# Module 1.2 Framework for building national forest-monitoring systems for REDD+
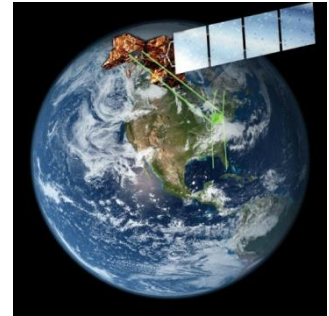
*Module developers:*

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Brice Mora, Wageningen University

*After the course the participants should be able to:*

- Understand the needs and priorities of a national REDD+ policy and implementation strategy

- Assess and characterize current forest monitoring and reporting capacities taking national circumstances into account

- Develop a roadmap for building sustained in-country capacities for REDD+ MRV

V1, May 2015

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For quality of life

GOFC-GOLD
Global Observation of Forest and Land Cover Dynamics

FOREST CARBON PARTNERSHIP FACILITY

# Background material

- GOFC-GOLD. 2014. *Sourcebook*. Sections 1 and 4.

- UNFCCC. 2013. Decision 11/CP.19. Modalities for national forest-monitoring systems. http://unfccc.int/resource/docs/2013/cop19/eng/10a01.pdf#page=31

- UNFCCC. 2010. Decision 1/CP.16. The Cancun Agreements. http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf#page=2

- UNFCCC. 2009. Decision 4/CP.15. Methodological guidance for activities related to reducing emissions . . . in developing countries. http://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf#page=11

- UN-REDD. 2013. National forest-monitoring Systems: Measurement, Reporting and Verification (M & MRV) in the context of REDD+ Activities.

- GFOI. 2014. Integrating Remote-sensing and Ground-based Observations for Estimation of Emissions and Removals of Greenhouse Gases in Forests: Methods and Guidance from the Global Forest Observation Initiative (MGD). Section 1.4.

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# Background material

- Hewson, J., Steininger, M., and Pesmajoglou, S., eds. 2013. REDD+ Measurement, Reporting, and Verification (MRV) Manual 2.0: Forest Carbon, Markets and Communities Program. Washington, DC: USAID. http://www.fcmcglobal.org/documents/mrvmanual/MRV_Manual.pdf

- FFPRI. Nov. 2012. REDD+ Cookbook: How to Measure and Monitor Forest Carbon. Tsukuba, Japan: REDD Research and Development Center. http://www.ffpri.affrc.go.jp/redd-rdc/en/reference/cookbook.html

- Herold, M. 2009. An Assessment of National forest-monitoring Capabilities in Tropical Non-Annex I Countries: Recommendations for Capacity Building. Report for the Prince's Rainforests Project and the Government of Norway. Friedrich-Schiller-Universität Jena and GOFC-GOLD. http://princes.3cdn.net/8453c17981d0ae3cc8_q0m6vsqxd.pdf

- UNFCCC. 2009. Cost of Implementing Methodologies and Monitoring Systems. Technical Paper FCCC/TP/2009/1. http://unfccc.int/resource/docs/2009/tp/01.pdf

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# Outline of lecture

1. UNFCCC requirements for national forest-monitoring systems (NFMS) and measurement, reporting, and verification (MRV) of REDD+ activities

2. Framework for NFMS

3. Building technical and institutional capacity for NFMS and REDD+ MRV

4. Planning and implementing a NFMS for REDD+ MRV

5. Cost implications and different factors contributing to the costs

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# National forest-monitoring systems and MRV

- REDD+ results-based actions should be fully **measured, reported, and verified**.

- **Forest reference emissions levels** and **forest reference levels** are benchmarks for assessing performance in implementing REDD+ activities and need to be consistent with historical data in greenhouse gas (GHG) inventories

- Countries need to set up a **robust and transparent national forest-monitoring system** to estimate emissions and establish a reference level which will be subject to technical assessment in the context of results-based payments

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# Modalities for national forest-monitoring systems

Full implementation of results-based actions requires national forest-monitoring systems (UNFCCC 2014, 11/CP.19).

National forest-monitoring systems, with, if appropriate, subnational monitoring and reporting as an interim measure, should:

- Build upon existing systems, as appropriate
- Enable the assessment of different types of forest in the country, including natural forest
- Be flexible and allow for improvement
- Reflect, as appropriate, the phased approach

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# Methodological guidance from UNFCCC

National forest-monitoring systems should:

- Use a combination of remote sensing and ground-based forest carbon inventory approaches

- Provide estimates that are transparent, consistent, and, as far as possible accurate and that reduce uncertainties, taking into account national capabilities and capacities

- Be transparent and the results should be available and suitable for review

UNFCCC (2009, 4/CP.15) methodological guidance for REDD+

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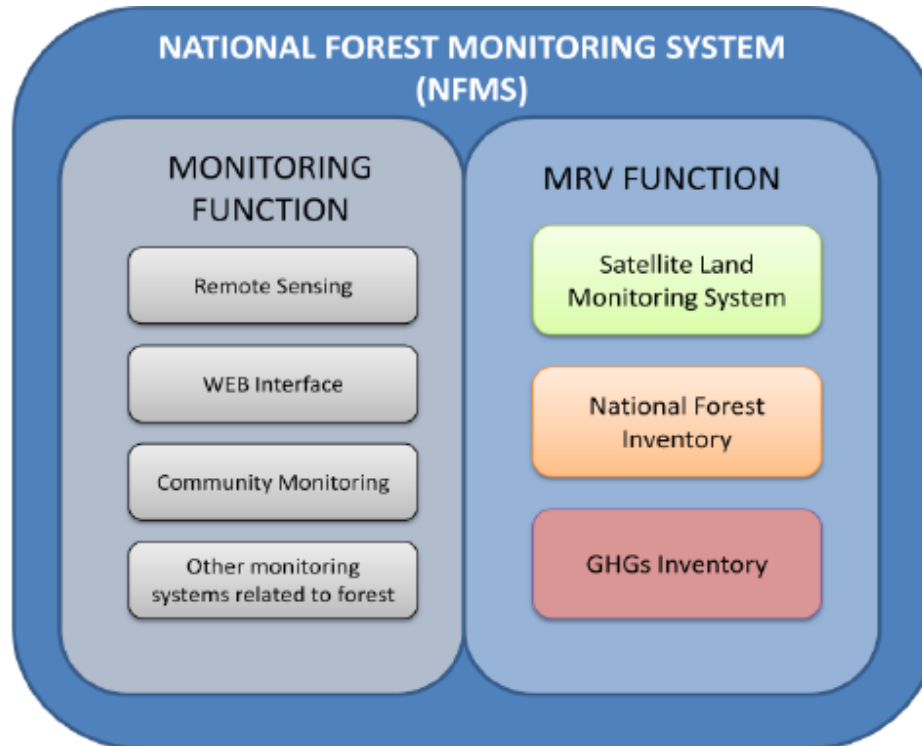
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# Link between REDD+ MRV and national forest-monitoring systems



**NATIONAL FOREST MONITORING SYSTEM (NFMS)**

MONITORING FUNCTION
- Remote Sensing
- WEB Interface
- Community Monitoring
- Other monitoring systems related to forest

MRV FUNCTION
- Satellite Land Monitoring System
- National Forest Inventory
- GHGs Inventory

Source: UN-REDD, 2013.

