack of income source is suspected to resort into illegal wildlife trade including NWFPs and timber. Less number of people living in the village or more people living outside the village as student, monk, employee, etc. is expected to exert minimal pressure to the Forests in case of natural resource utilization.

Expected outcome: Structure of household composition (age, type of occupation and job responsibility in the family), land holding, source of household income and area of expenses is understood.

Objective: To determine household profile in terms of their resource (human, land and income) and area of expenses.

Agriculture farming

Hypothesis: A lack of income generation and insufficient grains from the sale of agriculture products may induce pressure on forest through NWFPs collection and poaching the wild animals. Challenges in agriculture crop protection may entail to killing wild animals by farmers using lethal weapons. Constraints of inadequate irrigation water may lead to food crisis and subsequent impact on forest ultimately.

Expected outcome: Household agriculture farming and its associated problem, and income generation from the sale of agriculture products understood.

Objectives:

- i. To understand varieties of crops grown and annual income generated from the sale of agriculture products by a household;
- ii. To determine agriculture farming associated challenges/problems and food security or grain-self-sufficiency of a household.

Livestock farming

Hypothesis: A household involve in rearing various types of livestock succeeds better livelihood than those households not rearing cattle at all. On other hand, breed type and mode of rearing of cattle type varies in product and impacts on forest. For example, local breed, mithun and yaks compared to Jersey and Brown Swiss are expected to induce more pressure on the forests and carry more vulnerability of loss to predators if they are migrated. So, retaliatory killing of predators by herdsmen for cattle loss is one accounted factor that can decimate or even wipe out predator population in the locality.

Expected outcome: Household livestock farming practices and its associated problem, and income generation from the sale of livestock products understood.

Objectives:

- i. To understand various types of livestock (cattle, horse, poultry, pig, etc.) reared and annual income generated from the sale of livestock products;
- ii. To determine mode of livestock rearing and their associated problem?

Forest Resource use

Hypothesis: Maximum dependence on various forest resources by the household is assumed to impact adversely and exacerbate the conservation problems in the locality. Unregulated collection of forest products (example NWFPs) entails to local extinction at a faster rate in the future.

Expected outcome: Household forestry resource use pattern and trend, and income generation from the sale of forest products understood.

Objectives:

- i. To understand the use of forest resources and its trend, and income generation from the sale of forest products;
- ii. To determine forestry associated challenges and their perception on resource availability.

Wildlife Conservation and people's outlook

Hypothesis: A few segments of local people's positive attitude in respect of conservation is appreciated and acknowledged by conservationist. On the other hand, some people's negative attitude and perceptions are never taken into account rationally. Therefore, frequent occurrence of wildlife species of high conservation value in the locality is more vulnerable in unavoidable situation with human encounter.

Expected outcome: People's attitude and perceptions about wildlife conservation understood.

Objective: To determine the attitude of people about wildlife conservation and perception about the trend of wildlife occurrence in the locality.

Human-wildlife conflict

Hypothesis: Wild animals that are responsible for agriculture crop depredation and livestock predation are highly vulnerable to retaliatory killing by farmers. Crop protection measures prevailing in the locality are barely effective depending upon the wildlife species while migratory cattle are largely predated due to complacent herding practices.

Expected outcome: Human-wildlife conflict pattern and prevailing mitigation measure in the locality understood.

Objectives:

- i. To better understand driving factors and area of human-wildlife conflict, and its pattern in the locality;
- ii. To determine the prevailing HWC measures and potential intervention measures.

Climate change and adaptation

Hypothesis: Local people are the better source for reporting on climate change impacts on some of the predetermined indicators. Interactions between farmers and wildlife have changed over the resource sharing and use pattern due to climate change impacts. People are already into resilient climate change adaptation measures especially in the area of agriculture and livestock farming practices.

Expected outcome: Knowledge on climate change impacts and resilient adaptation measures prevailing in the locality is enhanced

Objectives:

- i. To determine the climate change impacts (both adverse and benign) and its trend in the locality in a given time frame;
- ii. To understand the prevailing climate adaptation measures being practiced by the local people.

