Proceedings of the meeting on identification of biophysical variable identification for the National Forest Inventory

Bangladesh Forest Department
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The Forest Department of Bangladesh leads actions to improve forest management and conservation, adopting forward thinking, innovative approaches in its management of approximately 1.55 million hectares of land across the country.

In 2015, the Forest Department began a process to establish a National Forest Inventory and Satellite Land Monitoring System for improved forest and natural resource management. The process addresses domestic information needs and supports national policy processes related to forests and the multitude of interconnected human and environmental systems that forests support. The process also supports climate change mitigation and implementation of REDD+.

The Bangladesh Forest inventory, led by the Forest Department, is a constant and comprehensive process that assesses, evaluates, interprets and reports on the status of trees and forest resources nationally. The activities implemented under the Bangladesh Forest Inventory process are implemented in collaboration between several national and international institutions and stakeholders. National partners from multiple government departments and agencies assist in providing a nationally coordinated approach to land management. International partners, including the United Stated Agency for International Development (USAID), the Food and Agriculture Organization of the United Nations (FAO) and SilvaCarbon are supporting the development of technical and financial resources that will assist in institutionalizing the process.

The results will allow the Forest Department to provide regular, updated information about the status of trees and forests for a multitude of purposes including for assessment of role of trees for firewood, medicines, timber, and climate change mitigation.

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Executive Summary

The Meeting on Identification of Biophysical Variable for the National Forest Monitoring and Assessment was held on the 17th of February 2016 under "Strengthening National Forest Inventory and Satellite Land Monitoring System in Bangladesh" was held at Korobi Conference Hall, Ban Bhaban, Agargaon, Dhaka, Bangladesh. The national meeting was organized in two sessions (1) inaugural and (2) technical session.

The 43 participants were from several national institutions including the Forest Department, Bangladesh bureau of Statistics (BBS), Bangladesh Space Research and Remote Sensing Organization (SPARRSO), Bangladesh Forest Research Institute (BFRI), (Appendix II).

The objectives of the meeting were to (1) engage national stakeholders in the Bangladesh Forest Inventory development process; (2) identify the potential national variables for the national forest inventory; (3) identify the national objectives and (4) priorities the biophysical variables and define them.

The inaugural session was followed by group discussion animated around six major variables: (1) Value of Forests (ecosystem services), (2) Forest Productivity, (3) Biological Diversity, (4) Ecosystem Restoration, (5) Forest Governance, and (6) Carbon Sequestration.

All participants were able to express themselves into small groups and then each group representative presented the results of the discussion to the board audience.

The major output of the consultative meeting was refining of variables to be integrated to meet national objectives, and finalize refining of variables to be integrated to meet national objectives and support the preparation of the field manual for the biophysical variables.

Contents

1. Introduction

The Bangladesh Forest Inventory (BFI) aims at assessing and monitoring tree and forest resources and values at regular interval, nationally and to ensure that the information meet local, district, national and international needs. The assessment of the status of tree and forest status is being done by measuring various variables that can be classified as biophysical and socio-economic, field and remote sensed. The combination of the various types of data provides information about the status of the relation between human activities, natural events and ecological processes.

Hundreds of biophysical variables can be measured in the field. However, there importance differs depending on human interests in measuring them. In addition, the cost and the time to measure them vary. Different types of equipment can be used and their use depends on the biophysical contexts, the human, financial and technical capacities and the conditions for the sustainability of the system to assess the resources.

The NFI aims to be sustainable and adopted by national stakeholders. A stakeholder engagement process facilitates the decision making, ensuring the feasibility, adoption, adaptation and sustainability of the BFI. While hundreds of biophysical variables can be measured, it is important to identify the ones to be measured in priority in order to ensure that the BFI will meet national objectives and contributes to national policies and measures.

In order to identify the biophysical variables and priorities them, a national consultation was organized, involving the different national stakeholders involved in forestry and forestry related aspects in order to identify and priorities the biophysical variables to be considered by the BFI.

Since the societal demands evolve over time, a particular attention was given to the future needs of the Bangladesh society and to ensure that the same method for the BFI can be used in the future and allow assessment of changes and continuity and sustainability of the process. It is important to mention that the first National Forest Inventory was implemented in 2005-2007 and the second NFI is considered as an improved version and built on the experience of the previous inventory.

2. Objectives of the national consultation

A tentative list of biophysical variables have been prepared through several consultative meetings. The general objective of the national meeting was to:
- Engage national stakeholders in the Bangladesh Forest Inventory development process;
- Identify the potential national variables for the national forest inventory;
- Identify the national objectives;
- Priorities the biophysical variables and define them.

The national meeting builds on the National Forest Inventory Information Needs Workshop held in March 2015 in Dhaka.

3. Summary of the meeting

Welcome remarks were made by Md. Mozaharul Islam Conservator of Forests and National Focal Point UN-REDD. During the welcome address Mr. Md Mozaharul Islam emphasized the importance of the biophysical variables to meet the need and objective of forest inventory. The objectives of the Bangladesh Forest Inventory were presented by Matieu Henry, Chief Technical Adviser (CTA). He presented the context of the of forest resource assessment and the need to identify and prioritize the bio-physical variables to improve forestry related information to better guide decision making and planning in forestry sector. Mr. Md. Yunus Ali, Chief Conservator of Forests, Forest Department, Bangladesh highlighted the importance of forest inventory, and identification and prioritization of biophysical variables. He urged the participants to provide well thought contribution to the identification and prioritization of biophysical variables.

