Development of Forest Carbon Monitoring Methodologies for REDD+

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Side Event, Bonn

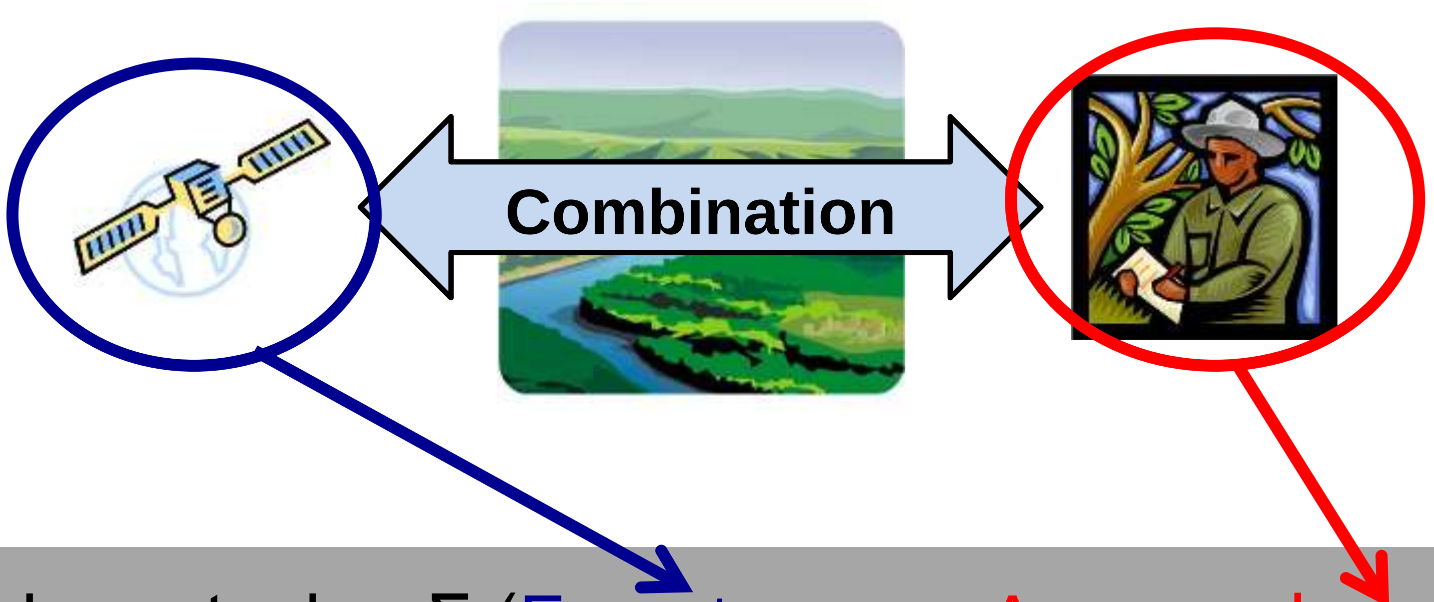
Mitsuo Matsumoto
Director of REDD Research and Development Center,
Forestry and Forest Products Research Institute (FFPRI), Japan

Overview

- Tentative report from ongoing REDD+ project in Cambodia, Malaysia and Paraguay
- Development of forest carbon monitoring methods
- Capacity building
- REDD+ Guidelines

How to estimate nationwide forest carbon stocks

- To establish national forest monitoring systems, use a combination of **remote sensing** and **ground-based forest carbon inventory** approaches for estimating forest carbon stocks and forest area changes.



Total carbon stock = Σ (Forest area$_i$ x Averaged carbon stock$_i$)

- The method is the calculation of carbon stock by monitoring forest land and summing up the forest area and its averaged carbon stock for important forest types.

Monitoring land uses and land-use changes using remote sensing techniques

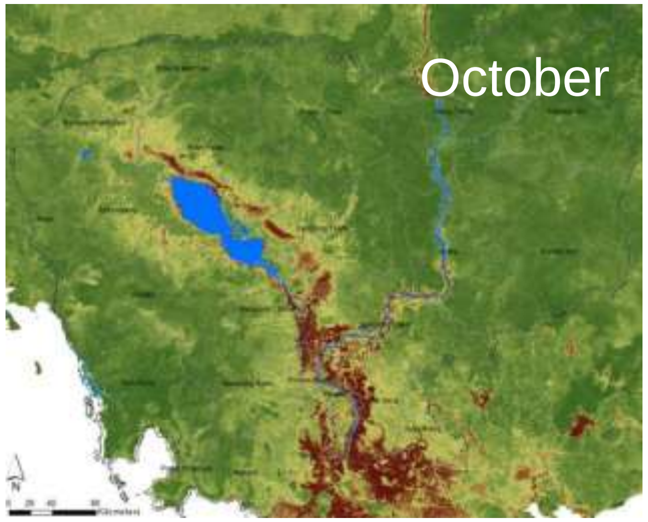
Total carbon stock = Σ (Forest area$_i$ x Averaged carbon stock$_i$)

The present challenges of RS techniques:
“ Automatic classification in seasonal forest”

Key points on Remote Sensing Technique for REDD+

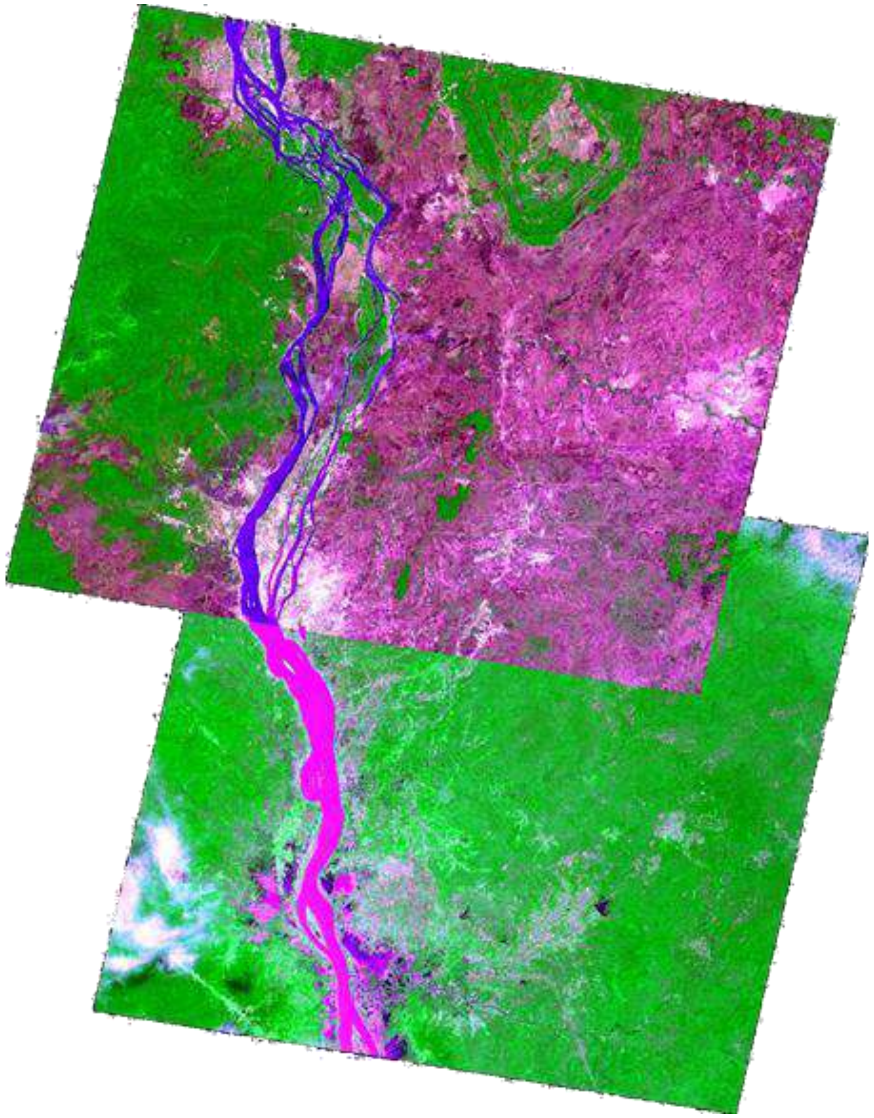
1. Removing cloud and haze
2. Removing seasonality of forests
3. Classification of land uses and forest types using object-based classification technique
4. Time-series analysis of forest maps