2 simultaneous functions of NFMS:

■ **Monitoring function**

- More than assessment of only carbon

- Harmonization of existing and new forest-monitoring tools important

- Should be well harmonized with development of MRV capacities

■ **MRV function**

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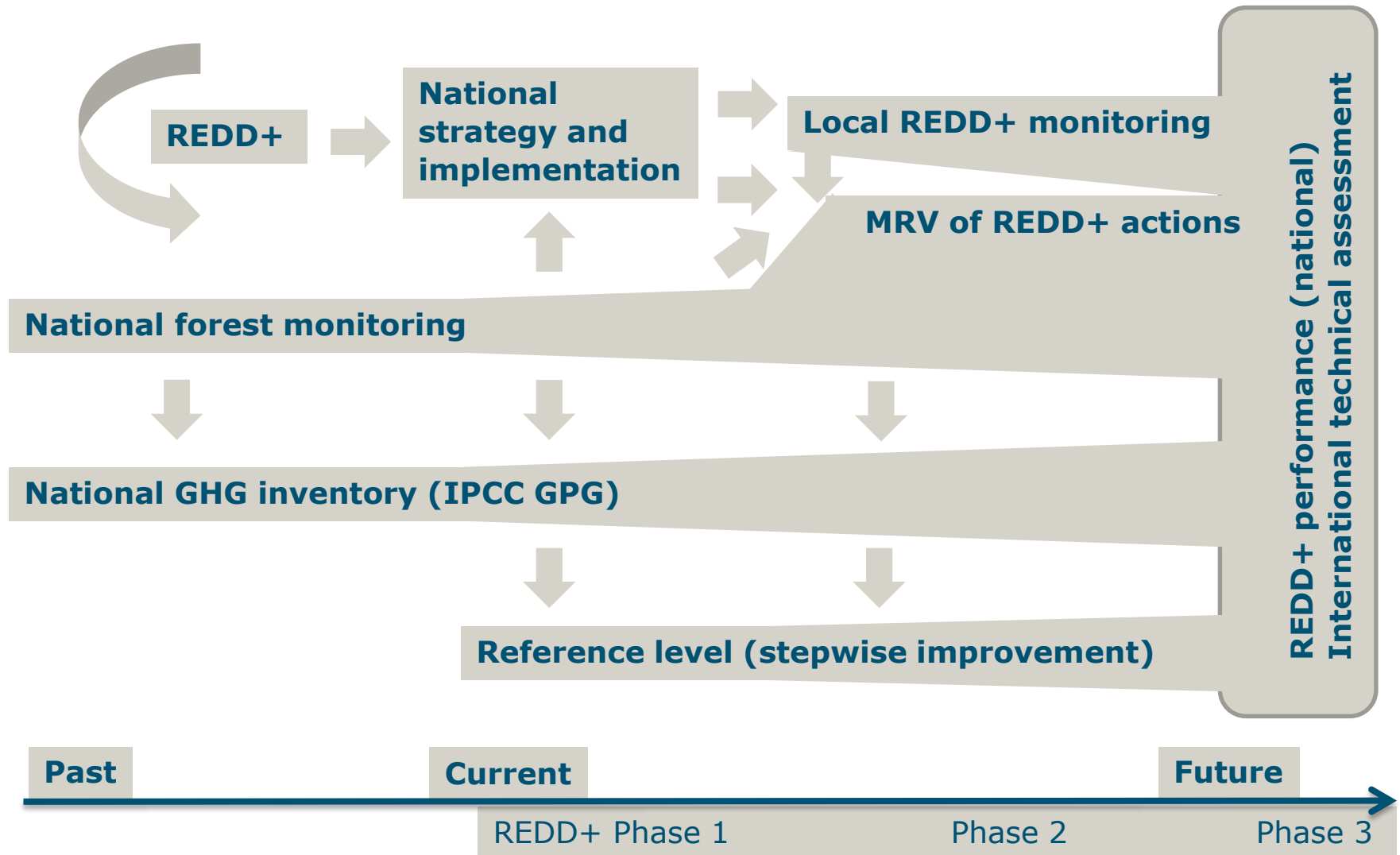
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# Multiple benefits of a national forest-monitoring system (NFMS)

1.  Address domestic and international monitoring needs:

    - Keep track of a country's forest resources—forest area, number of trees planted, ecosystem types, etc.

    - Monitor water resources and quality

    - Monitor biodiversity conservation

    - Monitor land rights / use NFMS for land tenure

2.  Assess countries REDD+ policies and measures:

    - MRV for REDD+: MRV is only one part of a national forest-monitoring system!

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# Framework for national REDD+ monitoring

# Use of remote sensing within the NFMS

- Requirements for estimating forest emissions in the context of REDD+:

  - Historical data on forest area changes and changes in forest carbon pools, consistent with IPCC guidance and Conference of the Parties (COP) decisions
    → Needed to establish forest reference emission levels and to estimate forest GHG emissions and reductions

  - Understanding of deforestation processes and drivers

- Use of remote sensing for REDD+ measurements:

  - Provides primary source of data to measure forest area changes

  - Provides indicators for areas affected by forest degradation

  - Forest area change maps can be linked to specific activities of deforestation (follow-up land use), which are useful for assessing drivers