The technical session of the meeting started with presentation of matrix developed earlier through consecutive consultations. Later four groups were formed to discuss, identify and prioritize the bio-physical variables which were concluded by group presentation and open discussion. Latest version of the field manual for the biophysical variables was presented by Matieu Henry, Chief Technical Adviser (CTA) and followed by group discussion and group presentation (Appendix III).

4. Group Discussions

4.1. For what purposes do you need land cover/use maps?

There is a large consensus that land over and use maps are crucial for land resource assessment, planning, management, and for decision making. In addition, such maps can be used to spatialise various important land cover related parameters such as the floristic composition, tree species distribution, wildlife, carbon stocks, and fishery. The integration of fine series data, combined with land cover/use maps, provide a huge potential of information about the status of the resources and changes of resources over time. In consequence, maps are important to manage forest and the forest related aspects for a multitude of needs including forestry and non-forestry needs. They provide information about the status of the resources, its quality and extent for the past, the present and the future, allowing the assessment of the changes, depending on their quality and consistency. Land cover maps with additional predictive information about key parameters such as climate can be used for modeling and predicting changes of the resources in the future. The data about the past, present and expected future land cover/use are used for national and international purposes, to better manage natural resources at local and international levels.

4.2. What is the benefit of using a single map for multiple purposes and agencies?

There is a general consensus that a single map to represent the various land cover/use units within the country will significantly decrease confusion related to the status of natural resources, contribute to improve the robustness, consistency, accuracy and reliability of the information captured by spatial land monitoring institutions and ensure that the land cover products can be used by everyone. By providing a single product for various purposes, confusion about the status of natural resources will be decreased; decision makers will be better informed and oriented for improved natural resource management.

In addition, the development of a single land cover/use map will contribute to improve collaboration and coordination, improve cost- efficiency and to minimize conflicts between national institutions and conflicts related to land tenure.

Land is very much fragmented and it is the development of a single map would be a good contribution to minimize discrepancies between the maps developed by different institutions. For doing this, a national classification system needs to be developed and institutions to agree on the sustainability of the land cover monitoring system. Such a classification system should be able to provide information about forest, agriculture, crop suitability, infrastructure, water bodies, fisheries and other purposes.

However, before being able to develop a single map for the different institutions and land management objectives, several aspects need to be well considered such as the issues related to definitions, national and sub-national boundaries, project systems, infrastructures and mandates for the development of the land cover maps. In order to ensure the sustainability and improvement of the system, the documentation and archiving of all the elements used for the development of the system are fundamental.

4.3. Which data should be shared and under which format?

All participants agreed that the term "data" includes biophysical and socio-economic information. While all participants agreed on the need to share data for better resource management and improved collaboration between the different sectors and institutions, the type of data to be shared differ between the groups and participants. While most of the participants agreed that maps, shapefiles, and any processed data are results and should be shared, sharing shapefiles is not agreed between the participants. Most participants agreed that sharing raw data should be done carefully and with restricted access. Some participants mentioned that raw data can be shared but without the geographic coordinates. All participants agreed on sharing documents and reports but there is no interface at current status. For digital information, most of the participants mentioned that sharing the digital data through a webportal would be useful. In addition, sharing high resolution images between institutions will significantly reduce the cost related to land cover/map development. It will contribute to increase the resources related to the accuracy and the validity of the geospatial products and provide better information for decision makers. Sharing data will improve the collaboration between the various institutions towards the implementation of a national system based on national standards.

4.4. Which is the current national framework to support data sharing between national public institutions?

There is a general consensus that there is no existing national framework for data sharing and a centralized information system would be very helpful. The RTI act targets rights to information and can be a good basis to develop a national framework for data sharing.

Several names of institutions were mentioned such as BBS, NSDI platform, survey of Bangladesh. While BBS has the mandate to archive and make available statistics information for Bangladesh, they do not have a repository or a web-platform for geo-informatics information. On the other hand, survey of Bangladesh is the national entity with the mandate to provide geographic information of Bangladesh.

4.5. How are the most important results to come from forest monitoring?

The participants mentioned the following important results

- Forest cover change and in particular monitoring of forest degradation and deforestation;
- Assessment of forestry services such as medicinal plants/ nutrition/ food security/ firewood;
- Soil degradation and soil fertility;
- Estimation of forest carbon stocks;
- The potential economic value of Ecosystem services;
- Socio-economic information and forest dependent people;

- Land use change;
- Growing stocks and productivity;
- Impacts of policies and measures on forestry resources;
- Preparation of scenarios for decision making;
- Biodiversity;
- Wildife;
- Measure, Report and Verify forest carbon stock and stock changes for national and international reporting;
- Tourism.

4.6. How might forest-related data be of benefit to other sectors (e.g., agriculture, health, nutrition, energy, water)

All participants recognized the role of forestry to contribute to various sectors. In Bangladesh, almost all citizens and sectors depend on the status of forest resources in the short and long term. People are dependent on the status of ecosystems and particularly on the status of tree and forest resources. Variables such as the following ones mentioned in the paragraph above contribute to guide policies and measures in a multitude of sectors.

In consequence, the national forest monitoring system does not aim at supporting only forestry activities but to contribute to natural resource management and the national economic system too. Furthermore, the consistency between the forest monitoring system with the land cover monitoring will contribute to improve the management of natural resources. In particular, participants pointed that forest related data will be beneficial to watershed management, soil degradation, human health and nutrition, adaptation to climate change, tourism, research.

In addition to the information mentioned above, the participants added some information not directly related to the six proposed questions.

The first point raised was related to the necessity to strengthen the capacities of the forest department for monitoring and assessing trees and forest. This concerns human capacities but also hardware, software etc.

The second point was related to the sustainability of such a system and the need to assess the resources every 5 or 10 years.

