



Forestry Department

Food and Agriculture Organization of the United Nations

# BRIEF ON NATIONAL FOREST INVENTORY NFI

## BRUNEI DARUSSALAM

**Forest Resources Development Service**

**Rome, June 2007**



## **Strengthening Monitoring, Assessment and Reporting (MAR) on Sustainable Forest Management (SFM)**

FAO initiated activities to strengthen Monitoring, Assessment and Reporting on Sustainable Forest Management in January 2006 with the objective to facilitate development of harmonized forest related national monitoring, assessment and reporting (MAR) for contributing directly to the improvement of national sustainable forest management (SFM) regimes. It also aims to catalyze national discussions, analyses, policy actions and planning that promote national SFM regimes besides clarifying the contribution of forests to global environment and to human well-being. This initiative shares the ambition of the Collaborative Partnership on Forests (CPF) about simple, harmonised, efficient and action oriented MAR systems both at international and national levels and thus provides a response to some of the key recommendations made by the CPF task force on streamlining the reporting on forests with particular focus on national capacity building.

The MAR recently updated goals include country capacity building for better, consistent and regularly updated information to facilitate implementation of non-legally binding instrument (NLBI) on SFM, adopted at UNFF 6 (2007) that aims to,

- Strengthen political commitment and action at all levels to implement effectively sustainable management of all types of forests and to achieve the shared four global objectives ((a) reverse the loss of forest cover worldwide, (b) enhance forest-based economic, social and environmental benefits, (c) increase significantly the area of protected forests worldwide, and (d) reverse the decline in official development assistance for SFM);
- Enhance the contribution of forests to the achievement of the internationally agreed development goals, including the Millennium Development Goals, in particular with respect to poverty eradication and environmental sustainability; and
- Provide a framework for national action and international cooperation.

All countries can participate in this initiative, although the actual level and intensity of their involvement may vary among them. The initiative is organized under the Forest Resources Development Service (FOMR) of FAO Forestry Department. The contact persons are:

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### **DISCLAIMER**

The MAR-SFM Working Paper Series is designed to reflect the activities and progress of the MAR on SFM programme of FAO. Working Papers are not authoritative information sources – they *do not* reflect the official position of FAO and should not be used for official purposes. Please refer to the FAO forestry website ([www.fao.org/forestry](http://www.fao.org/forestry)) for access to official information.

The MAR-SFM Working Paper Series provides an important forum for the rapid release of preliminary findings needed for validation and to facilitate the final development of official quality-controlled publications. Should users find any errors in the documents or have comments for improving their quality they should contact [Kailash.Govil@fao.org](mailto:Kailash.Govil@fao.org) or [Dan.Altrell@fao.org](mailto:Dan.Altrell@fao.org).

## Brief Note on MAR-SFM Working Paper Series (AP) on NFI- Brief

The NFI – Brief for a country attempts to provide a bird’s eye view of the National Forest inventories (NFI). However, some countries conduct forest inventories at sub-national and or field management unit level. Therefore, this brief presents brief information on the forest inventories in a country at national level, sub-national level and or field management level depending on the available information.

It is useful to regularly update our understanding of elements and specifications of forest inventories because the information generated by forest inventories is simply manifestation of its span, design and methods to collect and analyse the primary information during its implementation. This is important because the NFI provides information on the state and trends of forest resources, their goods and services, and other related variables that support and many time define the policy and trade decisions, science and field initiatives, national and international reporting, and direct and indirect contribution of forests to society like poverty alleviation. Regular updates are necessary because countries do change the set of elements, their specifications, designs and methods over period of time to address new emerging demands and to take advantage of new technologies.

The purpose of developing the NFI-briefs is, therefore, to document (working paper) the current and historical span of elements (variables or fields), their specifications, sampling designs and methods used in NFI. The document may serve as data source as well as reference material.

These briefs have been initially developed on the basis of the country submission to FAO. The initial draft of this report was sent to following national focal point for review and country validation before its finalisation.