Issue of seasonality in seasonal forests

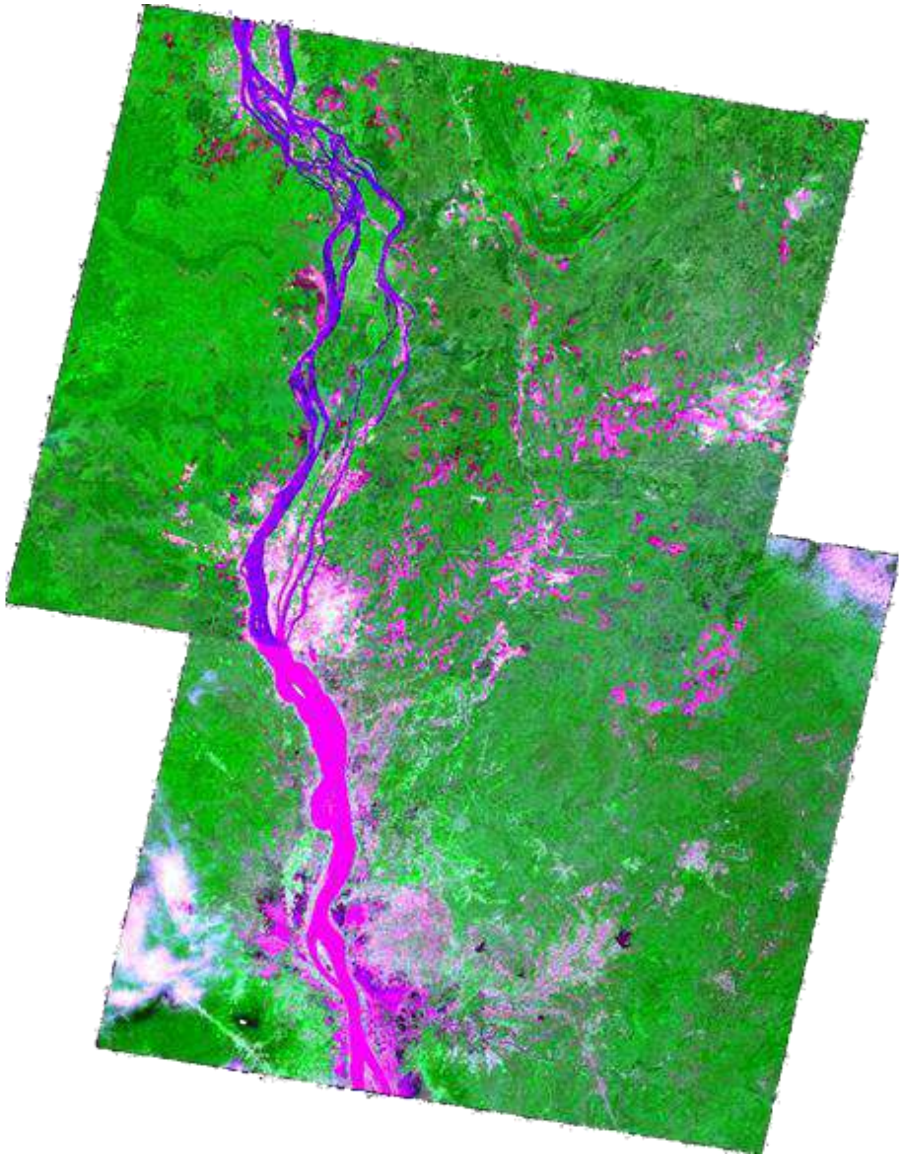


NDVI values in deciduous forests highly fluctuate according to the season.