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# Technical challenges for the use of remote sensing

| Factor | Challenges | Potential solutions |
|---|---|---|
| **Mean annual cloud cover** | Annual cloud cover probability varies from <10% to >90% cover between countries. With optical imagery, it is not possible to take measurements through clouds. | - Optical data: combination of multiple sensors enhancing artificially revisited time period (e.g. Landsat, Sentinel-2)<br>- Use of synthetic aperture radar (SAR) data: not constrained by cloud cover<br>- Use of data fusion methods (Optical+SAR) |
| **Seasonality** | Variability in cloud cover during the year in tropical Non-Annex I countries | Increase frequency of satellite images (higher satellite revisit time period) to increase chance to obtain optical observations at appropriate periods (e.g., upcoming Sentinel-2 constellation) |
| **Topography** | Variations in altitude in mountainous regions cause topographic effects in satellite images, making it difficult to analyze the remote sensing signal | Use of adequate orthorectification procedures available in some image processing software (e.g., ENVI, Idrisi, ERDAS, PCI Geomatics), requires the use of digital elevation models (DEMs) |
| **Average Internet download speed** | Problems / delays to regularly download large image datasets | Use CD ROMs, external hard drives to disseminate data and products, externalize data processing, foster regional approaches, i.e., cross-country coordination, use of networks (GOFC-GOLD, FAO, etc.) |

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# Requirements for NFMS and building capacity

- Requirements at national level:

  - International: Requirements of COP decisions on MRV, including consistency with the IPCC Good Practice Guidance (GPG)*

  - National: Needs and priorities of the national REDD+ policy and implementation strategy

- Bridging the capacity gap:

  - Assessment of existing national forest-monitoring technical capabilities versus the requirements for the MRV system

  - Develop and implement a roadmap: to build sustained in-country capacities for MRV based on international requirements and national needs to implement REDD+ policy

* For information on using the IPCC GPG and Guidelines in the REDD+ context, see Module 1.1 and GFOI MGD.

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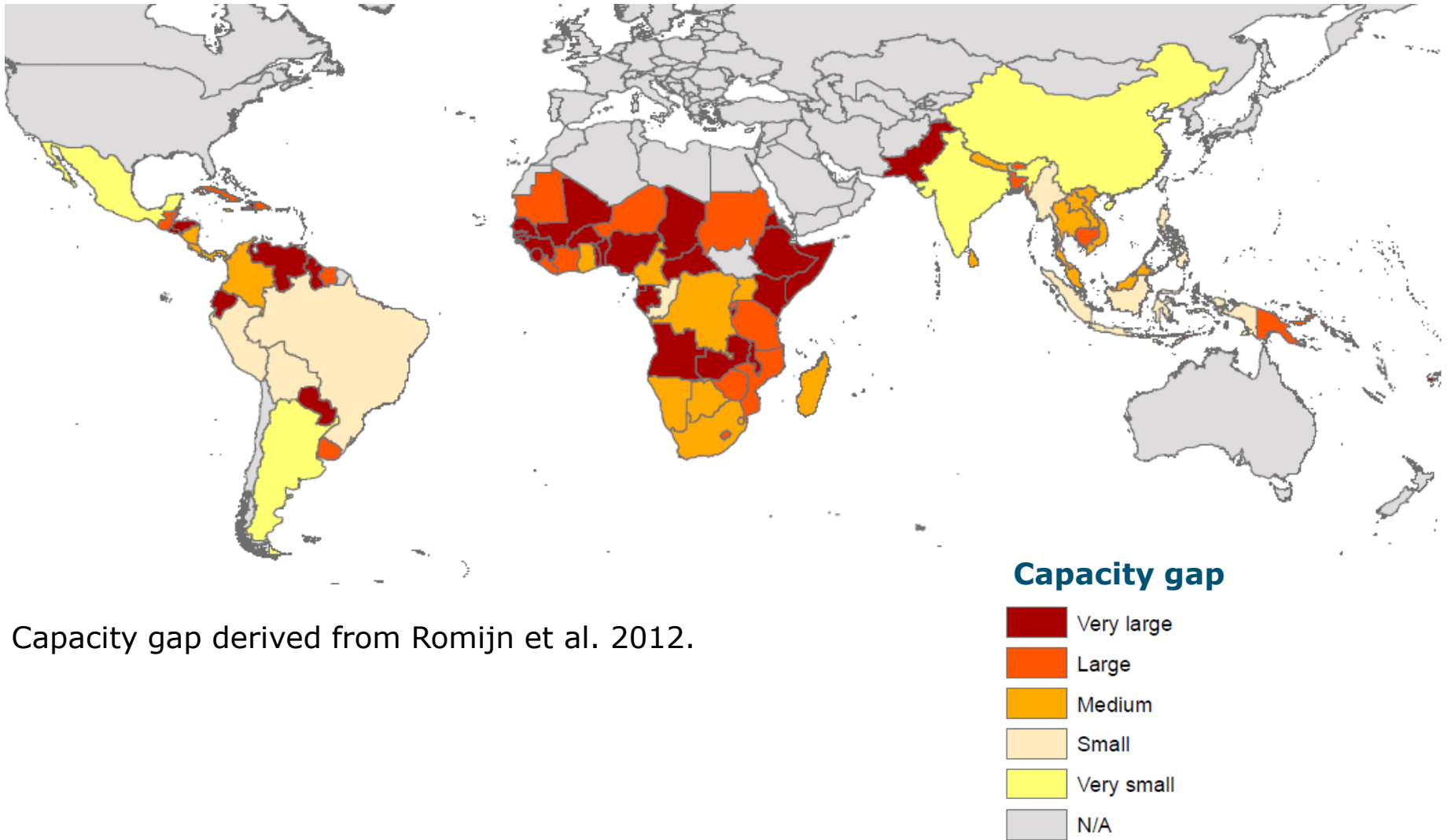
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# Assessment of existing national forest-monitoring technical capabilities versus the requirements for the MRV system

Consideration of factors:

1. Requirements for monitoring forest carbon at the national level (IPCC GPG)

2. Existing national capacities for national forest monitoring

3. Progress in national GHG inventory to estimate GHG associated with REDD+ activities (GFOI MGD describes how to do this)

4. REDD+ particular characteristics: importance of forest fires, soil carbon, deforestation rate, etc.

5. Specific technical challenges (remote sensing): cloud cover, seasonality, topography, remote sensing data availability, and access procedures

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# REDD+ monitoring capacities



Capacity gap derived from Romijn et al. 2012.