The third point was related to the need to use new technologies and that the launch of the first satellite of Bangladesh will contribute to the sustainability of the national system.

The fourth point was related to the fact that stakeholders need to be engaged as much as possible into this process to ensure a participatory process and national ownership. People should be taken on boat to develop this forest monitoring system. Co-management and social forestry are crucial to improve the social responsibility and awareness towards better management of trees and forest and towards the recognition of local actors into national decision making policies and measures.

The fifth point was related to the need for forest and land cover monitoring to have a clear picture of the current status and to take lessons from past and current programmes and projects.

The last point was related to the role of land cover monitoring in this project, about mandates of the different institutions and the use of different tools for monitoring for different purposes. It was explained that this project aims at ensuring that the forest related information are being integrated within the land cover map information and that

national institutions collaborate together for the development of a national land cover map. The aim is to ensure that one product can provide the necessary information to different national stakeholders, for their different needs. Data sharing between national institutions and collaboration will allow the development of one national system and the development of the maps can be updated depending on available resources.

5. Conclusion

While it was not possible to finalize the list of variables to be considered by the BFI, the meeting helped better understanding the objectives of the BFI and to better understand how the field inventory variable measurement is link to national objectives. The list of identified variables is being improved taking into account the progress of the Forest Master Plan. Indeed, the national forest Policy and the forest master plan are under revision and it is important for the BFI to be considered and for the BFI to ensure the appropriate information is collected to guide their implementation. The Bangladesh Forest Inventory is the main tool for the Bangladesh Forest Department to evaluate the progress of the implementation of the national forest policies and the Forest master Plan.

APPENDIX 1: Agenda

Date	Topic	Speaker/facilitator
	Session 1: Inaugural	
9:00-9:30	Inaugural session	
	Welcome address	Mr. Md. Mozaharul Islam, Conservator of Forests
	Introduction to Bangladesh Forest Inventory (BFI)	Matieu Henry, Chief Technical Adviser
	National Policies and Measures related to the BFI	Mr. Md. Yunus Ali Chief Conservator of Forests
	Group Formation	Ms Mariam Akhter Forestry Officer
9:30-9:45	Tea Break	
	Session 2: Technical Session	
9:45-10:00	Presentation of the latest version of the field manual for the biophysical variables	Matieu Henry Chief Technical Adviser

10:00-11-45	Group discussion:
	   Objectives of the BFI
	   Refining of variables to be integrated to meet national objectives
		Laskar Muqsudur Rahman Senior Forestry Officer NFI Institutionalisation

11-45-12:30	Group presentation	Matieu Henry, Chief Technical Adviser
12:30:1:30	Open discussion and closing	Laskar Muqsudur Rahman Senior Forestry Officer NFI Institutionalisation
1:30-2:00	Closing Remarks & Lunch	

APPENDIX 2: list of participants

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APPENDIX 3: List of variables for the group discussion

Social forestry - value to livelihoods, including non-carbon benefits

	Key Question: Social forestry - value to livelihoods, including non-carbon benefits			
	Broad Objective: Value of Forests (ecosystem services)			
	Generic Question	**Metric No.**	**Metric**	**Field Variable**
8	What is the composition, abundance and diversity of understory vegetation by forest type? Is the native understory richness declining over time?	1	Area of forest and other land use/cover (ha)	
		14	Number of live seedlings/saplings (trees)	
		56	Species Abundance (stems)	
		57	Species Diversity Index (index)	
		58	Species Evenness (index)	
		59	Species Frequency (%)	
	Indicator	60	Species Richness (# species)	
	Understory native plant richness	50	Road/Trail Cover (%)	
		52	Water Cover (%)	
		54	Live Shrub Cover (%)	
18	What species and size classes have the highest harvest rates? What is the distribution of forest land by harvest intensity? Where are the most valuable forests for commercial use and local use located?	1	Area of forest and other land use/cover (ha)	
		6	Stand Age (years)	
		12	Area with Timber extraction (ha)	
		13	Area by Silviculture actions (ha)	
		17	Gross volume of live trees (m^3)	
	Indicator	18	Gross sawtimber volume of live trees (Commercial volume) (m^3)	
	Tree harvest	28	Removals (harvested trees) (m^3/year)	
		29	Removals of sawtimber trees (m^3/year)	
		30	Removals - biomass ()	
20	What type of Non-Woody Forest Products (NWFPs) are harvested? What are the most important NWFPs to local communities? Has there been a decrease/increase in availability of these NWFPs?	61	Tree product/service use ()	
	Indicator	62	Tree product/service ranking ()	
	Forest & tree products use	65	Availability of forest product/service ()	
21	What food products are forests providing to local populations? What percentage of households depend on forests as food for consumption? What percentage of households depend on forests for their energy source?	61	Tree product/service use ()	