Standardization of images with algorithm for reducing the effect of seasonality

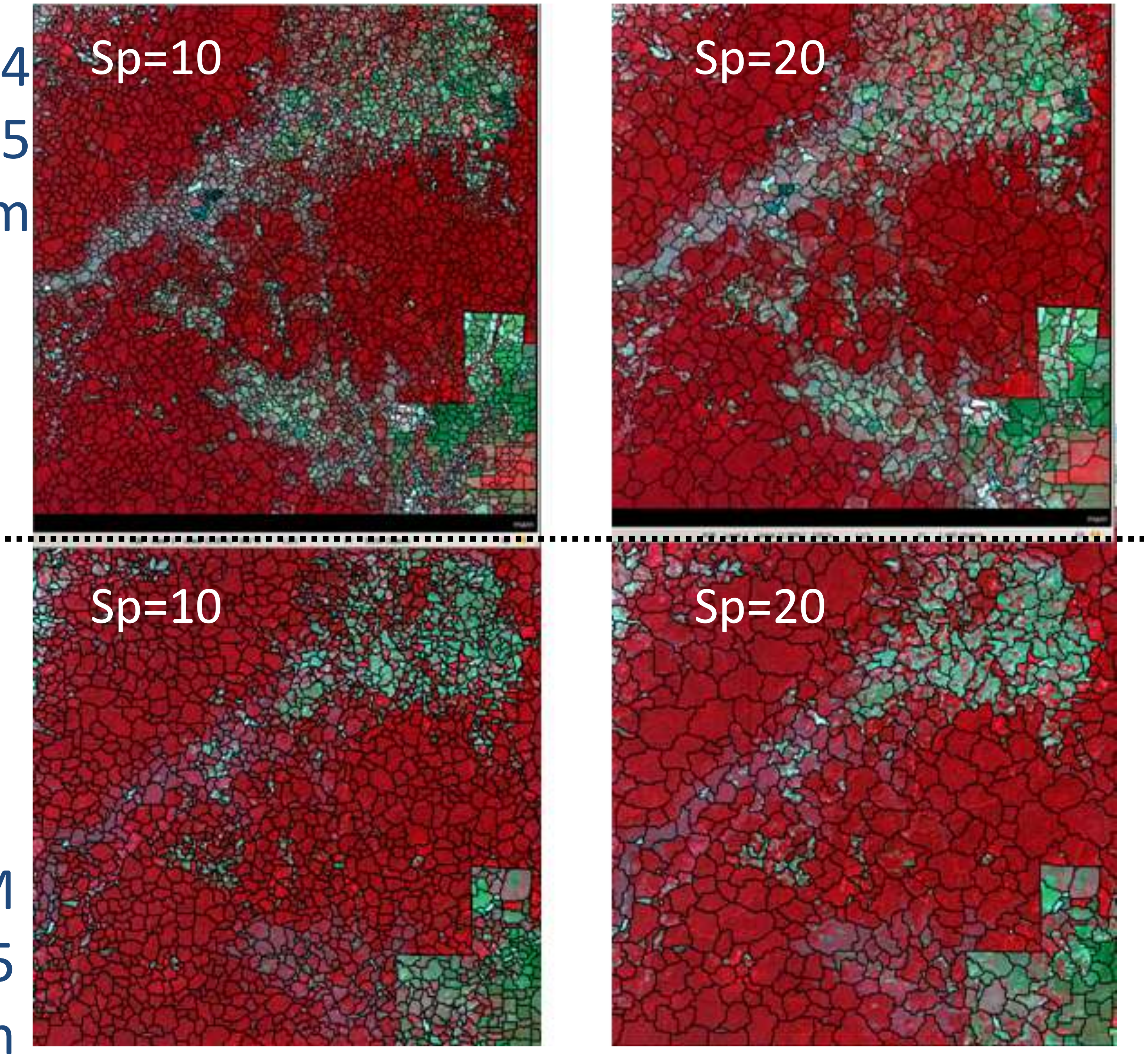


SPOT images (upper: the end of dry season, lower: the beginning of dry season)



Reduction of effect of seasonality by standardizing images with developed algorithm.

Adjusting parameters of Object-based classification for different ground resolutions



SPOT 4
2006.02.05
Resolution: 20m

Appropriate parameter setting in classification made it possible to compare multi-temporal results from satellite images with different ground resolutions.

Landsat TM
2006.02.05
Resolution: 30m

Monitoring forest carbon stocks by ground measurements under a sampling system

Total carbon stock = Σ (Forest area$_i$ x Averaged carbon stock$_i$)

The present challenges of ground base sampling:
“ Development of accurate and simplified measuring methods”

How to estimate averaged carbon stock

- Applying Permanent Sampling Plots (PSPs)
- Estimating biomass using allometry equations
- Appropriate forest type classifications for reduction of uncertainty
- Estimating carbon stock changes with repeated measurements

Example of forest type classifications

Cambodia
Evergreen forests (including Semi-evergreen forests)
Deciduous forests

Malaysia
Lowland dipterocarp forests
Hill dipterocarp forests

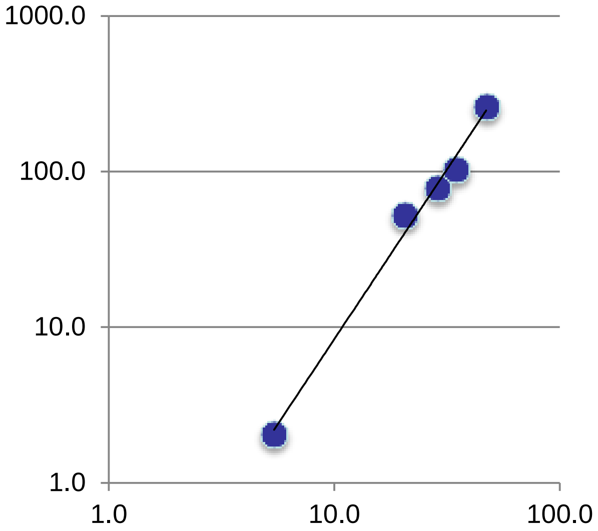
Approach to Reduce Uncertainty

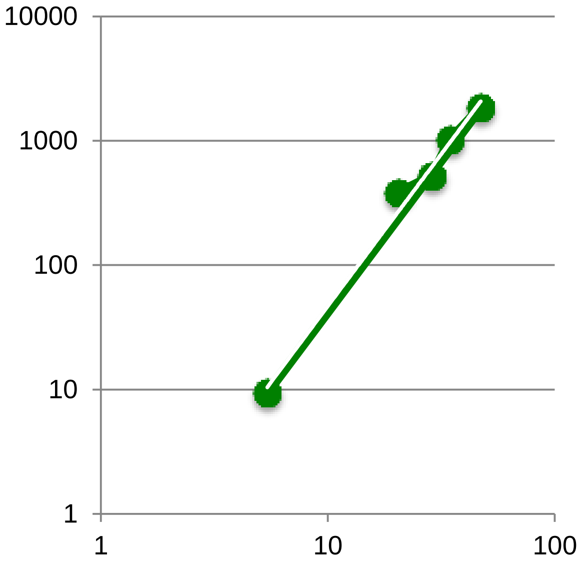
Setting up distinct stake within each sampling plot

Marking measuring position

Making clear rules for DBH measuring

Developing new allometry equations in blank biomes





Destructive sampling in Cambodia

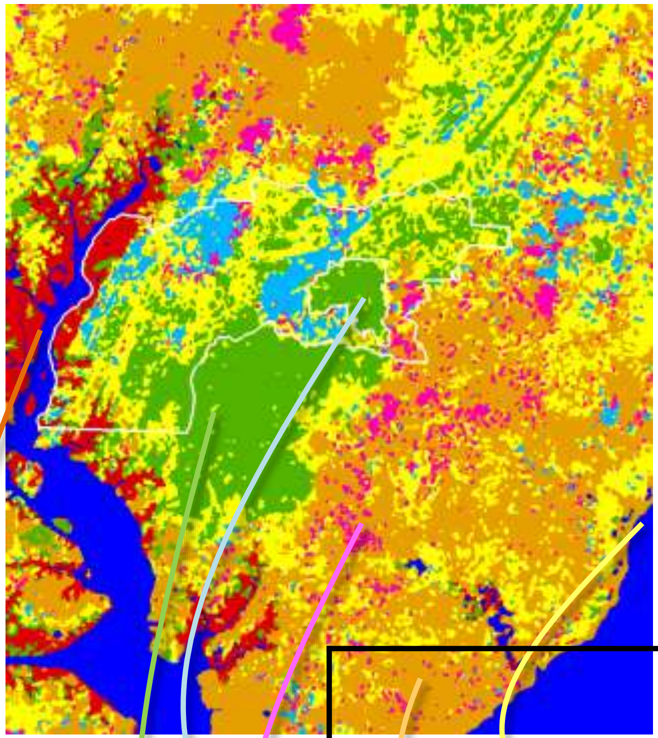
[Tropical monsoon forests]

Destructive sampling in Paraguay

[Alto Parana forests]

A trial in Peninsula Malaysia: Ground-based inventory of C stocks by forest types