4.4.1.10.4 MATERIAL REQUIRED

Basic equipment required for the survey;

- Survey forms (Household Questionnaire Survey and PRA)
- GPS
- Pencil, eraser
- Clip board
- Chart paper/flip chart
- Marker pen
- Voice recorder

4.4.1.10.5 ETHICS

- You should be presentable and wearing proper uniform national dress or forestry uniform.
- Respect the timing of the communities (avoid busy hours/season).
- Self-introduction and greetings before you start your questioner.
- Describe the purpose and objective of the survey and explain the rules on confidentiality.
- Create conducive environment for the interview.
- Use simple language, be prepared to find alternative ways to ask same question.
- Respect the various view, tradition and local culture.
- In case of use of recorder, get prior permission from the respondent.
- Kindly acknowledge the respondent for their information and time.

4.4.2 Bibliography

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5. Linkages with Other Volumes

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5 Linkages with Other Volumes

5.1 Introduction

The Forests and Nature Conservation Code of Best Management Practices of Bhutan (*Code*), 2021 is the revision of the Forest Management Code of Bhutan (FMCB) 2004 and provides detailed guidelines for various management regimes prescribed to the forests and wildlife in Bhutan. While the FMCB 2004 specifically caters to the management of the Forest Management Unit (FMU), this *Code* encompasses and guides the management of all other management regimes currently prescribed in Bhutan. The *Code*, comprising of six volumes, guide forest managers and others, on management of the forest and wildlife in Bhutan, starting with the resource assessment, preparation and effective implementation, monitoring and evaluation of scientific plans.

This Chapter provides a brief account on the organizational structure of the *Code* and delves very briefly into what each volume prescribes and the linkages between different volumes. It also provides information on how to use the *Code* and the limitations of the *Code*.

5.2 Structure of the Code

The *Code* is mainly constituted of the following structure.

Table 5.1 Contents of the Code 2021

| Volumes | Chapters |
|---|--|
| Volume I. General Provisions | <ol style="list-style-type: none"> 1. Guiding Principles 2. Forest Management in Bhutan 3. Climate Change and Forests 4. National Forest and Biodiversity Monitoring System 5. Linkages with other Volumes |
| Volume II. National Forest Resources Assessment | <ol style="list-style-type: none"> 1. National Forest Inventory 2. Forest Resources Potential Assessment 3. National Wildlife Survey 4. National Wetland Inventory |
| Volume III. Sustainable Forest Management Unit | <ol style="list-style-type: none"> 1. Forest Management Unit 2. Community Forests 3. Local Forest Management Area 4. Private Forests |
| Volume IV. Protected Area Management | <ol style="list-style-type: none"> 1. National Parks and Wildlife Sanctuaries 2. Biological Corridors |
| Volume V. Cross-cutting Management Regimes | <ol style="list-style-type: none"> 1. Watershed Management 2. Wetland Management 3. Non-Wood Forest Produce 4. Forest Pests and Disease 5. Forest Fire 6. Other Conservation Areas 7. Plantation and Nursery 8. Agroforestry |
| Volume VI. Research and Development | <ol style="list-style-type: none"> 1. Forest Biodiversity and Ecosystem Research (FoBER) 2. Mainstreaming Research Findings into Forest and Biodiversity Policies, Plans and Programs |

5.2.1 Volume

There are six volumes constituting the *Code*. Volume I is the introductory volume and discusses the general principle of the *Code*, Volume II provides guidance on the resource assessment, Volume III and IV provides prescriptions on preparing scientific management plans for State Reserved Forest (SRF) Land and Volume V describes the cross-cutting regimes (Watershed and wetland management, Forest Fire, Pests and Disease, Ecotourism and other conservation areas) in the country. Volume VI provides guidance on conducting research in SRF land in Bhutan.

5.2.2 Chapter

The *Code* has a total of 25 chapters with each volume having at least two chapters. The chapters in Volume I provide the general framework of the *Code* and the general principles on which the *Code* is based. Volume II has four chapters describing the different resources assessment carried out in Bhutan. These resource inventories form the basis of which management plans are prepared under different prescriptions defined in the chapters under Volume III-V. The two chapters in Volume VI mainly guide the foresters and others in research activities in the SRF in Bhutan.

5.3 Description and Linkages to other Volumes

Each volume contains chapters which are relevant to the broad theme or topic of the volume followed by references. The brief introduction and description of the different chapters under each volume are detailed below:

5.3.1 Volume I: Guiding Provisions

Volume I is the introductory volume to the *Code* and provides general information and principles of forest management in Bhutan. It also provides a brief description of the content of the different volumes of the *Code*.

Guiding Principles emphasis on the need of revision of the *Code* and the institutional and legal framework in place for the implementation of the *Code*.