	What percentage of households depend on forests for income?			
	Indicator	62	Tree product/service ranking ()	
	Forest & tree product use	65	Availability of forest product/service ()	
		67	Awareness of legislation ()	
22	What forest products and related species experience the greatest demand? Which experience conflicts?	61	Tree product/service use ()	
	Indicator	62	Tree product/service ranking ()	
	Ecosystem services and traditional social uses of the forest	63	Conflicts over tree product/service ()	
		65	Availability of forest product/service ()	
		64	User rights of tree product ()	
		68	Compliance with legislation ()	
23	What, if any, non-market values of the forest are considered in government policies and decision making?	61	Tree product/service use ()	
	Indicator	62	Tree product/service ranking ()	
	Ecosystem services and traditional social uses of the forest	64	User rights of tree product ()	
24	What is the value of non-market forest functions (e.g. protection of property, water, outdoor recreation, traditional cultural values, etc)	10	Area by Designation/Protection status (ha)	
	Indicator	48	Mineral Soil Cover (%)	
	Value of non-market functions of the forest	52	Water Cover (%)	
		61	Tree product/service use ()	
		62	Tree product/service ranking ()	
		63	Conflicts over tree product/service ()	
		64	User rights of tree product ()	
		65	Availability of forest product/service ()	
26	What is the current and net change in carbon by pool? How are the changes related to human activity?	30	Removals - biomass ()	
	Indicator	34	Aboveground carbon of all live trees (tons)	
	Carbon balance	35	Belowground carbon of all live trees (tons)	
		39	Carbon in standing dead trees (tons)	
		40	Carbon in down dead wood (tons)	
		46	Coarse Woody Debris (tons)	
		41	Soil organic carbon (tons)	
		42	Carbon in litter (tons)	

Timber production

Key Question: Timber production			
Broad Objective: Forest Productivity			
Generic Question	**Metric No.**	**Metric**	**Field Variable**
1 What is the distribution of tree species across the forested landscape? What tree species are increasing or decreasing in ecological importance?	1	Area of forest and other land use/cover (ha)	
Indicator	15	Number of live trees (trees)	
Tree abundance	17	Gross volume of live trees (m^3)	
	56	Species Abundance (stems)	
	57	Species Diversity Index (index)	
	58	Species Evenness (index)	
	59	Species Frequency (%)	
	60	Species Richness (# species)	
	14	Number of live seedlings/saplings (trees)	
	24	Net change of live gross volume (m^3/year)	
	32	Aboveground biomass of live trees and saplings (oven-dry tons)	
	55	Species Canopy Cover Total (%)	
2 What are growth and mortality rates overall and for individual species and how are these rates changing?	15	Number of live trees (trees)	
Indicator	17	Gross volume of live trees (m^3)	
Tree growth and mortality rates	20	Mortality (trees/year)	
	25	Growth of live gross volume (m^3/year)	
	23	Mortality - biomass ()	
5 Are forests replacing themselves? What factors are impacting regeneration?	1	Area of forest and other land use/cover (ha)	
Indicator	6	Stand Age (years)	
Tree regeneration	8	Area of management actions (ha)	
	9	Area burned (ha)	
	10	Area by Designation/Protection status (ha)	
	11	Area by Ownership (ha)	
	12	Area with Timber extraction (ha)	
	13	Area by Silviculture actions (ha)	
	14	Number of live seedlings/saplings (trees)	

6	What is the number and area of management activities? How are forests managed? What is the human impact to forests? Are they progressing towards achieving desired conditions?	7	Number of management actions ()	
	Indicator	8	Area of management actions (ha)	
	Management activities	12	Area with Timber extraction (ha)	
		13	Area by Silviculture actions (ha)	
		63	Conflicts over tree product/service ()	
7	Are we gaining or losing forest land? What is the distribution of forest cover types across the landscape? What is the status of rare cover types?	1	Area of forest and other land use/cover (ha)	
	Indicator	8	Area of management actions (ha)	
	Land cover	10	Area by Designation/Protection status (ha)	
		6	Stand Age (years)	
		9	Area burned (ha)	
		11	Area by Ownership (ha)	
		12	Area with Timber extraction (ha)	
9	What is the distribution of structural or age classes and how is this changing? How does it compare to that expected under natural disturbance regimes? What percentage is classified as late-successional or old-growth?	1	Area of forest and other land use/cover (ha)	
	Indicator	6	Stand Age (years)	
	Stand structure	5	Area inaccessible (ha)	
		13	Area by Silviculture actions (ha)	
		55	Species Canopy Cover Total (%)	
18	What species and size classes have the highest harvest rates? What is the distribution of forest land by harvest intensity? Where are the most valuable forests for commercial use and local use located?	1	Area of forest and other land use/cover (ha)	
	Indicator	6	Stand Age (years)	
	Tree harvest	12	Area with Timber extraction (ha)	
		13	Area by Silviculture actions (ha)	
		17	Gross volume of live trees (m^3)	
		18	Gross sawtimber volume of live trees (Commercial volume) (m^3)	
		28	Removals (harvested trees) (m^3/year)	
		29	Removals of sawtimber trees (m^3/year)	
		30	Removals - biomass ()	
19	What is the distribution of biomass across the forested landscape? Is total biomass increasing or decreasing? Does total net growth exceed	1	Area of forest and other land use/cover (ha)	

	removals?				
	Indicator	23	Mortality - biomass ()		
	Biomass/ Production	27	Growth - biomass ()		
		30	Removals - biomass ()		
		32	Aboveground biomass of live trees and saplings (oven-dry tons)		
		33	Biomass of standing dead trees (oven-dry tons)		

Plant Diversity

	Key Question: Plant Diversity				
	Broad Objective: Biological Diversity				
	Generic Question	**Metric No.**	**Metric**		**Field Variable**
1	What is the distribution of tree species across the forested landscape? What tree species are increasing or decreasing in ecological importance?	1	Area of forest and other land use/cover (ha)		
	Indicator	15	Number of live trees (trees)		
	Tree abundance	17	Gross volume of live trees (m^3)		
		56	Species Abundance (stems)		
		57	Species Diversity Index (index)		
		58	Species Evenness (index)		
		59	Species Frequency (%)		
		60	Species Richness (# species)		
		14	Number of live seedlings/saplings (trees)		
		24	Net change of live gross volume (m^3/year)		
		32	Aboveground biomass of live trees and saplings (oven-dry tons)		
		55	Species Canopy Cover Total (%)		
5	Are forests replacing themselves? What factors are impacting regeneration?	1	Area of forest and other land use/cover (ha)		
	Indicator	6	Stand Age (years)		
	Tree regeneration	8	Area of management actions (ha)		
		9	Area burned (ha)		
		10	Area by Designation/Protection status (ha)		
		11	Area by Ownership (ha)		
		12	Area with Timber extraction (ha)		
		13	Area by Silviculture actions (ha)		