Y Year



Inventories at sampling plots for each forest type

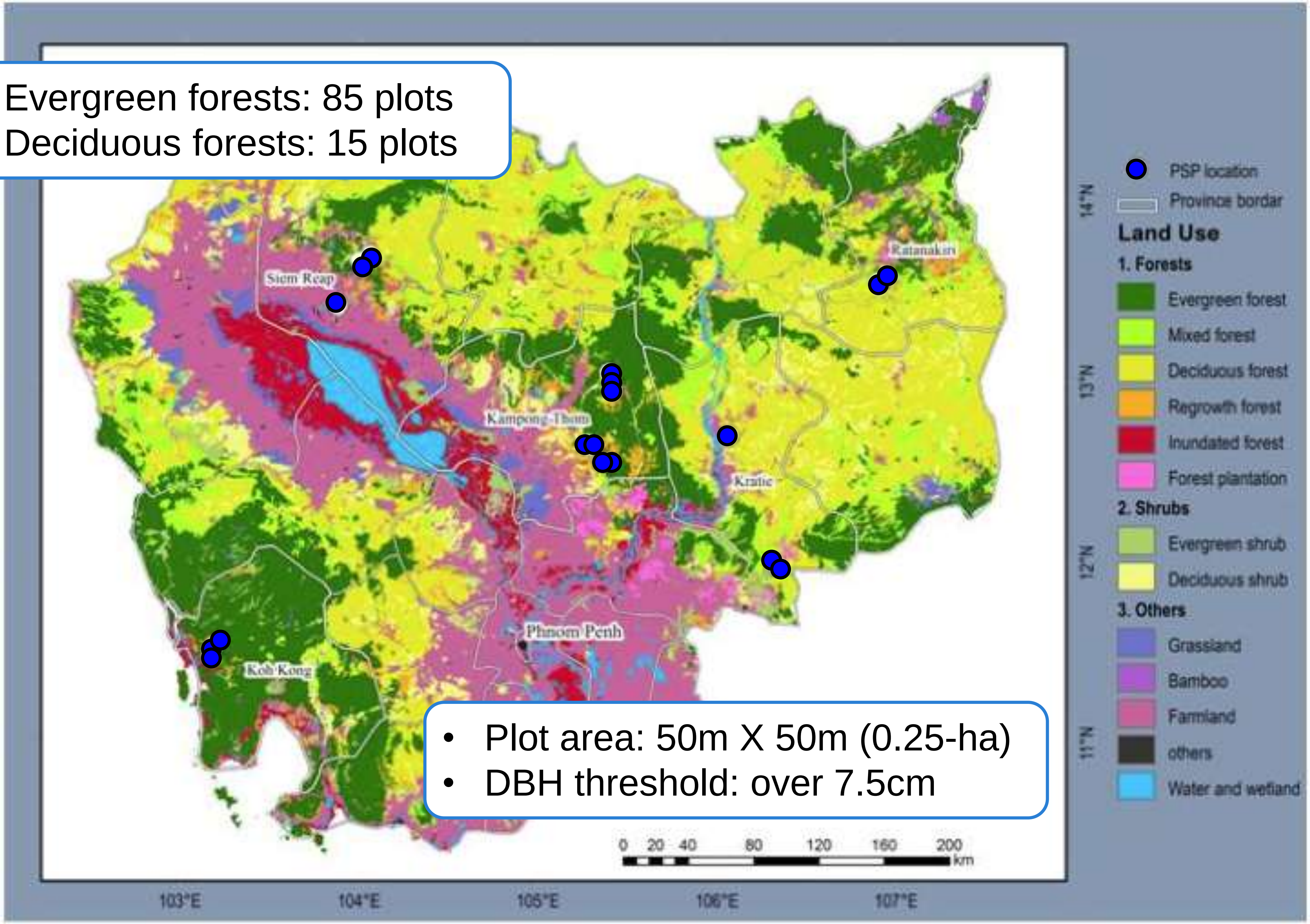
	Undisturbed	Disturbed (logged-over) Logged within 10 yrs	Disturbed (logged-over) Logged before10 yrs or more
Lowland forests	🟥 mean ± SE	🟧 mean ± SE	🟨 mean ± SE
Hill forests	🟩 mean ± SE	🟪 mean ± SE	🟦 mean ± SE

Case study for carbon stock estimation using PSPs data

- Cambodia's case-

Forest cover map (2006) and locations of FA's PSPs in Cambodia

- Evergreen forests: 85 plots
- Deciduous forests: 15 plots



- Plot area: 50m X 50m (0.25-ha)
- DBH threshold: over 7.5cm

National-wide forest carbon stocks in Cambodia (tentative)

Forest Types	Forest Area （2006） Unit: ha	Average Carbon Stock （2000～2001） Unit: t-C/ha	Carbon Stock Unit: Mt-C
Evergreen Forests (inc. Semi-evergreen forests)	5,031,540	163.8 ± 7.8	824.2 ± 39.2
Deciduous Forests	4,692,098	56.2 ± 6.7	263.9 ± 31.3
Total	9,723,638		1,088.1 ± 50.2

Source: Samreth et al.

Values of carbon stocks are shown as average with SE

How many plots are required?

- Calculated required plots number using 2001’s PSP data on the assumption that precision level was 5% at a 95% confidence intervals.

336 plots are needed in national scale.

- Breakdown was 260 plots for evergreen forests and 76 plots for deciduous forests
- Establishment cost was estimated as USD336,000.
- Need only 71 plots if we applied 10% as precision level.

- However some sampling plots would be destroyed due to deforestation and degradation.
- Additional plots number would need under the condition of deforestation and degradation.