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## Table of Contents

GENERAL INFORMATION.....	2
MAP OF THE COUNTRY .....	2
LAND AREA AND LANDUSE .....	2
FORESTS .....	3
BRIEF HISTORY OF FOREST INVENTORIES .....	5
CURRENT NATIONAL FOREST INVENTORY DESIGN.....	10
REMOTE SENSING .....	10
FIELD SURVEY .....	10
MEASUREMENTS .....	11
CURRENT CONTENT AND METHODOLOGY OF DATA COLLECTION .....	12
GEO-PHYSICAL.....	12
BIO-PHYSICAL .....	12
FOREST EXTENT .....	12
FOREST CHARACTERISTICS (NATURALNESS) AND FOREST TYPE.....	12
USE (DESIGNATED FUNCTIONS) OF FORESTS.....	13
SOCIAL SERVICES .....	13
MAPPING OF FOREST DISTRIBUTION .....	13
STATUS OF THE FOREST AND DISTURBANCES AFFECTING FOREST HEALTH AND VITALITY .....	13
BIODIVERSITY .....	14
BENEFICIARIES OF FOREST GOODS AND SERVICES .....	14
ECONOMIC VALUE.....	14
POLICY, LEGAL AND INSTITUTIONS (PLI) FRAMEWORK.....	15
BIBLIOGRAPHIES AND REFERENCES FOR FURTHER READING.....	16

### List of Figures

- Figure 1 Maps of Brunei Darussalam
- Figure 2 Layout of Inventory Field Sample

### List of Tables

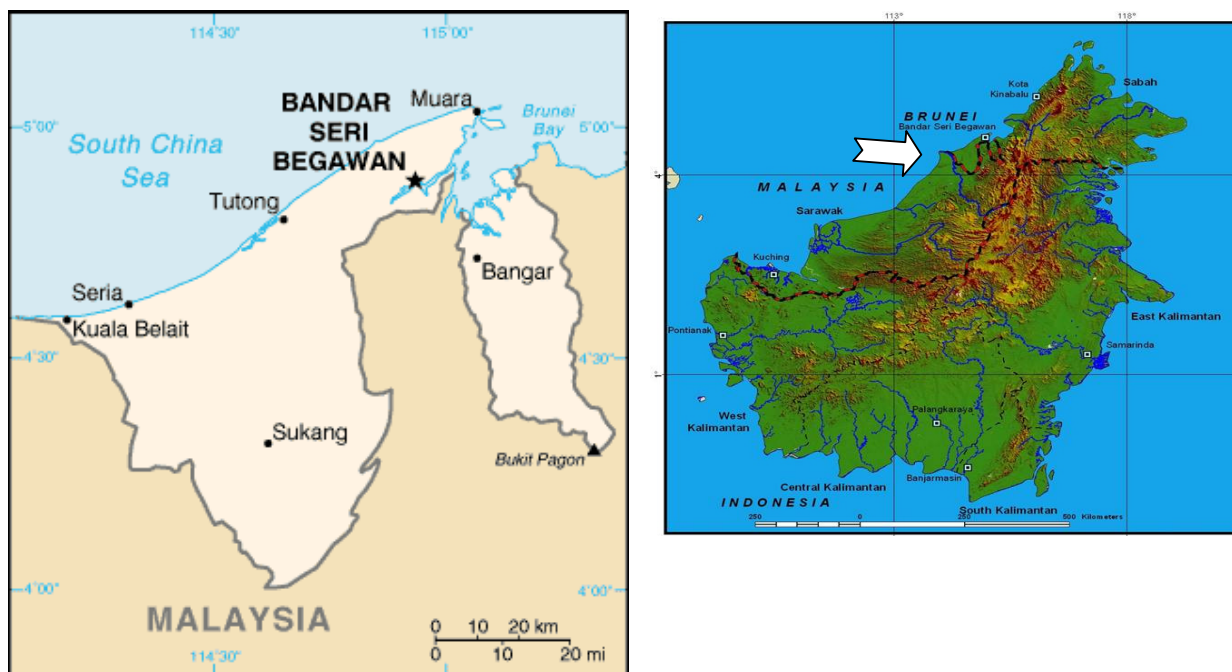
- Table 1 Categorisation and projection of land use in Brunei (FRA 2005)
- Table 2 Forest types and Bio-ecotypes of Brunei
- Table 3 Area of different forest types of Brunei
- Table 4 History of Assessments