**Capacity gap**

- Very large
- Large
- Medium
- Small
- Very small
- N/A

# REDD+ monitoring capacities vs. engagement
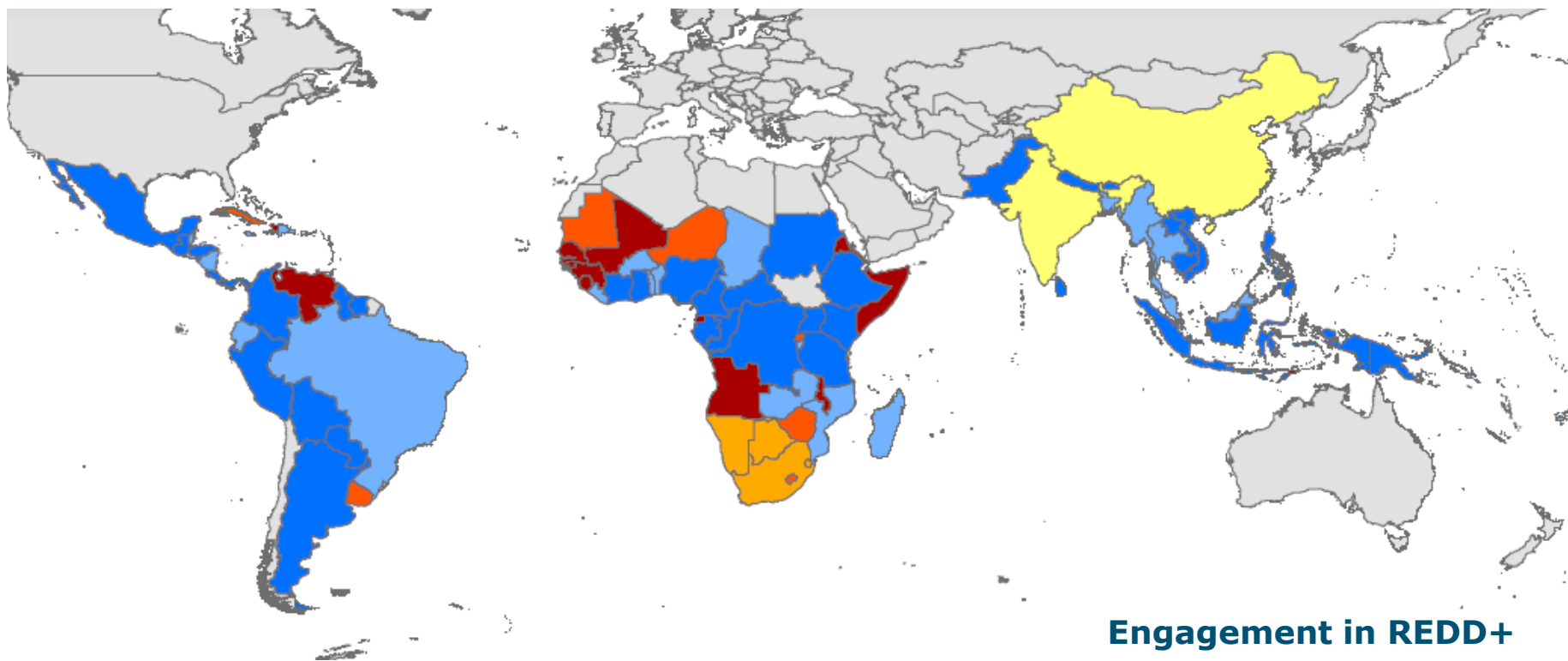


Notes:
Capacity gap derived from Romijn et al., 2012, ESP
Engagement: UN-REDD, WB-FCPF, Norway NIFCI

**Engagement in REDD+**

- Engaged in two or more REDD activities
- Engaged in one REDD activity
- No engagement, very large capacity gap
- No engagement, large capacity gap
- No engagement, medium capacity gap
- No engagement, very small capacity gap
- N/A

# Building technical and institutional capacity

- Technology transfers from developed countries are encouraged.

- Building technical and institutional capacity for NFMS should take into account:

  - National circumstances (forest types, institutional arrangements, economy, culture)

  - Drivers of deforestation (see Module 1.3)

  - Existing capacities

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# Capacity improvements for NFMS through REDD+ phased approach

NFMS can be implemented starting at phase 1 and moving toward phase 3 of REDD+, with step-by-step improvements

| Implementation phase | | Characteristics | MRV activities |
|---|---|---|---|
| **Phase 1** | Readiness | National strategy or action plan formulation; development of policies and measures and capacity building | Capacity-development needs assessment; develop roadmap development |
| **Phase 2** | Transition, implementation, and capacity building | Implementation of national policies and measures and national strategies or action plans (further capacity building); technology development and transfer and results-based demonstration activities | Demonstration activities; monitoring system development |
| **Phase 3** | Full implementation | Implementation of national policies and measures on the entire national territory; results-based actions that should be fully measured, reported, and verified | National performance-monitoring system; fully operational MRV system to report REDD+ mitigation performance in $CO_2e$ |

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# MRV coordination on different levels

- **International support:**
  - South-South cooperation
  - Donors and supporting agencies/organizations
  - Technical community providing guidance

- **National strategy and MRV development:**
  - MRV roadmap and policy priorities
  - Institutional setup and multisector partnerships
  - Maximize country benefits from multidonor support

- **Subnational implementation:**
  - Stakeholder involvement in MRV
  - Linking national and local monitoring and verification

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# Institutional framework

- Create **Strong institutional set up** as enabling framework.

- Establish and maintain **partnership and cooperation** on all levels.

- **Coordinate and integrate** national datasets through a high-level national technical committee.

- Develop **national data management** system and infrastructure.

  → See Module 3.1

- Sustain internal and national **communication mechanisms.**

- Involve all relevant **national stakeholders** involved in MRV and REDD implementation and mechanisms to ensure transparent and open exchange and management of data streams.

- Engage with **local and international community**

- Clarify **roles and responsibilities**

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# Institutional capacity development

- A suitable degree of **organizational capacity** within the country is required to establish and operate a national forest-monitoring system for REDD+.
- Consider establishing and maintaining the following **institutions** with clear definition of roles and responsibilities:
  - A national coordination and steering body or advisory board, including a national carbon registry
  - A central carbon monitoring, estimation, reporting, and verification authority, including forest carbon measurement units
- Consider building a link to subnational implementation activities and benefit sharing mechanisms.