Forest Management in Bhutan provides a brief background and general principles of scientific forest management in Bhutan. The impact of climate change on forest and wildlife is becoming more pronounced. Therefore, adaptation and mitigation measures implemented and envisioned in forest management has been dealt in the chapter on *climate change*.

Further, the *National Forest Monitoring and Biodiversity System* discusses in detail the tools and techniques adopted to monitor forest activities in Bhutan.

5.3.2 Volume II: National Forest Resources Assessment

Volume II of the *Code* encompasses assessment guidelines on forest, wildlife and water resources to enable appropriate planning and scientific management.

National Forest Inventory (NFI) provides guidelines on collecting data and information on forests and allied resources for compilation, assessment and analysis to enable policy and management decisions.

The *Forest Resources Potential Assessment (FRPA)* discusses the need of and the process of identifying and assessing the potential forest resources of Bhutan for sustainable timber production.

The National Wildlife Survey provides guidelines on survey of various wild animals and notably on the mammals in Bhutan while the *National Wetland Inventory* defines wetland in the national context and provides new guidelines on the conduct of wetland inventory in Bhutan.

5.3.3 Volume III: Sustainable Forests Management

This volume deals with management of production forests namely Forest Management Unit (FMU), Local Forest Management Area (LFMA), Community Forests (CF), and Private Forest. The *Forest Management Unit* provides detailed description of the preparation and implementation of FMU plans. This is an updated version of the procedures defined in the FMCB 2004; mainly in respect to forest inventory and function mapping.

The *Local Forest Management Area* plan is a Gewog based forest management plan prepared mainly to cater to the rural timber requirement of the people. This is envisioned towards managing all SRF under scientific management prescription.

Community Forest is a participatory forest management initiative whereby SRF are designated for sustainable management of forest resources by a local community.

Though the *Code* is mainly aimed towards management of SRF, this Volume also provides provisions for *private forest*, the management prescriptions of which may be adopted by private forest owners.

5.3.4 Volume IV: Protected Area Management

This Volume deals with guidelines on the management of Protected Areas in Bhutan. This guides the managers through the process of management of the different types of PA network in Bhutan. *National Parks and Wildlife Sanctuaries* provides prescriptions for the management of different types of PA (National Park, Wildlife Sanctuaries and Strict Nature Reserves) in Bhutan. The chapter on *Biological Corridor* (BC) focuses on the identification and management of BC in Bhutan.

5.3.5 Volume V: Cross-Cutting Management Regimes

While Volume III and IV deal with management of production forest and protected area networks, there are other management prescriptions and regimes which are cross-cutting. Themes such as *Watershed*, *Wetland*, *Non-wood Forest Produce (NWFP)*, *Forest Pest and Diseases*, *Forest Fires*, *Plantation & Nursery*, *Agroforestry and other Conservation Areas*, can occur in any other management regimes which is classified as cross cutting.

5.3.6 Volume VI: Research and Development

Volume VI of the *Code* focuses on guiding principle of forest and biodiversity research and development in Bhutan. It provides procedures for identification of research needs and the modality of conduct of and dissemination of research findings in Bhutan.

5.4 Usage of the Code

The *Code* is a complete set of technical guidance developed to assist the Department of Forests and Park Services, other researchers, scholars and private forest owners to manage the forest sustainably. It is a comprehensive document compiled after review of the FMCB 2004, existing guidelines and frameworks for other management regimes, literature review and consultation meeting held with frontline forest managers. The *Code* serves to provide the best management prescriptions from practical, economic, social and technical

point of view for a particular forest area. Therefore, it serves as guidance to identify, assess and adopt a particular or set of different management prescriptions to the forest land.

The *Code* provides clear guidance on what, when and how to implement the management activities. Further, the *Code* is not rigid and shall be updated and upgraded on discovery of better techniques and prescriptions for forest management. Any change or upgrade in methodology shall be disseminated as amendment or refinement of the *Code*.

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3. Second Consultation Workshop, DoFPS Conference Hall (3rd January 2020)

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4. Writeshop in Phuentsholing (3-7th February 2020)

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5. Consultation with Chief Forestry Officer (8-10th February 2020)

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Forest and Nature Conservation Code of Best Management Practices of Bhutan

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6. Writeshop in Punakha (25-30th July, 2020)

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7. Finalization workshop in Thimphu (12-24th October 2020)

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