## General Information

Brunei Darussalam, is a country located on the island of Borneo, in Southeast Asia. Apart from its coastline with the South China Sea it is completely surrounded by the state of Sarawak, East Malaysia. Its capital and largest city is Bandar Seri Begawan.

## Map of the Country

Figure 1. Maps of Brunei Darussalam



(Source: <https://www.cia.gov/library/publications/the-world-factbook/geos/bx.html>)

## Land Area and Landuse

The total area of Brunei Darussalam is 5 770 square km and the following table presents the categorisation and projection of land use in Brunei for 1990, 2000 and 2005 (FRA 2005).

**Table 1.** Categorisation and projection of land use in Brunei (FRA 2005).

FRA 2005 Categories)	Area (1000) hectares		
	1990	2000	2005
Forest	313	288	278
Other wooded land	142	155	160
Other land	72	84	89
Inland water bodies	50	50	50
<b>TOTAL</b>	<b>577</b>	<b>577</b>	<b>577</b>

## Forests

In terms of geographic and altitudinal distribution, there are only following two broad categories (Swamp and Hill forests) of forests in Brunei Darussalam

### *Swamp Forests*

Those which occurs in low-lying lands which are subject to tidal, seasonal, or continuous flooding and inundation by water. This group is composed by the mangrove, freshwater swamp, and peat swamp forest.



### *Hill Forests*

Those that occur in generally high and dry grounds, including the *kerangas* or tropical heath forest, mixed dipterocarp forest, and montane forest.



However, in terms of ecological and biological systems being encompassed, the forest of the country is among the most complex and diverse in the region. There are at least 32 distinguishable *bio-ecotypes* found in Brunei Darussalam as follows:

**Table 2.** Forest types and Bio-ecotypes of Brunei

Forest type	Bio-Ecotypes
Mangrove	7
Fresh Water Swamp Forest	3
Peat Swamp Forest	9
Kerangas Forest	5
Mixed Dipterocarp	3
Montane Forest	5
<b>Total</b>	<b>32</b>

Table 3 presents a further subdivision of the above 6 classes of forests into following 9 classes based on their characteristic and provides their area estimates. It may be noted that the area figures in table include area of other wooded lands.

**Table 3.** Area of different forest types of Brunei

	<b>Primary</b>	<b>Disturbed</b>	<b>Total</b>
Mangrove	10.798	7.620	18,418
Fresh water swamp forest	12.668		12,668
Peat swamp forest	87.267	16.438	103.705
Kerangas	1.517	5.041	6.558
Mixed dipterocarps	164.775	58.979	223.754
Montane	7.196		7.196
Mixture	13.988	38.683	52.671
Plantations		2.360	2.360
Secondary / Others		20.788	20.788
<b>Total Forests</b>	<b>298.209</b>	<b>149.909</b>	<b>448.118</b>

Source: FRA 2005 Country Report- Brunei, data of 1996

The main objectives of forest management include attaining long-term self-sufficiency in timber production and the supply of other essential forest products; promoting downstream processing for high value-added products; tapping forest biodiversity for industrial biotechnology; boosting ecotourism; and developing a competitive forestry niche in the international market. All of these are geared toward maximising the contribution of the forestry sector in the Government's national economic diversification programme. The forestry is slowly getting mainstreamed in the development process.

Brunei Darussalam recognizes the protection and conservation values and attempting to increase area under conservation to enhance the protection of the natural life-support systems, maintenance of environmental amenities, promotion of scientific endeavours and nature education, and perpetuation of the national patrimony.