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# Planning and implementation of REDD+ MRV

1. Define initial priorities for capacity development:
   - Understanding the national REDD+ implementation strategies and policies
   - Identifying high priority areas to focus MRV activities (and demonstrations) using a stratified national approach

2. Early actions may be subnational, but leakage needs to be assessed nationally.

3. Synergy of national and local monitoring and ensurance that REDD+ safeguards are in place:
   - Role of local communities and how to engage national expertise in REDD+ implementation (See Module 2.4)
   - Possible links with monitoring of biodiversity or co-benefits in general

4. Link with development of benefit-sharing mechanisms.

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# Process for establishing a national monitoring system
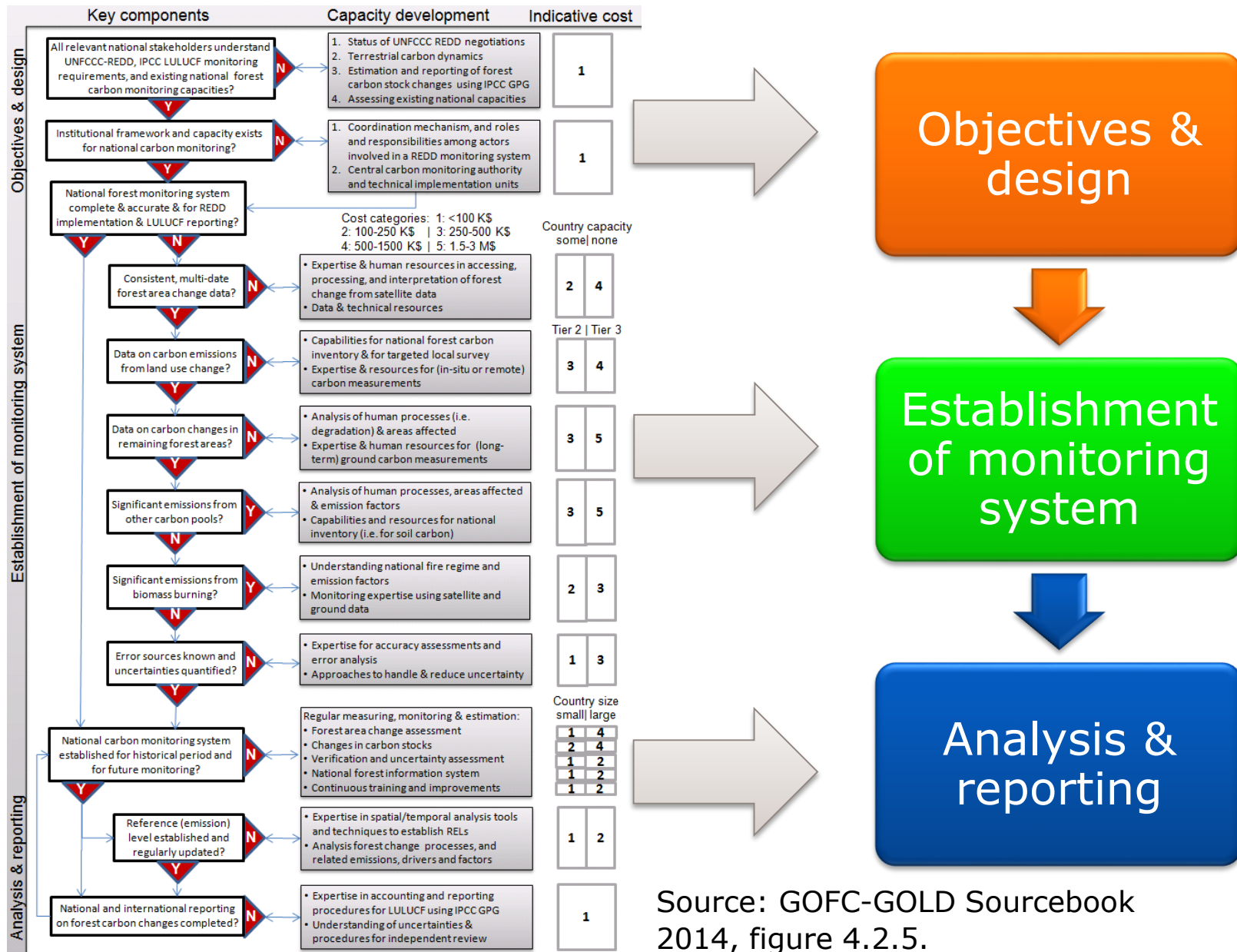


Source: GOFC-GOLD Sourcebook 2014, figure 4.2.5.

# Objectives and design



* GFOI MGD describes how to use the IPCC GPG to estimate GHG emissions and removals associated with REDD+ activities

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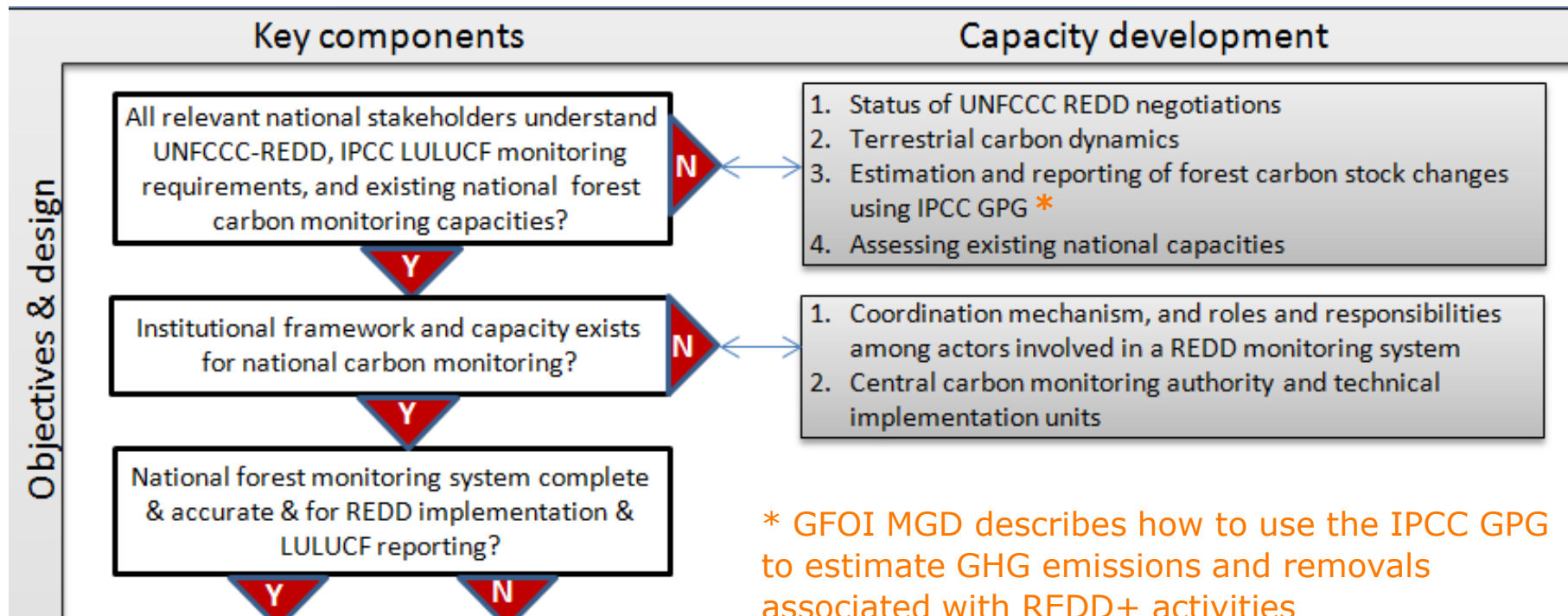
# Objectives and design phase of NFMS