		14	Number of live seedlings/saplings (trees)	
13	What is the composition, abundance and diversity of understory vegetation by forest type? Is the native understory richness declining over time?	1	Area of forest and other land use/cover (ha)	
	Indicator	14	Number of live seedlings/saplings (trees)	
	Understory native plant richness	56	Species Abundance (stems)	
		57	Species Diversity Index (index)	
		58	Species Evenness (index)	
		59	Species Frequency (%)	
		60	Species Richness (# species)	
		50	Road/Trail Cover (%)	
		52	Water Cover (%)	
		54	Live Shrub Cover (%)	
14	What exotic or invasive species are present? Are exotic or invasive plant species increasing in abundance?	56	Species Abundance (stems)	
	Indicator	58	Species Evenness (index)	
	Exotic or invasive plants	59	Species Frequency (%)	
		60	Species Richness (# species)	
		57	Species Diversity Index (index)	
15	What site descriptors are key ecosystem drivers, such as slope, aspect, elevation, ecological system, etc.? Note: these are often used as By variables for other questions.	1	Area of forest and other land use/cover (ha)	
		4	Percent Slope (%)	
	Site context	48	Mineral Soil Cover (%)	
		51	Rock Cover (%)	
		52	Water Cover (%)	
		53	Live Herbaceous Cover (%)	
		50	Road/Trail Cover (%)	
		60	Species Richness (# species)	
28	What are the effects of human use and developments?	1	Area of forest and other land use/cover (ha)	
	Indicator	8	Area of management actions (ha)	
	Human/development impact	12	Area with Timber extraction (ha)	
		13	Area by Silviculture actions (ha)	
		17	Gross volume of live trees (m^3)	
		24	Net change of live gross volume (m^3/year)	
		28	Removals (harvested trees) (m^3/year)	
		61	Tree product/service use ()	
		63	Conflicts over tree product/service ()	

		65	Availability of forest product/service ()	
		30	Removals - biomass ()	
		64	User rights of tree product ()	

Plant Diversity

	Key Question: Expanding forest cover (degradation, reforestation, afforestation)			
	Broad Objective: Ecosystem Restoration			
	Generic Question	**Metric No.**	**Metric**	**Field Variable**
1	What is the distribution of tree species across the forested landscape? What tree species are increasing or decreasing in ecological importance?	1	Area of forest and other land use/cover (ha)	
	Indicator	15	Number of live trees (trees)	
	Tree abundance	17	Gross volume of live trees (m^3)	
		56	Species Abundance (stems)	
		57	Species Diversity Index (index)	
		58	Species Evenness (index)	
		59	Species Frequency (%)	
		60	Species Richness (# species)	
		14	Number of live seedlings/saplings (trees)	
		24	Net change of live gross volume (m^3/year)	
		32	Aboveground biomass of live trees and saplings (oven-dry tons)	
		55	Species Canopy Cover Total (%)	
5	Are forests replacing themselves? What factors are impacting regeneration?	1	Area of forest and other land use/cover (ha)	
	Indicator	6	Stand Age (years)	
	Tree regeneration	8	Area of management actions (ha)	
		9	Area burned (ha)	
		10	Area by Designation/Protection status (ha)	
		11	Area by Ownership (ha)	
		12	Area with Timber extraction (ha)	
		13	Area by Silviculture actions (ha)	
		14	Number of live seedlings/saplings (trees)	
6	What is the number and area of management activities? How are forests managed? What is the human impact to forests? Are they progressing	7	Number of management actions ()	

	towards achieving desired conditions?			
	Indicator	8	Area of management actions (ha)	
		12	Area with Timber extraction (ha)	
	Management activities	13	Area by Silviculture actions (ha)	
		63	Conflicts over tree product/service ()	
7	Are we gaining or losing forest land? What is the distribution of forest cover types across the landscape? What is the status of rare cover types?	1	Area of forest and other land use/cover (ha)	
	Indicator	8	Area of management actions (ha)	
	Land cover	10	Area by Designation/Protection status (ha)	
		6	Stand Age (years)	
		9	Area burned (ha)	
		11	Area by Ownership (ha)	
		12	Area with Timber extraction (ha)	
8	What is the extent (area) of land by land use? How has it changed over time? What is the proportion of surrounding area in natural cover and in anthropogenic landuse?	1	Area of forest and other land use/cover (ha)	
	Land use	11	Area by Ownership (ha)	
13	What is the composition, abundance and diversity of understory vegetation by forest type? Is the native understory richness declining over time?	1	Area of forest and other land use/cover (ha)	
	Indicator	14	Number of live seedlings/saplings (trees)	
	Understory native plant richness	56	Species Abundance (stems)	
		57	Species Diversity Index (index)	
		58	Species Evenness (index)	
		59	Species Frequency (%)	
		60	Species Richness (# species)	
		50	Road/Trail Cover (%)	
		52	Water Cover (%)	
		54	Live Shrub Cover (%)	
14	What exotic or invasive species are present? Are exotic or invasive plant species increasing in abundance?	56	Species Abundance (stems)	
	Indicator	58	Species Evenness (index)	
	Exotic or invasive plants	59	Species Frequency (%)	
		60	Species Richness (# species)	
		57	Species Diversity Index (index)	