## Brief History of Forest Inventories

The Forestry Department, established in 1933, was one of the pioneer government agencies in Brunei. The Forest Act was first promulgated in 1934. In the early years, forestry administration was concerned mainly with the collection of revenue; a minimal volume of timber and non-wood forest products was harvested, including latex of jelutong for domestic and export purposes. In the past few years, most of the development activities have been focused on the rational exploitation and management of the commercial natural forest, particularly the mixed dipterocarp forests.

There has been no complete National Forest Inventory although partial forest inventories have been carried out as early as in 1934. Further surveys have been done in the 1950s while in the 1970s tracts of forest have been inventoried through reconnaissance surveys by lumber companies to develop feasibility studies and assess commercial value of the forest. Detailed information on these past inventories are presented in the final report of the Forest Resources and Strategy Planning Study by Anderson and Marsden (1984).

The latest inventory was carried by Anderson and Marsden for their “Brunei Forest Resources and Strategic Planning Study”. They carried out a survey covering mostly the primary forest in “Mixed Dipterocarp Forest” and “Peat Swamp Forest”, which are the main constituent Brunei forest resources. They estimated only the “net industrial stem wood” (NIS) volume of grade 1 and grade 2 trees. Following is the summary information.

Total forest area surveyed	202 (000ha)
Total NIS volume	17.7 (million cubic meters)
Average commercial growing stock	87.62 cubic meters per hectare

The Brunei Forest Resources and Strategic Planning Study Report is the only comprehensive and detailed forest inventory work available to date. It was used as the basis for the 1986 National Master Plan which is being implemented under the series of 5-year National Development Plans. There is no newer work of similar or comparable coverage.

The 1983 aerial survey was done to determine the limits of the potentially commercial forest area, to identify the forest types, density strata and terrain classes and to prepare a forest type map of complete national coverage. For most of the country, 1:25 000 aerial colour photos were available from 1975 and 1976. Black and white 1:25 000 photos from 1981 and 1982 were available for some of the remaining areas. The quality of the photographs for delineating forest types was variable. The resulting nine-sheet 1:50 000 forest cover map delineated six forest types (mangrove, freshwater swamp, peat swamp, tropical heath, mixed dipterocarp and montane) and also mapped non-forest areas including secondary forest, cultivated areas (which include forest plantations, as well as rubber plantations and rice cultivation) and urban and industrial land.

The JICA implemented a Development Survey on the Forest Resources in Brunei Darussalam (published in March 1994) which included an inventory of 50,000 hectares in the Inter-Riverine Zone (IRZ) between the Tutong and the Belait Rivers that is earmarked for Forest Plantation Development, mainly for timber crops, and a survey of 10,000 hectares in Temburong District that is within the Ulu Temburong National Park. The latter component of the study did not involve any timber resource inventory. The inventory was limited to a selected group of species on areas intended for forest plantation. The study did not provide volume by individual species. The study indicates that the undisturbed Alan Forest (stratum 3.3, 3.5) has the highest volume, ranging from 528 to 585 cubic meter per hectare. It is



followed by undisturbed Peat Swamp (stratum 3.1, 3.2) and Mixed Dipterocarp Forest (stratum 5) whose per hectare volume ranges from 331 to 448 cubic meter.