Objectives and design:

- Should result in a national **monitoring framework** that includes elements, such as definitions, monitoring variables, and an institutional framework

- Should result in a **plan for capacity development** and long-term improvement of the system and estimation of the costs of establishing such a system

- Requires **resources** for **training and capacity building**, for participating in / organizing dedicated national or regional workshops, and for expert support

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# Establishment of monitoring system



National forest-monitoring system complete & accurate & for REDD implementation & LULUCF reporting? **Y** **N**

Consistent, multi-date forest area change data? **N**
- Expertise & human resources in accessing, processing, and interpretation of forest change from satellite data
- Data & technical resources

**Y**

Data on carbon emissions from land use change? **N**
- Capabilities for national forest carbon inventory & for targeted local surveys
- Expertise & resources for (in-situ or remote) carbon measurements

**Y**

Regular reporting on forest area change and change in aboveground carbon on Tier 2 level should be minimum target for near term.

Data on carbon changes in remaining forest areas? **N**
- Analysis of human processes (i.e. degradation) & areas affected
- Expertise & human resources for (long-term) ground carbon measurements

**Y**

Significant emissions from other carbon pools? **Y**
- Analysis of human processes, areas affected & emission factors
- Capabilities and resources for national inventory (i.e. for soil carbon)

**N**

Significant emissions from biomass burning? **Y**
- Understanding national fire regime and emission factors
- Monitoring expertise using satellite and ground data

**N**

Some flexibility and entry points for countries based on:
- Importance (key) category
- National strategy and REDD objectives
- Existing capacities

Error sources known and uncertainties quantified? **N**
- Expertise for accuracy assessments and error analysis
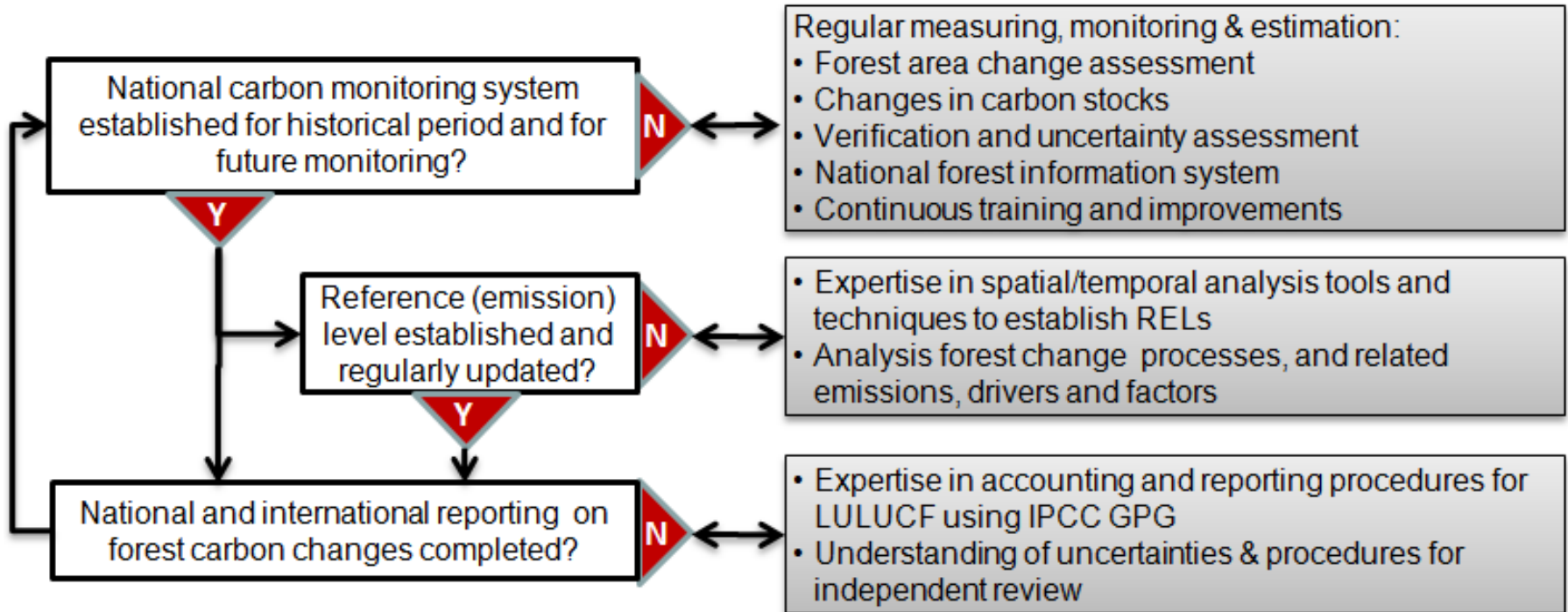- Approaches to handle & reduce uncertainty

**Y**

# Monitoring in establishment phase

- Assess and make best use of **existing observations and information**.

- Specify a methodology and operational implementation framework for **monitoring forest area change** on a national level.

- Perform analysis of historical satellite data for establishing forest **reference emission levels** or forest reference levels.

- Develop understanding of areas affected by **forest degradation** and provide assessment on how to monitor relevant forest degradation processes.

- Complete **recruitment** and provide **training** to national team to perform monitoring activities.

- Complete an **accuracy and error analysis** for estimates from the historical period.