Expanding forest cover (degradation, reforestation, afforestation)

	Key Question: Expanding forest cover (degradation, reforestation, afforestation)			
	Broad Objective: Ecosystem Restoration			
	Generic Question	**Metric No.**	**Metric**	**Field Variable**
1	What is the distribution of tree species across the forested landscape? What tree species are increasing or decreasing in ecological importance?	1	Area of forest and other land use/cover (ha)	
	Indicator	15	Number of live trees (trees)	
	Tree abundance	17	Gross volume of live trees (m^3)	
		56	Species Abundance (stems)	
		57	Species Diversity Index (index)	
		58	Species Evenness (index)	
		59	Species Frequency (%)	
		60	Species Richness (# species)	
		14	Number of live seedlings/saplings (trees)	
		24	Net change of live gross volume (m^3/year)	
		32	Aboveground biomass of live trees and saplings (oven-dry tons)	
		55	Species Canopy Cover Total (%)	
5	Are forests replacing themselves? What factors are impacting regeneration?	1	Area of forest and other land use/cover (ha)	
	Indicator	6	Stand Age (years)	
	Tree regeneration	8	Area of management actions (ha)	
		9	Area burned (ha)	
		10	Area by Designation/Protection status (ha)	
		11	Area by Ownership (ha)	
		12	Area with Timber extraction (ha)	
		13	Area by Silviculture actions (ha)	
		14	Number of live seedlings/saplings (trees)	
6	What is the number and area of management activities? How are forests managed? What is the human impact to forests? Are they progressing towards achieving desired conditions?	7	Number of management actions ()	
	Indicator	8	Area of management actions (ha)	
	Management activities	12	Area with Timber extraction (ha)	
		13	Area by Silviculture actions (ha)	
		63	Conflicts over tree	

			product/service ()	
7	Are we gaining or losing forest land? What is the distribution of forest cover types across the landscape? What is the status of rare cover types?	1	Area of forest and other land use/cover (ha)	
	Indicator	8	Area of management actions (ha)	
	Land cover	10	Area by Designation/Protection status (ha)	
		6	Stand Age (years)	
		9	Area burned (ha)	
		11	Area by Ownership (ha)	
		12	Area with Timber extraction (ha)	
8	What is the extent (area) of land by land use? How has it changed over time? What is the proportion of surrounding area in natural cover and in anthropogenic landuse?	1	Area of forest and other land use/cover (ha)	
	Land use	11	Area by Ownership (ha)	
13	What is the composition, abundance and diversity of understory vegetation by forest type? Is the native understory richness declining over time?	1	Area of forest and other land use/cover (ha)	
	Indicator	14	Number of live seedlings/saplings (trees)	
	Understory native plant richness	56	Species Abundance (stems)	
		57	Species Diversity Index (index)	
		58	Species Evenness (index)	
		59	Species Frequency (%)	
		60	Species Richness (# species)	
		50	Road/Trail Cover (%)	
		52	Water Cover (%)	
		54	Live Shrub Cover (%)	
14	What exotic or invasive species are present? Are exotic or invasive plant species increasing in abundance?	56	Species Abundance (stems)	
	Indicator	58	Species Evenness (index)	
	Exotic or invasive plants	59	Species Frequency (%)	
		60	Species Richness (# species)	
		57	Species Diversity Index (index)	

Forest Governance

	Key Question: Forest Governance			
	Broad Objective: Forest Governance			
	Generic Question	**Metric No.**	**Metric**	**Field Variable**
6	What is the number and area of management activities? How are forests managed? What is the human impact to forests? Are they progressing towards achieving desired conditions?	7	Number of management actions ()	
	Indicator	8	Area of management actions (ha)	
		12	Area with Timber extraction (ha)	
	Management activities	13	Area by Silviculture actions (ha)	
		63	Conflicts over tree product/service ()	
23	What, if any, non-market values of the forest are considered in government policies and decision making?	61	Tree product/service use ()	
	Indicator	62	Tree product/service ranking ()	
	Ecosystem services and traditional social uses of the forest	64	User rights of tree product ()	
25	What are the regulations associated with harvesting forest products? Are local communities knowledgeable about formal rules regarding ownership, access, and use of forest land? Are they generally complied with?	67	Awareness of legislation ()	
	Awareness/compliance of legislation/enforcement	68	Compliance with legislation ()	
27	What is the land tenure system by land use/cover? What are the user rights of the forests?	1	Area of forest and other land use/cover (ha)	
	Indicator	11	Area by Ownership (ha)	
	Land ownership & user rights	64	User rights of tree product ()	
28	What are the effects of human use and developments?	1	Area of forest and other land use/cover (ha)	
	Indicator	8	Area of management actions (ha)	
	Human/development impact	12	Area with Timber extraction (ha)	
		13	Area by Silviculture actions (ha)	
		17	Gross volume of live trees (m^3)	
		24	Net change of live gross	

				volume (m^3/year)	
			28	Removals (harvested trees) (m^3/year)	
			61	Tree product/service use ()	
			63	Conflicts over tree product/service ()	
			65	Availability of forest product/service ()	
			30	Removals - biomass ()	
			64	User rights of tree product ()	
29	Do relevant authorities give public notice of proposed forest policies, programs, laws, and projects?		67	Awareness of legislation ()	
	Transparency of forest policies		68	Compliance with legislation ()	
30	Are forest dependent communities actively involved in forest management and planning?		7	Number of management actions ()	
	Indicator		11	Area by Ownership (ha)	
	Stakeholder awareness & engagement		13	Area by Silviculture actions (ha)	
			63	Conflicts over tree product/service ()	
			68	Compliance with legislation ()	
31	Do forest dependent communities have secure access to the resources that they depend on?		11	Area by Ownership (ha)	
	Indicator		61	Tree product/service use ()	
	Resource accessibility		63	Conflicts over tree product/service ()	
			64	User rights of tree product ()	
			65	Availability of forest product/service ()	
			8	Area of management actions (ha)	
			68	Compliance with legislation ()	
32	Are there serious conflicts between different communities and user groups in the context of forest access and use?		61	Tree product/service use ()	
	Indicator		62	Tree product/service ranking ()	
	Frequency of conflicts		63	Conflicts over tree product/service ()	
			65	Availability of forest product/service ()	
			67	Awareness of legislation ()	
			68	Compliance with legislation ()	
			11	Area by Ownership (ha)	