**Table 4.** History of Assessments

Publication Year <sup>1</sup>	Title <sup>2</sup>	Institution <sup>3</sup>	Ground Inv. Year(s) <sup>4</sup>	Remote Sensing		Estimation Level <sup>7</sup>	Country Coverage (Full/Partial, %) <sup>8</sup>	Thematic cover**
				Data Year(s) <sup>5</sup>	Scale of Interpretation <sup>6</sup>			
1934		C.L.Durant, Assistant Conservator of Forests (Malayan Forest Service)	1932				25.9 ha in Swamp forest; 21.9 ha. in Hill Forest	Dbh recorded for volume estimation
1961	The Ecology and Forest Types of the Peat Swamp Forests of Sarawak and Brunei. PhD Thesis.	Anderson - Badas	1954				Establishment of 5-mile transects and with 0.2 ha sample plots.	All trees of 12 cm Dbh measured and classified, and botanically identified.
1964	Ecological Study of MDF	Ashton	1964	1958-60	1:60,000 – b&w aerial photos		50 1-acre plots	taxonomical identification. All trees of 12 cm Dbh measured
1973	Temburong Reconnaissance (for the Mid –Temburong Timber Development Project)	commissioned by the Brunei Forest Department	1973-76				Five companies surveyed sample areas of various size	Volume assessment.
1973	The Belait swamp Forest Development Project	commissioned by the Brunei Forest Department	1976/77; 1981				Three companies surveyed sample areas of various size	Volume assessment.
1974	Study of the Kerangas forests of Sarawak and Brunei	Brunig	1974				.	All trees of 3 inches and more in Dbh measured. Forest types; growing stock and site potential.

**\*\*Legend:** **NF**=Natural Forest; **PL**=Plantations; **OWL**=Other Wooded land; **FAC**=Forest Area Change; **TV**=Total Volume; **TB**=Total Biomass; **CV**=Commercial Value; **PA**=Protected Areas; **BD**=Biodiversity; **FO**=Forest Ownership; **WSP**=Wood Supply Potential; **NWGS**=Non-wood Goods and services; **TOF**=Trees outside of forest; **FF**=Forest Fires

Publication Year <sup>1</sup>	Title <sup>2</sup>	Institution <sup>3</sup>	Ground Inv. Year(s) <sup>4</sup>	Remote Sensing		Estimation Level <sup>7</sup>	Country Coverage (Full/Partial, %) <sup>8</sup>	Thematic cover <sup>**</sup>
				Data Year(s) <sup>5</sup>	Scale of Interpretation <sup>6</sup>			
1984	Forest Resources and Strategy Planning Study. Vol.1: The Forest Resources of Brunei Darussalam. Vol.2: Strategic Planning for the Forests and Forest Resources	authors: Anderson and Marsden (Forestry Consultants) Ltd.	1981-84			National – includes forest type maps and strategic planning maps at 1:50,000 scale	Produced Forest type maps (1:50,000 and 1:200,000)	NF, PL, OWL, FAC, TV, CV, PA, BD, WSP
1994	JICA - Development Survey of the Forest Resources in Brunei	Japan International Cooperation Agency (JICA)	1992-94		512 aerial photos taken at 1:25,000 covering 350,000 ha.	Partial	50,000 ha in the Inter-Riverine Zone between Tutong and Belait Rivers; 10,000 ha. in Temburong District within the Ulu Temburong National Park	NF, PL, OWL, FAC, TV, CV, PA, BD, WSP
1996	An Introduction to Forestry in Brunei Darussalam.	DOF Ministry of Industry and Primary Resources				National	.	Overview of forestry Sector only. Provides good descriptions of National classes based on Anderson & Marsden, 1984.

**\*\*Legend:** NF=Natural Forest; PL=Plantations; OWL=Other Wooded land; FAC=Forest Area Change; TV=Total Volume; TB=Total Biomass; CV=Commercial Value; PA=Protected Areas; BD=Biodiversity; FO=Forest Ownership; WSP=Wood Supply Potential; NWGS=Non-wood Goods and services; TOF=Trees outside of forest; FF=Forest Fires

**Legend:**

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<b>[1] Publication Year</b>	Year in which the assessment was published
<b>[2] Title</b>	Title of the assessment
<b>[3] Institution</b>	Institution(s) responsible for the Assessment
<b>[4] Ground Inventory Year(s)</b>	Year or Interval of years during which the field inventory has been carried out
<b>[5] Remote Sensing Data Year(s)</b>	Year(s) of the Remote Sensing Images
<b>[6] Remote Sensing Scale of Interpretation</b>	Scale of Remote Sensing Images (e.g. 1:250,000)
<b>[7] Estimation Level</b>	Whether the Assessment was at National, Sub-national, District, Management Unit, etc. level
<b>[8] Country Coverage (Full / Partial, %)</b>	Amount of country area covered by the assessment (e.g. full, partial). If partial, indicated by % of total area.