Methods to Estimate Carbon Stock Changes

Default Method or Gain-Loss Method

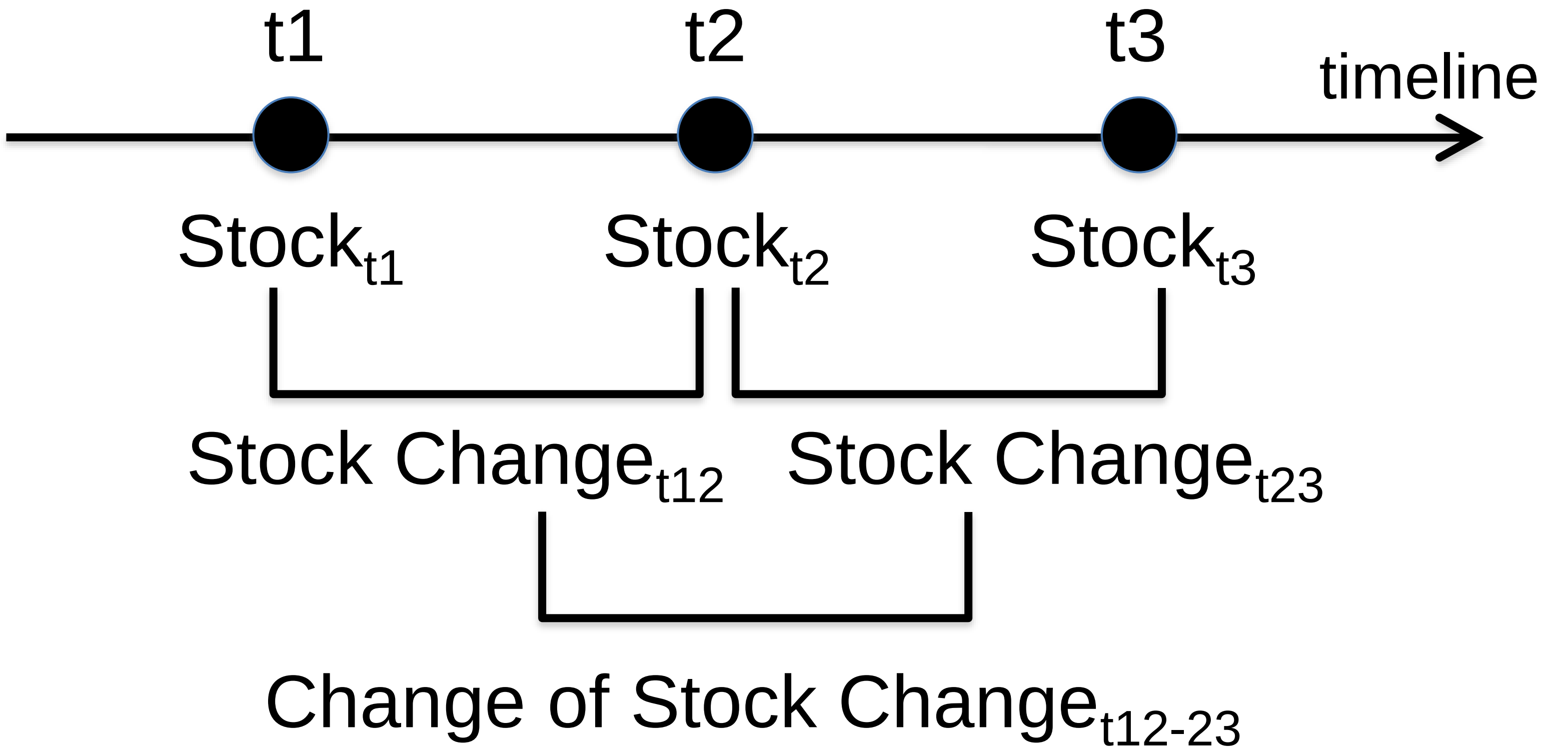
Changes in carbon stocks

= Gain by growth – Loss by disturbance

Stock Change Method or Stock-Difference Method

Changes in carbon stocks

= (Carbon stocks$_{t2}$ – Carbon stocks$_{t1}$)/(t2 - t1)



t1 t2 t3 timeline

Stock$_{t1}$ Stock$_{t2}$ Stock$_{t3}$

Stock Change$_{t12}$ Stock Change$_{t23}$

Change of Stock Change$_{t12-23}$

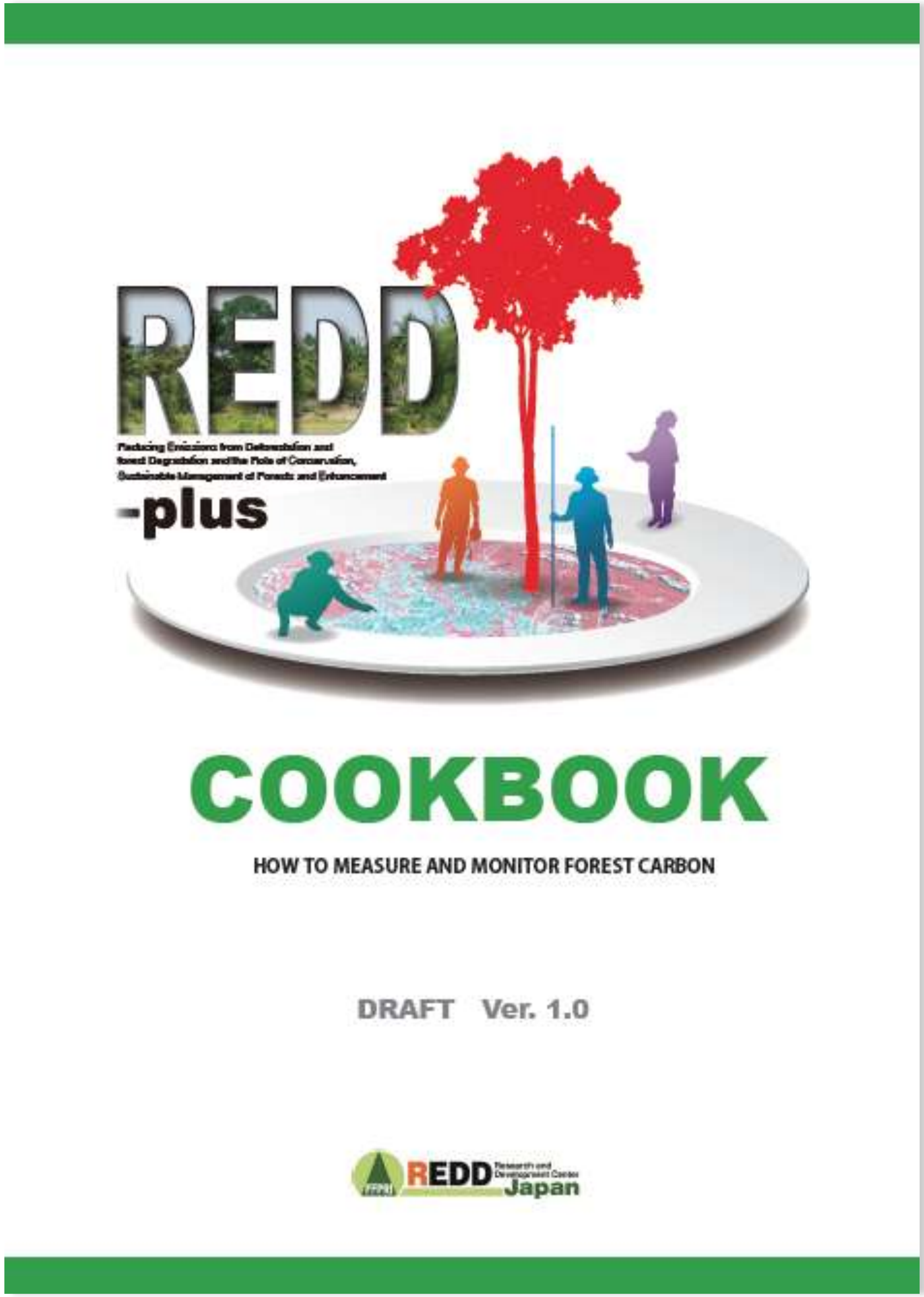
For establishment of long-term monitoring

Not only scientists

But also local people!