- Perform **a test run** of the operational forest area change monitoring system.

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# Analysis and reporting



National carbon monitoring system established for historical period and for future monitoring? — N

Regular measuring, monitoring & estimation:
- Forest area change assessment
- Changes in carbon stocks
- Verification and uncertainty assessment
- National forest information system
- Continuous training and improvements

Reference (emission) level established and regularly updated? — N

- Expertise in spatial/temporal analysis tools and techniques to establish RELs
- Analysis forest change processes, and related emissions, drivers and factors

National and international reporting on forest carbon changes completed? — N

- Expertise in accounting and reporting procedures for LULUCF using IPCC GPG
- Understanding of uncertainties & procedures for independent review

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# Example: REDD+ MRV roadmap for Ethiopia

1.  Establish institutional arrangements.

2.  Improve national forest-monitoring: activity data.

3.  Improve national forest monitoring: carbon stocks and emission factors.

4.  Improve estimation and international LULUCF, GHG inventory, and REDD+ reporting capacities.

5.  Prepare for MRV of REDD+ activities on the national level.

6.  Implement a program for continuous improvement and capacity development.

7.  Continued national and local communication mechanism on REDD+ monitoring



Federal Democratic Republic of Ethiopia
Ministry of Agriculture

ROYAL NORWEGIAN EMBASSY

Federal Democratic Republic of Ethiopia
Environmental Protection Authority

Terms of Reference for Developing Capacities for a national

Measuring, Monitoring, Reporting and Verification System to

support REDD+ participation of Ethiopia

Background, Capacity Assessment and Roadmap

Prepared by

MoA, EPA, with support from the Norwegian embassy and

Wageningen University

Version 4.0

June 30, 2013

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# Cost implications of an NFMS

- Several categories of costs, including **opportunity costs** and costs for **transactions** and **implementation**

- MRV of forest carbon primarily reflected in transaction costs:

  - Proof that a REDD+ activity has indeed achieved a certain amount of emission reductions

- Resources needed for monitoring relatively small compared to all cost factors for REDD+ implementation in the long-term:

  - May be rather significant in the country readiness phase since many countries require the development of basic capacities

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# Costs for remote sensing

Implementation of a satellite-based monitoring system includes a number of cost factors:

- Satellite data, including data access and processing

- Software, hardware, and office resources, including satellite data archive

- Human resources for data interpretation and analysis

- Monitoring in readiness phase

- Operational monitoring

- Accuracy assessment

- Regional cooperation for capacity building and technical assistance

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# Utility of optical sensors at multiple resolutions for deforestation monitoring

| Sensor and resolution | Examples of current sensors | Minimum mapping unit (change) | Cost | Utility for monitoring |
|---|---|---|---|---|
| Coarse (250–1000 m) | SPOT-VGT (1998– ) Terra-MODIS (2000– ) Envisat-MERIS (2004–2012) VIIRS (2012– ) | ~ 100 ha ~ 10–20 ha | Low or free | Consistent pan-tropical annual monitoring to identify large clearings and locate "hotspots" for further analysis with mid resolution |
| Medium (10–60 m) | Landsat TM or ETM+, Terra-ASTER IRS AWiFs or LISS III CBERS HRCCD DMC SPOT HRV ALOS AVNIR-2 | 0.5–5.0 ha | Landsat & CBERS are free. For others: <$0.001/km² for historical data, $0.02/km² to $0.5/km² for recent data | Primary tool to map deforestation and estimate area change |
| Fine (<5 m) | RapidEye IKONOS QuickBird GeoEye WorldView Pleiades Aerial photos | < 0.1 ha | High to very high $2–30 per km² | Validation of results from coarser resolution analysis, and training of algorithms |

Source: GOFC-GOLD Sourcebook 2014, table 2.1.1.

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# Anticipated core optical missions with freely available data

| Agency | Mission | Launch | Resolution | Swath | Revisit | Planned Duration |
|---|---|---|---|---|---|---|
| USGS/NASA | Landsat-7 | 1999 | 15m, 30m | 185 km | 16 days | 5 years |
| USGS/NASA | Landsat-8 | 2013 | 15m, 30m | 185 km | 16 days | 5 years |
| INPE/CRESDA | CBERS-4 | 2015 | 5m 10m, 20m, 40m, 64m | 60-866 km | 26 days | 3 years |
| ESA | Sentinel 2A | 2014 | 10m, 20m, 60m | 290 km | 10 days | 7 years |
| ESA | Sentinel 2B | 2015 | 10m, 20m, 60m | 290 km | 10 days | 7 years |

Source: CEOS 2015.

See also GFOI MGD, annex B.

CEOS Missions, Instruments and Measurements database
See http://database.eohandbook.com

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# Anticipated core synthetic aperture radar (SAR) missions with freely available data