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## Current National Forest Inventory Design

The structure of the mixed Dipterocarp forest creates sampling problems because there are relatively few trees of commercial size per hectare. Therefore the sampling unit must cover a relatively large area in order to obtain sufficient data on the more valuable trees. Due to such variation and challenging land conditions, the last inventory followed a cluster sampling design.

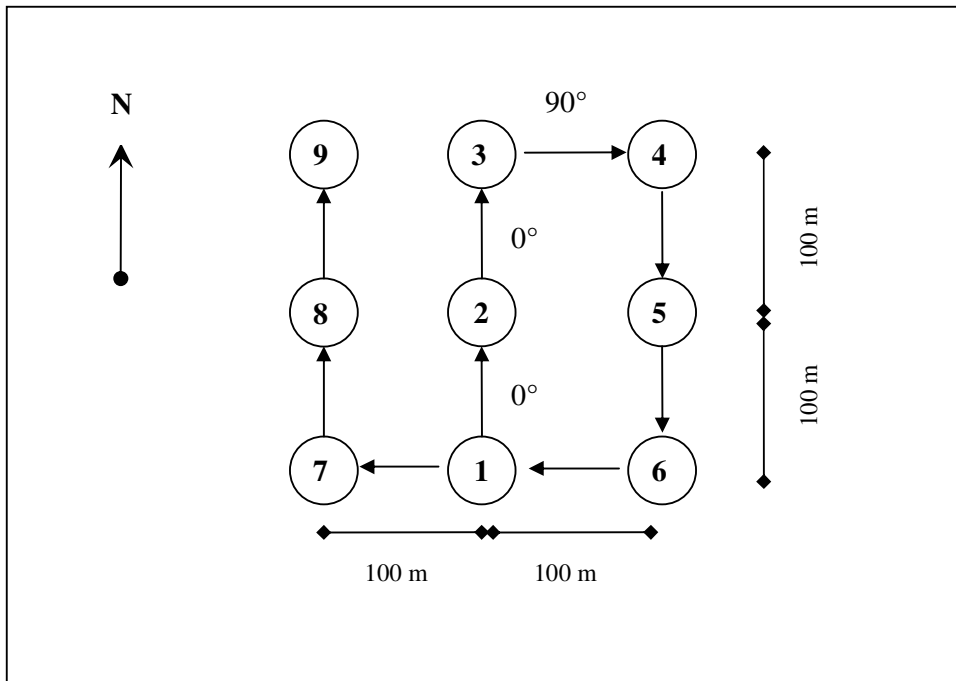
### Remote Sensing

The Forestry Department of Brunei Darussalam has conducted two studies on the national forest resources as mentioned in the previous sections (Anderson 1984, JICA 1994). As a result of the studies the following maps were produced: Forest type map 1 and map 2 (1:50,000 and 1:200,000); soil map and vegetation map (1:20,000). During Anderson's assessment in 1984, colour aerial photographs at a scale of 1:25,000 flown in 1975/76 were available for the greater part of the country. Black and white aerial photography was also done in 1981 for a substantial area south of Sukang in the headwaters of Belait and Tutong rivers. Additionally, black and white aerial photography covering the whole of Temburong District and coastal areas was done in 1981/82 but it was of average quality. The grid intersections on the maps were used to determine the overall surface area of the country with each intersection representing 100 ha.

### Field Survey

The field work consisted of (a) reconnaissance survey to a predetermined level of precision for strategic planning in three defined forest areas with possible commercial potential, (b) obtaining indicative information on the forest area and residual stand of commercial timber in the inter-riverine zone for mixed Dipterocarp forest and old secondary forest (with sample plots representing a sampling intensity of 0.1 percent) and for peat swamp forest (strip survey representing 0.54 percent sampling intensity) and (c) investigations of the various remaining forest areas to obtain volumetric data and to check the aerial photo interpretation.