		64	User rights of tree product ()	
33	Who primarily harvests the forest product (male/female)? Is there equal accessibility of these products for men and women?	61	Tree product/service use ()	
	Indicator	62	Tree product/service ranking ()	
		64	User rights of tree product ()	
		65	Availability of forest product/service ()	
	Gender equity	66	Gender of harvester ()	
		67	Awareness of legislation ()	
		68	Compliance with legislation ()	

Measurement, Reporting and Verification for REDD+

	Generic Question	Metric No.	Metric	Field Variable
	Key Question: Measurement, Reporting and Verification for REDD+			
	Broad Objective: Carbon Sequestration			
2	What are growth and mortality rates overall and for individual species and how are these rates changing?	15	Number of live trees (trees)	
	Indicator	17	Gross volume of live trees (m^3)	
		20	Mortality (trees/year)	
	Tree growth and mortality rates	25	Growth of live gross volume (m^3/year)	
		23	Mortality - biomass ()	
7	Are we gaining or losing forest land? What is the distribution of forest cover types across the landscape? What is the status of rare cover types?	1	Area of forest and other land use/cover (ha)	
	Indicator	8	Area of management actions (ha)	
		10	Area by Designation/Protection status (ha)	
	Land cover	6	Stand Age (years)	
		9	Area burned (ha)	
		11	Area by Ownership (ha)	
		12	Area with Timber extraction (ha)	
8	What is the extent (area) of land by land use? How has it changed over time? What is the proportion of surrounding area in natural cover and in anthropogenic landuse?	1	Area of forest and other land use/cover (ha)	
	Land use	11	Area by Ownership (ha)	
10	What is the amount and distribution of fine woody material or grass? Does the level of fuel loading present a fire hazard?	8	Area of management actions (ha)	
		42	Carbon in litter (tons)	
		44	Fine Woody Debris (tons)	
	Fine woody debris	45	Litter Depth (cm)	
		47	Litter/Duff Cover (%)	
		53	Live Herbaceous Cover (%)	
		54	Live Shrub Cover (%)	
		30	Removals - biomass ()	
11	What is the amount and distribution of coarse woody debris? And is it changing?	28	Removals (harvested trees) (m^3/year)	
	Coarse woody debris	46	Coarse Woody Debris (tons)	
12	What is the abundance of standing dead trees and is it changing?	16	Number of standing dead trees (trees)	
		19	Volume of standing dead trees (m^3)	

	Standing dead tree abundance	33	Biomass of standing dead trees (oven-dry tons)	
13	What is the composition, abundance and diversity of understory vegetation by forest type? Is the native understory richness declining over time?	1	Area of forest and other land use/cover (ha)	
	Indicator	14	Number of live seedlings/saplings (trees)	
	Understory native plant richness	56	Species Abundance (stems)	
		57	Species Diversity Index (index)	
		58	Species Evenness (index)	
		59	Species Frequency (%)	
		60	Species Richness (# species)	
		50	Road/Trail Cover (%)	
		52	Water Cover (%)	
		54	Live Shrub Cover (%)	
18	What species and size classes have the highest harvest rates? What is the distribution of forest land by harvest intensity? Where are the most valuable forests for commercial use and local use located?	1	Area of forest and other land use/cover (ha)	
	Tree harvest	6	Stand Age (years)	
		12	Area with Timber extraction (ha)	
		13	Area by Silviculture actions (ha)	
		17	Gross volume of live trees (m^3)	
		18	Gross sawtimber volume of live trees (Commercial volume) (m^3)	
		28	Removals (harvested trees) (m^3/year)	
		29	Removals of sawtimber trees (m^3/year)	
		30	Removals - biomass ()	
19	What is the distribution of biomass across the forested landscape? Is total biomass increasing or decreasing? Does total net growth exceed removals?	1	Area of forest and other land use/cover (ha)	
	Biomass/ Production	23	Mortality - biomass ()	
		27	Growth - biomass ()	
		30	Removals - biomass ()	
		32	Aboveground biomass of live trees and saplings (oven-dry tons)	
		33	Biomass of standing dead trees (oven-dry tons)	
26	What is the current and net change in carbon by pool? How are the changes related to human activity?	30	Removals - biomass ()	
	Carbon balance	34	Aboveground carbon of all live trees (tons)	
		35	Belowground carbon of all live trees (tons)	
		39	Carbon in standing dead trees	

			(tons)	
		40	Carbon in down dead wood (tons)	
		46	Coarse Woody Debris (tons)	
		41	Soil organic carbon (tons)	
		42	Carbon in litter (tons)	
27	What is the land tenure system by land use/cover? What are the user rights of the forests?	1	Area of forest and other land use/cover (ha)	
	Indicator	11	Area by Ownership (ha)	
	Land ownership & user rights	64	User rights of tree product ()	

APPENDIX 4: All combinations of Objectives, Questions and Metrics (example extracted from DTIM)