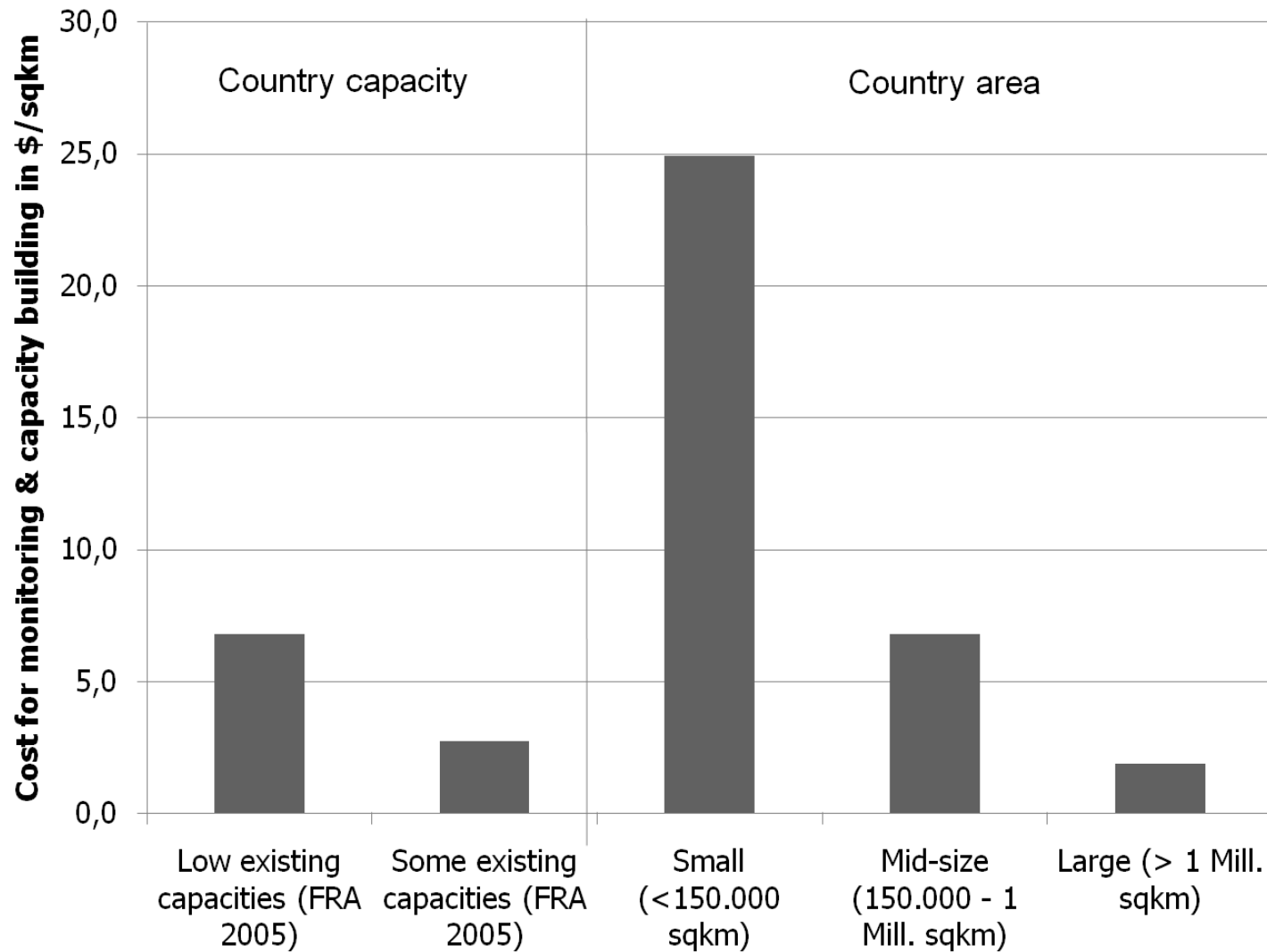| Agency | Mission | Launch | Band (wave length) | Polarization | Resolution | Revisit | Duration |
|---|---|---|---|---|---|---|---|
| ESA | Sentinel-1A and 1B | 2014 and 2015 | C (5.6 cm) | Single-, Dual-polarisation | 9 m, 20 m, 50 m | 12 days | 7 years |
| CSA | RADARSAT Constellation Mission (3 satellites) | 2018 | C (5.6 cm) | Single-, Dual-, Full-polarisation | 1 m, 3 m, 5 m, 16 m, 50 m, 100 m | 12 days | 7 years |
| CONAE/ASI | SAOCOM-1A and 1B | 2015 and 2016 | L (23.5 cm) | Single-, Dual-, Full-polarisation | 10 m, 30 m, 50 m, 100 m | 16 days | 5 years |

Source:
CEOS 2015.

See also:
GFOI MGD, annex B.

CEOS Missions, Instruments and Measurements database
See http://database.eohandbook.com

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# Cost for monitoring & capacity building



Source: GOFC-GOLD Sourcebook 2014, figure 4.3.1.

# In summary

1. Establishing a national forest-monitoring system is essential for measurement, reporting, and verification (MRV) of REDD+ activities.

2. There are different elements of a national forest-monitoring system: monitoring function and MRV function.

3. A strong institutional framework is important.

4. A roadmap is needed for building sustained in-country capacities for MRV along the three REDD+ implementation phases.

5. Thee are different factors contributing to the costs of establishing and operating a national forest-monitoring system—monitoring costs may be significant, especially in the start-up phase.

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# Country examples and exercises

## Country examples

- UN-REDD monitoring framework for Democratic Republic of Congo

- Establishment of a system for monitoring, reporting and verification of REDD+ in Guyana

## Exercise

- Assessing national forest-monitoring and reporting capacities

  1. Assessing forest-monitoring and reporting capacities for a few selected countries, based on FAO Forest Resources Assessment reports

  2. Assessing monitoring capacity and REDD+ and remote sensing (technical) challenges in your own country

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# Recommended modules as follow-up

- Module 1.3 for considering national circumstances within a national forest-monitoring system and assessing and analyzing drivers of deforestation and forest degradation

- Modules 2.1 to 2.8 to continue with REDD+ measuring and monitoring

- Modules 3.1 to 3.3 to learn more about REDD+ assessment and reporting

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# References

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- GOFC-GOLD (Global Observation of Forest Cover and Land Dynamics). 2014. *A Sourcebook of Methods and Procedures for Monitoring and Reporting  Anthropogenic  Greenhouse  Gas  Emissions  and Removals Associated with Deforestation,  Gains  and  Losses  of  Carbon  Stocks  in  Forests  Remaining Forests,  and  Forestation*.  (Often GOFC-GOLD Sourcebook.) Netherland: GOFC-GOLD Land Cover Project Office, Wageningen University. http://www.gofcgold.wur.nl/redd/index.php.

- Pagiola, S., and B. Bosquet, 2009. *Estimating the Costs of REDD at the Country Level.* Munich Personal RePEc Archive (MPRA) Paper No. 13726. Munich: Forest Carbon Partnership Facility, World Bank. http://mpra.ub.uni-muenchen.de/13726/1/MPRA_paper_13726.pdf.

- Romijn, E., M. Herold, L. Kooistra, D. Murdiyarso, and L. Verchot. 2012. "Assessing Capacities of Non-Annex I Countries For National Forest Monitoring in the Context of REDD+." *Environmental Science and Policy* 19–20: 33–48.

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- UNFCCC COP (United Nations Framework Convention on Climate Change Conference of the Parties) Decisions. This module refers to and draws from various UNFCCC COP decisions. Specific decisions for this module are listed in the "Background Material" slides. All COP decisions can be found from the UNFCCC webpage "Search Decisions of the COP and CMP." http://unfccc.int/documentation/decisions/items/3597.php#beg.

- UN-REDD. 2013. *National Forest-Monitoring Systems: Measurement, Reporting and Verification (M & MRV) in the Context of REDD+ Activities*. Rome: Food and Agricultural Organization. http://www.unredd.net/index.php?option=com_docman&task=doc_download&gid=10305&Itemid=53.

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