- Building capacity in partner countries
- Development of simplified techniques with high accuracy

Technical Guide Book for REDD+



REDD

Reducing Emissions from Deforestation and
forest Degradation and the Role of Conservation,
Sustainable Management of Forests and Enhancement

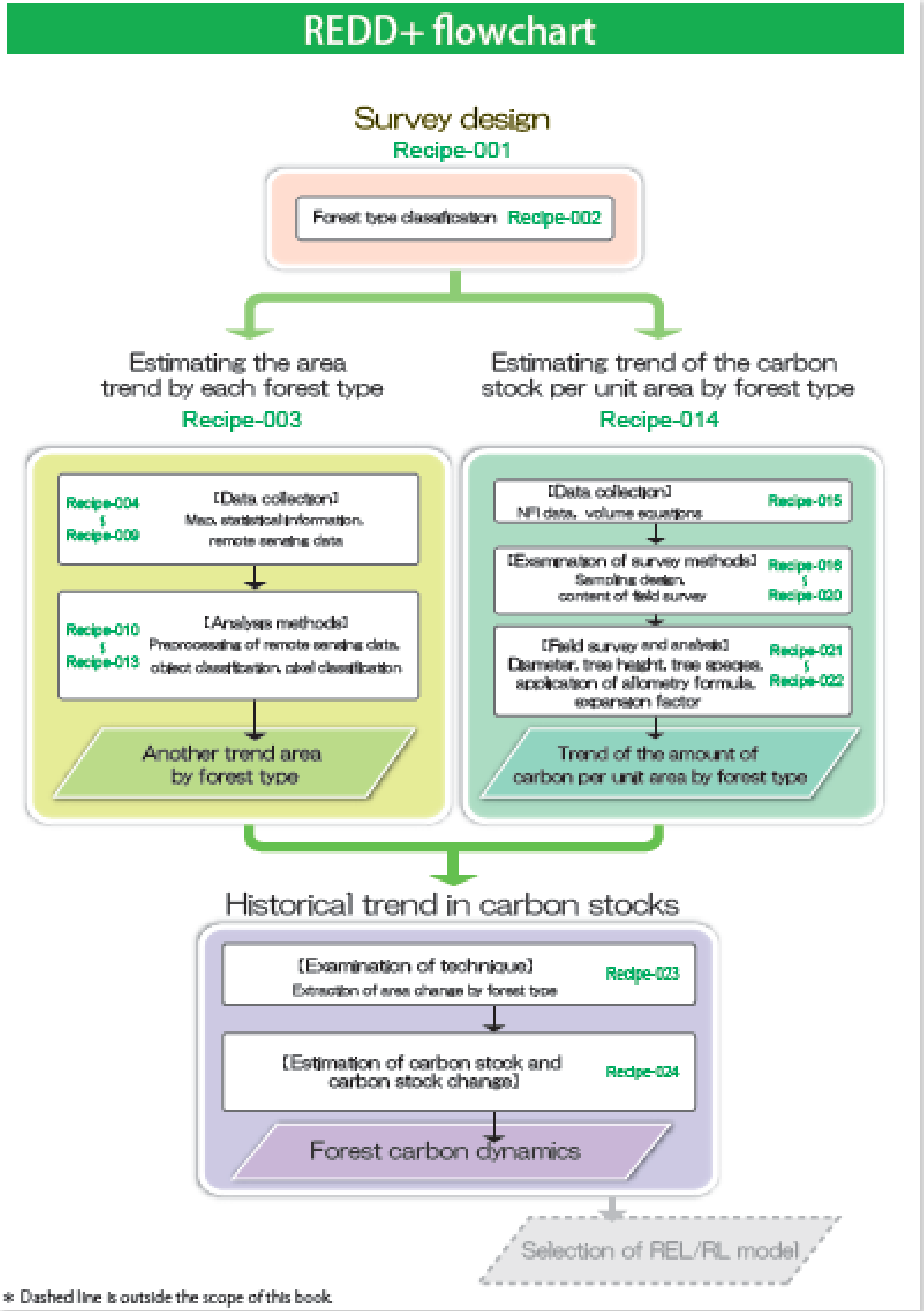
-plus

COOKBOOK

HOW TO MEASURE AND MONITOR FOREST CARBON

DRAFT Ver. 1.0

REDD Research and Development Center Japan



REDD+ flowchart

Survey design
Recipe-001

Forest type classification Recipe-002

Estimating the area trend by each forest type
Recipe-003

【Data collection】 Recipe-004 ～ Recipe-009
Map, statistical information, remote sensing data

【Analysis methods】 Recipe-010 ～ Recipe-013
Preprocessing of remote sensing data, object classification, pixel classification

Another trend area by forest type

Estimating trend of the carbon stock per unit area by forest type
Recipe-014

【Data collection】 Recipe-015
NFI data, volume equations

【Examination of survey methods】 Recipe-016 ～ Recipe-020
Sampling design, content of field survey

【Field survey and analysis】 Recipe-021 ～ Recipe-022
Diameter, tree height, tree species, application of allometry formula, expansion factor

Trend of the amount of carbon per unit area by forest type

Historical trend in carbon stocks

【Examination of technique】 Recipe-023
Extraction of area change by forest type

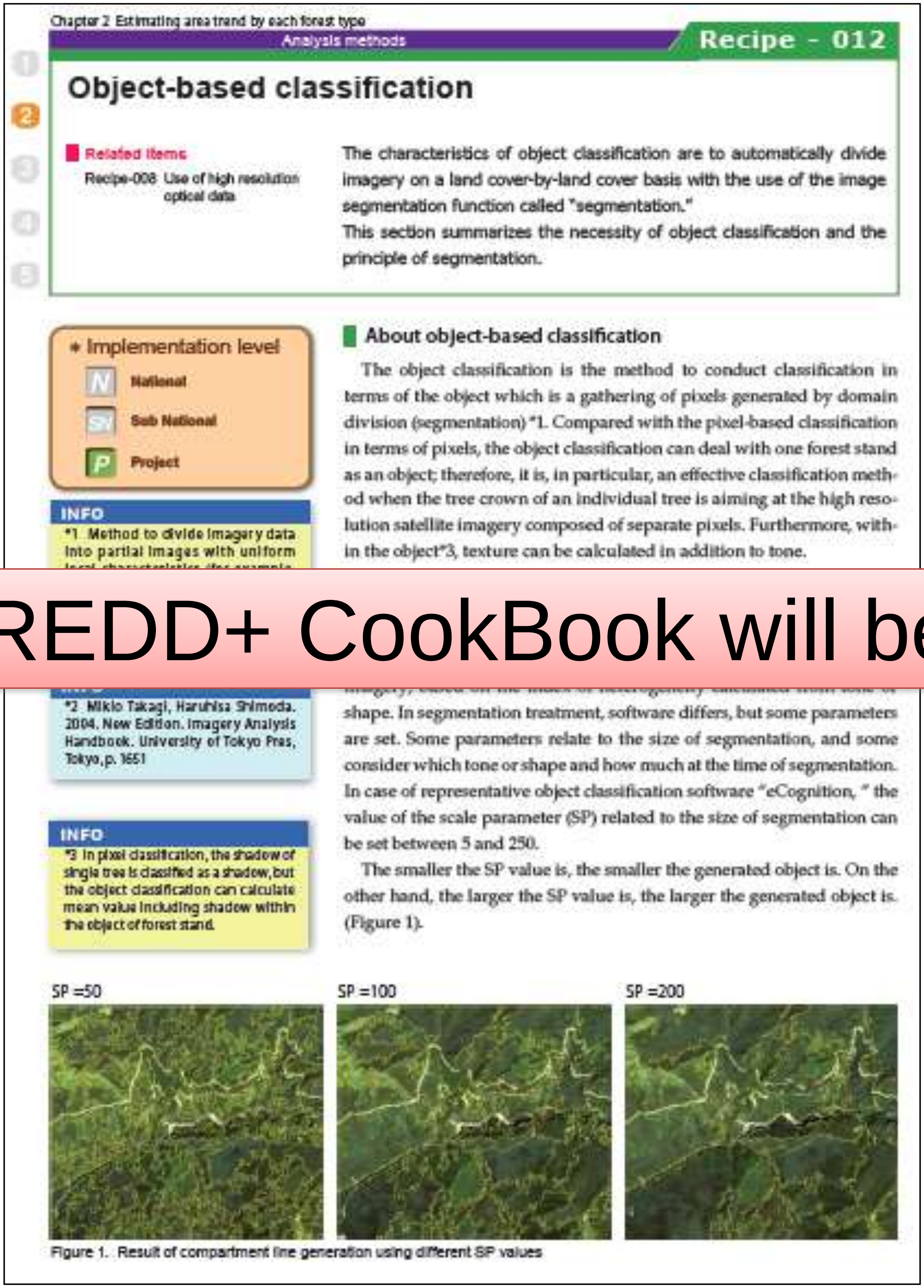
【Estimation of carbon stock and carbon stock change】 Recipe-024