Question No.	Key Question	Obj. No.	Broad Objective	Question	Generic Question	Indicator	Metric No.	Metric
1	Social forestery - value to livelihoods, including non-carbon benefits	8	Value of Forests (ecosystem services)	13	What is the composition, abundance and diversity of understory vegetation by forest type? Is the native understory richness declining over time?	Understory native plant richness	1	Area of forest and other land use/cover (ha)
1	Social forestery - value to livelihoods, including non-carbon benefits	8	Value of Forests (ecosystem services)	13	What is the composition, abundance and diversity of understory vegetation by forest type? Is the native understory richness declining over time?	Understory native plant richness	14	Number of live seedlings/saplings (trees)
1	Social forestery - value to livelihoods, including non-carbon benefits	8	Value of Forests (ecosystem services)	13	What is the composition, abundance and diversity of understory vegetation by forest type? Is the native understory richness declining over time?	Understory native plant richness	56	Species Abundance (stems)
1	Social forestery - value to livelihoods, including non-carbon benefits	8	Value of Forests (ecosystem services)	13	What is the composition, abundance and diversity of understory vegetation by forest type? Is the native understory richness declining over time?	Understory native plant richness	57	Species Diversity Index (index)
1	Social forestery - value to livelihoods, including non-carbon benefits	8	Value of Forests (ecosystem services)	13	What is the composition, abundance and diversity of understory vegetation by forest type? Is the native understory richness declining over time?	Understory native plant richness	58	Species Evenness (index)
1	Social forestery - value to livelihoods, including non-carbon benefits	8	Value of Forests (ecosystem services)	13	What is the composition, abundance and diversity of understory vegetation by forest type? Is the native understory richness declining over time?	Understory native plant richness	59	Species Frequency (%)
1	Social forestery - value to livelihoods, including non-carbon benefits	8	Value of Forests (ecosystem services)	13	What is the composition, abundance and diversity of understory vegetation by forest type? Is the native understory richness declining over time?	Understory native plant richness	60	Species Richness (# species)
1	Social forestery - value to livelihoods, including non-carbon benefits	8	Value of Forests (ecosystem services)	13	What is the composition, abundance and diversity of understory vegetation by forest type? Is the native understory richness declining over time?	Understory native plant richness	50	Road/Trail Cover (%)
1	Social forestery - value to livelihoods, including non-carbon benefits	8	Value of Forests (ecosystem services)	13	What is the composition, abundance and diversity of understory vegetation by forest type? Is the native understory richness declining over time?	Understory native plant richness	52	Water Cover (%)

Live Shrub Cover (%)	54	Understory native plant richness		What is the composition, abundance and diversity of understory vegetation by forest type? Is the native understory richness declining over time?	13	Value of Forests (ecosystem services)	8	Social forestery - value to livelihoods, including non-carbon benefits	1
Area of forest and other land use/cover (ha)	1	Tree harvest		What species and size classes have the highest harvest rates? What is the distribution of forest land by harvest intensity? Where are the most valuable forests for commercial use and local use located?	18	Value of Forests (ecosystem services)	8	Social forestery - value to livelihoods, including non-carbon benefits	1
Stand Age (years)	6	Tree harvest		What species and size classes have the highest harvest rates? What is the distribution of forest land by harvest intensity? Where are the most valuable forests for commercial use and local use located?	18	Value of Forests (ecosystem services)	8	Social forestery - value to livelihoods, including non-carbon benefits	1
Area with Timber extraction (ha)	12	Tree harvest		What species and size classes have the highest harvest rates? What is the distribution of forest land by harvest intensity? Where are the most valuable forests for commercial use and local use located?	18	Value of Forests (ecosystem services)	8	Social forestery - value to livelihoods, including non-carbon benefits	1
Area by Silviculture actions (ha)	13	Tree harvest		What species and size classes have the highest harvest rates? What is the distribution of forest land by harvest intensity? Where are the most valuable forests for commercial use and local use located?	18	Value of Forests (ecosystem services)	8	Social forestery - value to livelihoods, including non-carbon benefits	1
Gross volume of live trees (m^3)	17	Tree harvest		What species and size classes have the highest harvest rates? What is the distribution of forest land by harvest intensity? Where are the most valuable forests for commercial use and local use located?	18	Value of Forests (ecosystem services)	8	Social forestery - value to livelihoods, including non-carbon benefits	1
Gross sawtimber volume of live trees (Commercial volume) (m^3)	18	Tree harvest		What species and size classes have the highest harvest rates? What is the distribution of forest land by harvest intensity? Where are the most valuable forests for commercial use and local use located?	18	Value of Forests (ecosystem services)	8	Social forestery - value to livelihoods, including non-carbon benefits	1
Removals (harvested trees) (m^3/year)	28	Tree harvest		What species and size classes have the highest harvest rates? What is the distribution of forest land by harvest intensity? Where are the most valuable forests for commercial use and local use located?	18	Value of Forests (ecosystem services)	8	Social forestery - value to livelihoods, including non-carbon benefits	1
Removals of sawtimber trees (m^3/year)	29	Tree harvest		What species and size classes have the highest harvest rates? What is the distribution of forest land by harvest intensity? Where are the most valuable forests for commercial use and local use located?	18	Value of Forests (ecosystem services)	8	Social forestery - value to livelihoods, including non-carbon benefits	1
Removals - biomass ()	30	Tree harvest		What species and size classes have the highest harvest rates? What is the distribution of forest land by harvest intensity? Where are the most valuable forests for commercial use and local use located?	18	Value of Forests (ecosystem services)	8	Social forestery - value to livelihoods, including non-carbon benefits	1