The field inventory design consists of a cluster of nine plots positioned as shown in figure 2 below. The sample positions are laid on the aerial photograph. The central plot is marked as Plot 2. The Plot 3 is always positioned north (magnetic bearing) of plot 2. All plots are established 100 meters apart to reduce the chance of double measurement of large trees growing between two plots.



**Figure 2.** Layout of Inventory Field Sample

## Measurements

Following measurements are taken in each sample plot,

- Slope: the maximum slope at the plot center recoded in degrees
- Aspect: recorded by second order compass reading, eg. NW, SE etc.;
- Position: the position of the plot within a micro-terrain framework, eg. upper slope, mid slope, valley bottom, etc.;
- Forest: description of the forest type;
- Ground: ground conditions such as rocky, swamp, clay etc.

Trees are sampled with a probability proportional to their basal area through a basal area factor prism BAF2. Trees are numbered clockwise starting with the nearest talliable to the plot centre. The diameter at breast height (1.3 meter) is recorded at with a diameter tape. All trees with minimum diameter at breast height (Dbh) of 50 cm in case of Dipterocarp forest, 40 cm in case of all peat swamp forest species (except *S. albida*) and 30 cm in case of *S. albida* are measured.

Buttress type is observed and classified according to four classes based on buttress height, shape and stilt roots, if any. All Dipterocarp species which meet the minimum commercial tree specifications are drilled to assess the decay, if any and are classified accordingly. Tree merchantable height is measured with a clinometer up to the point with minimum top diameter of 30 cm. Species identification focuses on a list of obligatory (priority) species and the collection of leaf samples or bark fragments is recommended.

# Current Content and Methodology of data collection

Note: [N=National; SN=Sub-National; MU=Management Unit]

## Geo-physical

	N	SN	MU	Methodology
Geo-Coordinates	X			Map
Altitude	X			Map
Topography	X			Field Survey
Orientation (or Aspect)	X			Field Survey
Slope	X			Field Survey
Soil	X			Field Survey
Geological structure	X			Field Survey
Rainfall				

## Bio-Physical

	N	SN	MU	Methodology
Number of trees	X			Field Survey
Diameter of trees	X			Field Survey
Height of trees	X			Field Survey
Length of stem				
Stump height				
Age class	X			<i>Info not available</i>
Twigs				
Bark				
Leaves				

## Forest extent

	N	SN	MU	Methodology
Forest land area	X			Survey, Map
Area of forest canopy/crown cover				
Area under forest management	X			Survey, Record
Area under formal forest management plan	X			Survey, Record
Area under sustainable forest management	X			Survey, Record
Forest area with certification				
Area under public owned forest				
Area under private owned forest				

## Forest characteristics (Naturalness) and forest type

	N	SN	MU	Methodology
Primary forest	X			Survey, Record, Map
Modified natural forest	X			Survey, Record, Map
Semi-natural forest	X			Survey, Record, Map
Productive plantation	X			Survey, Record, Map
Protective plantation	X			Survey, Record, Map

<b>Coniferous</b>				
<b>Broadleaved</b>	X			Survey, Record, Map
<b>Mixed forest</b>	X			Survey, Record, Map
<b>Forest area by dominant species (bamboo, mangroves, rubber)</b>	X			Survey, Record, Map
<b>Forest area by ecological zone (tropical, subtropical, temperate, boreal, polar)</b>	X			Survey, Record, Map

### Use (designated functions) of forests

	N	SN	MU	Methodology
<b>Area of forest under production</b>				
<b>Area of forest for protection of soil and water</b>				
<b>Area of forest for conservation of biodiversity</b>				
<b>Area of forest for social services</b>				
<b>Area of forest for multiple purpose</b>				
<b>Forest area available for wood supply</b>				
<b>Forest area within protected areas</b>	X			Survey, Reports