Forest carbon dynamics

Selection of REL/RL model

＊Dashed line is outside the scope of this book.

Sample pages of REDD-plus Cook Book



Chapter 2 Estimating area trend by each forest type

Analysis methods

Recipe - 012

Object-based classification

Related items

Recipe-008 Use of high resolution optical data

The characteristics of object classification are to automatically divide imagery on a land cover-by-land cover basis with the use of the image segmentation function called "segmentation."

This section summarizes the necessity of object classification and the principle of segmentation.

Implementation level

N National

SN Sub National

P Project

INFO

*1 Method to divide imagery data into partial images with uniform

About object-based classification

The object classification is the method to conduct classification in terms of the object which is a gathering of pixels generated by domain division (segmentation) *1. Compared with the pixel-based classification in terms of pixels, the object classification can deal with one forest stand as an object; therefore, it is, in particular, an effective classification method when the tree crown of an individual tree is aiming at the high resolution satellite imagery composed of separate pixels. Furthermore, within the object*3, texture can be calculated in addition to tone.

shape. In segmentation treatment, software differs, but some parameters are set. Some parameters relate to the size of segmentation, and some consider which tone or shape and how much at the time of segmentation. In case of representative object classification software "eCognition," the value of the scale parameter (SP) related to the size of segmentation can be set between 5 and 250.

The smaller the SP value is, the smaller the generated object is. On the other hand, the larger the SP value is, the larger the generated object is. (Figure 1).

INFO

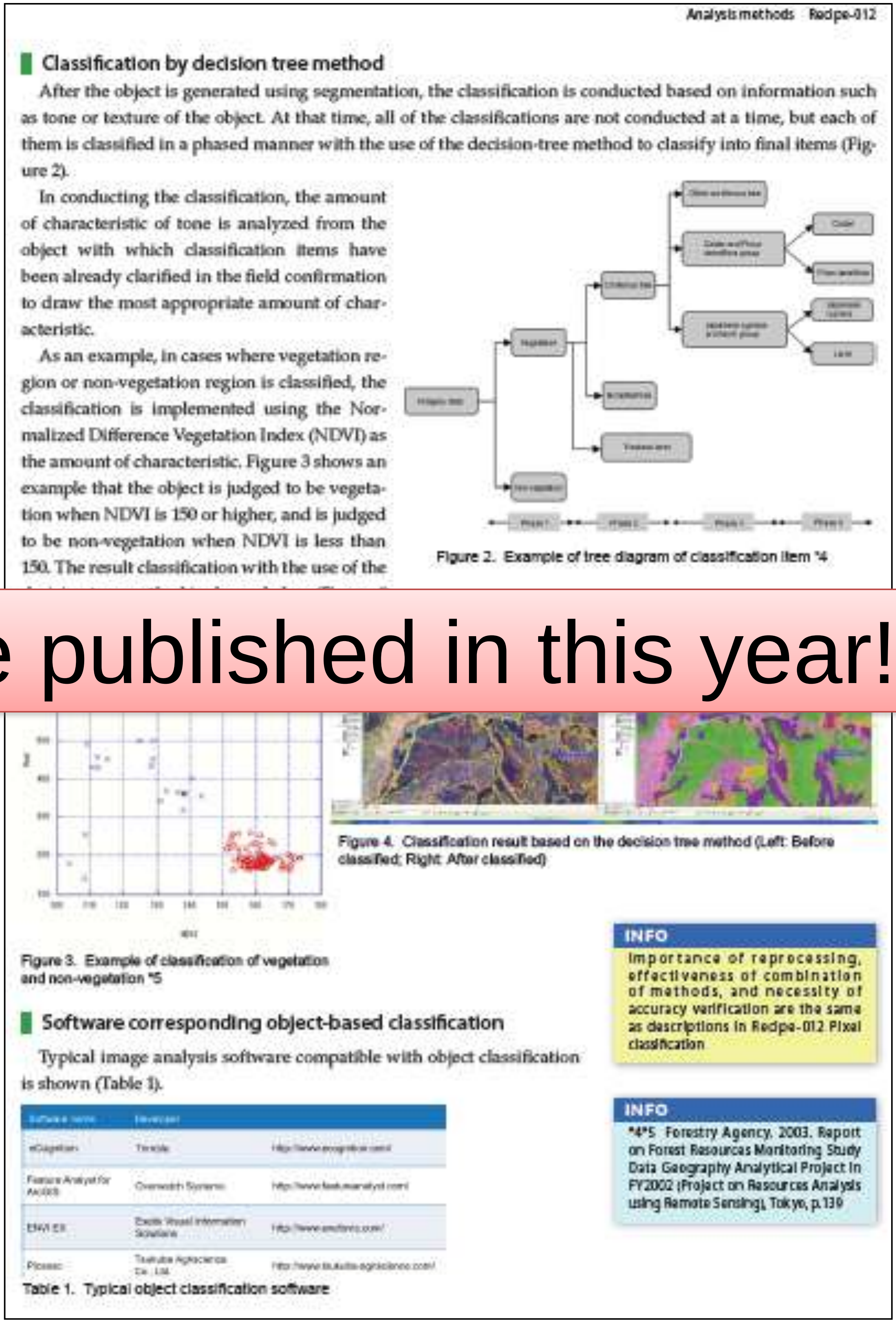
*2 Mikio Takagi, Haruhisa Shimoda. 2004. New Edition. Imagery Analysis Handbook. University of Tokyo Press, Tokyo, p. 1651

INFO

*3 In pixel classification, the shadow of single tree is classified as a shadow, but the object classification can calculate mean value including shadow within the object of forest stand.

SP =50 SP =100 SP =200

Figure 1. Result of compartment line generation using different SP values



Analysis methods Recipe-012

Classification by decision tree method

After the object is generated using segmentation, the classification is conducted based on information such as tone or texture of the object. At that time, all of the classifications are not conducted at a time, but each of them is classified in a phased manner with the use of the decision-tree method to classify into final items (Figure 2).

In conducting the classification, the amount of characteristic of tone is analyzed from the object with which classification items have been already clarified in the field confirmation to draw the most appropriate amount of characteristic.

As an example, in cases where vegetation region or non-vegetation region is classified, the classification is implemented using the Normalized Difference Vegetation Index (NDVI) as the amount of characteristic. Figure 3 shows an example that the object is judged to be vegetation when NDVI is 150 or higher, and is judged to be non-vegetation when NDVI is less than 150. The result classification with the use of the

Figure 2. Example of tree diagram of classification item *4

Figure 3. Example of classification of vegetation and non-vegetation *5

Figure 4. Classification result based on the decision tree method (Left: Before classified; Right: After classified)

Software corresponding object-based classification

Typical image analysis software compatible with object classification is shown (Table 1).

Table 1. Typical object classification software

INFO

Importance of reprocessing, effectiveness of combination of methods, and necessity of accuracy verification are the same as descriptions in Recipe-012 Pixel classification

INFO

*4*5 Forestry Agency. 2003. Report on Forest Resources Monitoring Study Data Geography Analytical Project in FY2002 (Project on Resources Analysis using Remote Sensing), Tokyo, p.139

REDD+ CookBook will be published in this year!

DVD for REDD+ Introduction

“Toward Implementation of REDD+ -Climate change and forest conservation-”

English and Japanese

- For training ABC of REDD+
- Contact to REDD Research & Development Center

E-mail:

redd-rd-center@ffpri.affrc.go.jp

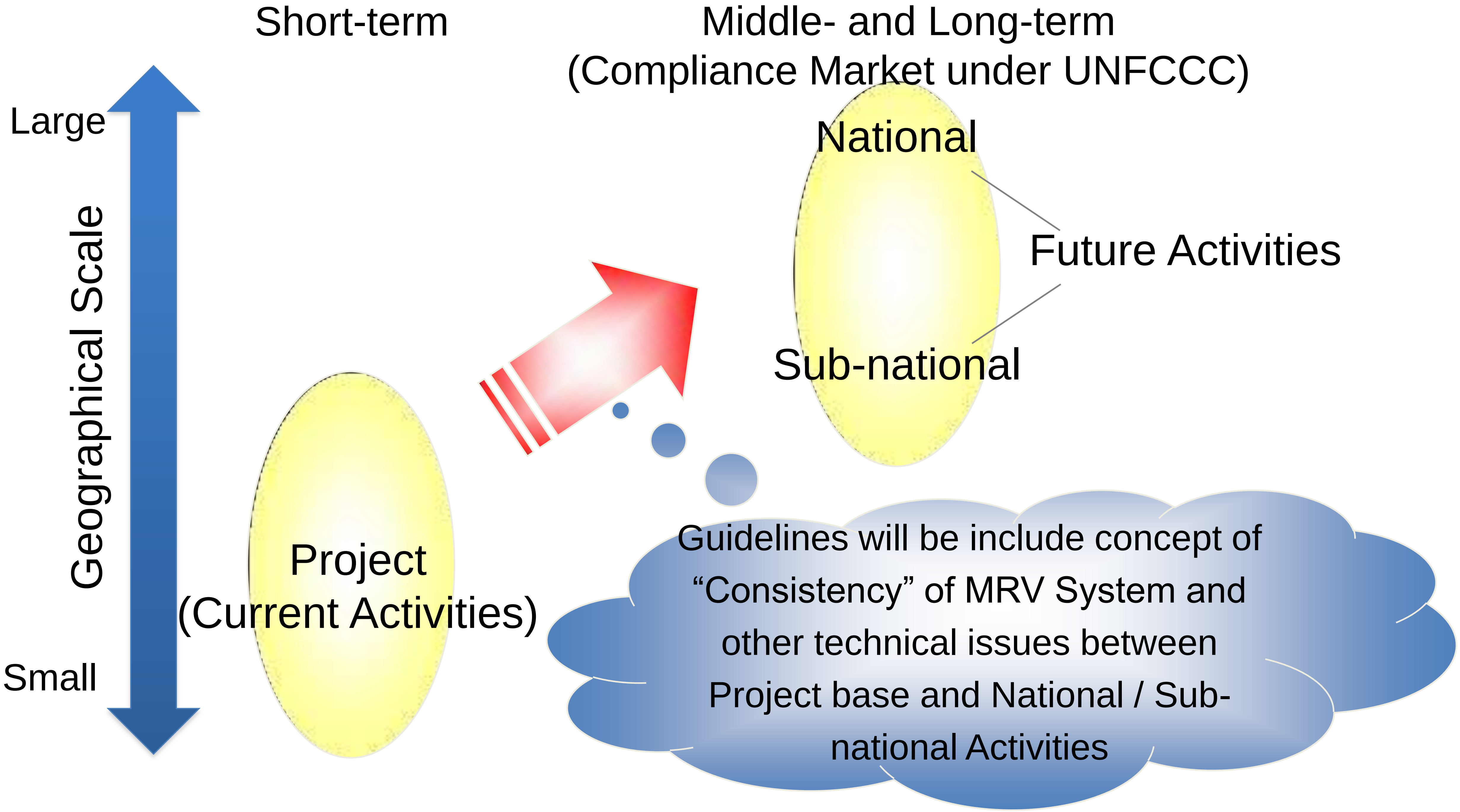
Available through Internet
http://agriknowledge.affrc.go.jp/RN/5020000136

Proposing REDD+ Guidelines

- UNFCCC negotiation on a framework of REDD+
- Japanese government is discussing “Bilateral Offset-Credit Mechanism (BOCM)”.
- We are elaborating REDD+ Guidelines, which would contribute to discussion under both UNFCCC and BOCM.
  - Key concept
    - To be operational
    - To respect decisions under UNFCCC
    - To consider Readiness activities

FFPRI REDD Research and Development Center Japan

Scaling-up Projects to National/SN



Short-term

Middle- and Long-term
(Compliance Market under UNFCCC)

Guidelines will be include concept of "Consistency" of MRV System and other technical issues between Project base and National / Sub-national Activities

Concept of Scaling-up
(from project base to sub-national/national base)

Conclusions

- Developing effective methodologies through collaboration with partner countries
- Forest carbon monitoring
  - applying new remote sensing techniques
  - repeated PSP measurements and developing allometory equations
- REDD+ Cook Book is coming soon
- Elaborating REDD+ guidelines

Thank you for your attention

Hill Dipterocarp Forest, Malaysia