### Social Services

	N	SN	MU	Methodology
<b>Area of forest managed for recreation</b>	X			Survey, Record, Maps
<b>Area of forest managed for tourism</b>				
<b>Area of forest used for education</b>				
<b>Area of forest managed for conservation of cultural/spiritual site</b>				

### Mapping of forest distribution

	N	SN	MU	Methodology
<b>Distribution of forests</b>	X			Remote Sensing Survey, Map, Reports
<b>Forest Characteristics</b>	X			Remote Sensing Survey, Map, Reports
<b>Land use</b>	X			Remote Sensing Survey, Map, Reports
<b>Administrative/political/legal boundaries</b>	X			Remote Sensing Survey, Map, Reports
<b>Designated functions of forests</b>	X			Remote Sensing Survey, Map, Reports
<b>Other wooded land</b>	X			Remote Sensing Survey, Map, Reports
<b>Other land with tree cover</b>	X			Remote Sensing Survey, Map, Reports
<b>Other land</b>				

### Status of the forest and disturbances affecting forest health and vitality

	N	SN	MU	Methodology
<b>Disturbance by insects</b>				
<b>Disturbance by diseases</b>				



<b>Disturbance by other biotic agents</b>				
<b>Disturbance by fire</b>				
<b>Disturbance caused by other abiotic factors</b>				

## Biodiversity

	<b>N</b>	<b>SN</b>	<b>MU</b>	<b>Methodology</b>
<b>Tree species</b>	X			Field Survey
<b>Shrub species</b>				
<b>Herbs species</b>				
<b>Endangered species</b>				
<b>Critically endangered species</b>				
<b>Vulnerable species</b>				
<b>Native species</b>				
<b>Endemic species</b>				
<b>Introduced species</b>				

## Beneficiaries of forest goods and services

	<b>N</b>	<b>SN</b>	<b>MU</b>	<b>Methodology</b>
<b>By locality of user (e.g. indigenous/local/national)?</b>	X			Records
<b>By good/service (e.g. timber, fuelwood, NWFP, bamboo/rattan, water, etc) used by them</b>	X			Records, Expert Knowledge
<b>By economic class of the beneficiaries (high, medium, low income)</b>	X			Records, Expert Knowledge
<b>By level of dependency on forest (as percentage of total employment)</b>	X			Records
<b>By physical accessibility to the forest (distance from forest)</b>	X			Records, Expert Knowledge

## Economic value

	<b>N</b>	<b>SN</b>	<b>MU</b>	<b>Methodology</b>
<b>Removal of timber</b>	X			Economic Survey, Expert estimation
<b>Removal of fuelwood</b>				
<b>Removal of other wood products</b>				
<b>Removal of wood products derived from forest under sustainable management</b>				
<b>Removal of wood products derived from forest plantations</b>				
<b>Removal of non wood forest products</b>				
<b>Annual allowable cuts/yields</b>	X			Economic Survey, Expert estimation
<b>Social services</b>	X			No info available
<b>Environmental services</b>	X			No info available
<b>Employment</b>				
<b>Support to livelihood of communities</b>				
<b>Market price/cost of wood in forest</b>	X			No info available
<b>Market price/cost of non wood forest</b>				

<b>products</b>				
<b>Estimate of value of social services</b>				
<b>Estimate of value of environmental services</b>				
<b>Estimate of value of employment</b>				
<b>Estimate of the contribution of forest sector to national economy</b>	X			No info available

## Policy, legal and institutions (PLI) framework

	<b>N</b>	<b>SN</b>	<b>MU</b>	<b>Methodology</b>
<b>Forest policy</b>	X			Reports
<b>Forest legislation</b>	X			Reports
<b>Forest administration</b>	X			Reports
<b>Forest education and research</b>				
<b>Annual outlay, expenditure, investment in forestry sector</b>				

## **Bibliographies and References for further reading**

**Anderson and Marsden.** 1984. The Forest Resources of Brunei Darussalam. Brunei Forest Resources and Strategy Planning Study. Vol.1 and 2.

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<http://www.fao.org/forestry/site/32245/en/>