Mangroves for the Future
INVESTING IN COASTAL ECOSYSTEMS

Mangrove carbon estimator and monitoring guide

Food and Agriculture Organization of the United Nations

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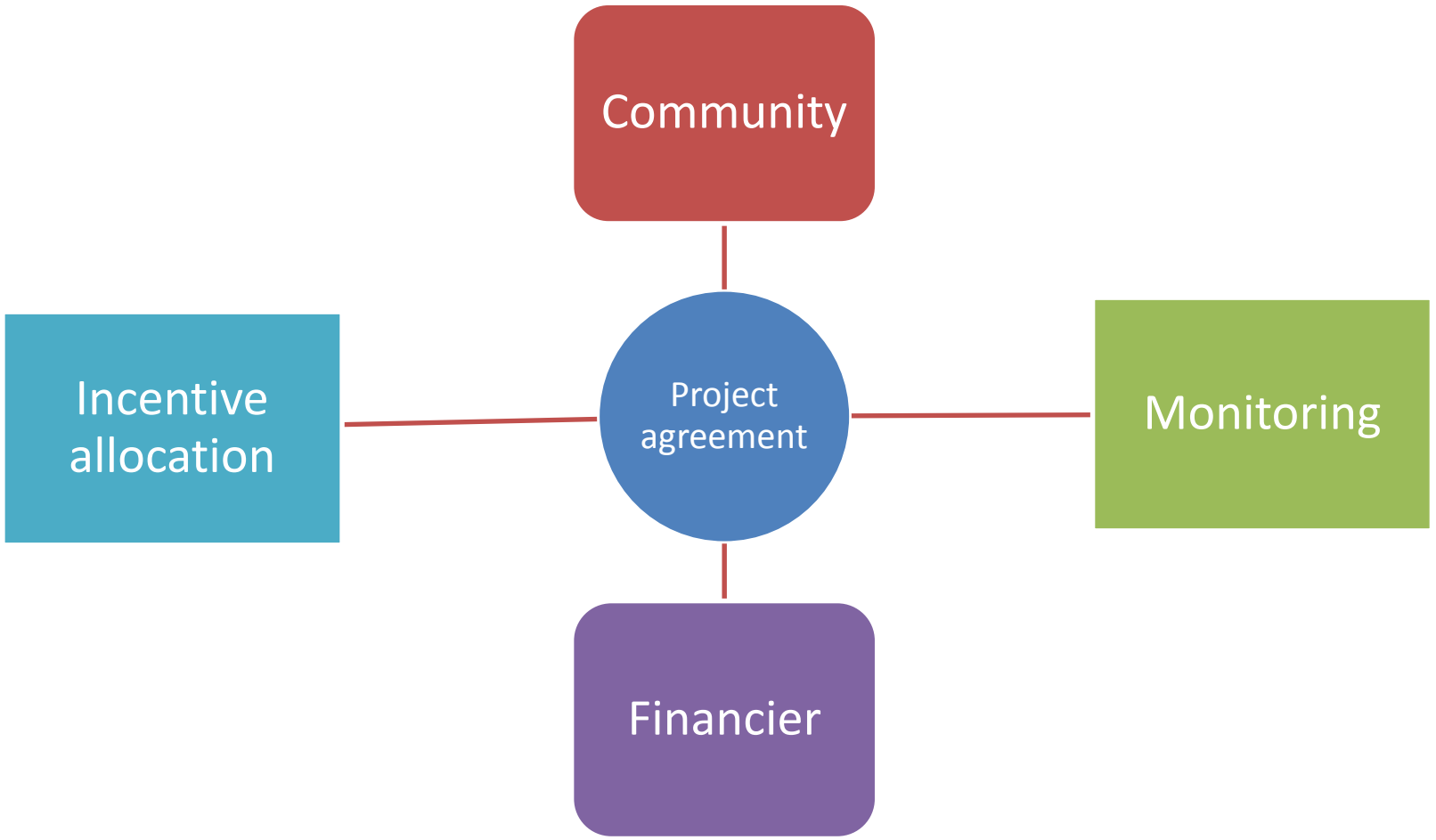
Overview

- Methodology for measuring mangrove carbon stocks and monitoring mangroves
- Provides the basis for incentive allocation
  - Verification of activity implementation
  - Verification of performance
- Integral part of project agreement
- Described in detail in the 'Mangrove carbon estimator and monitoring guide' publication (http://www.fao.org/3/a-i6500e.pdf)

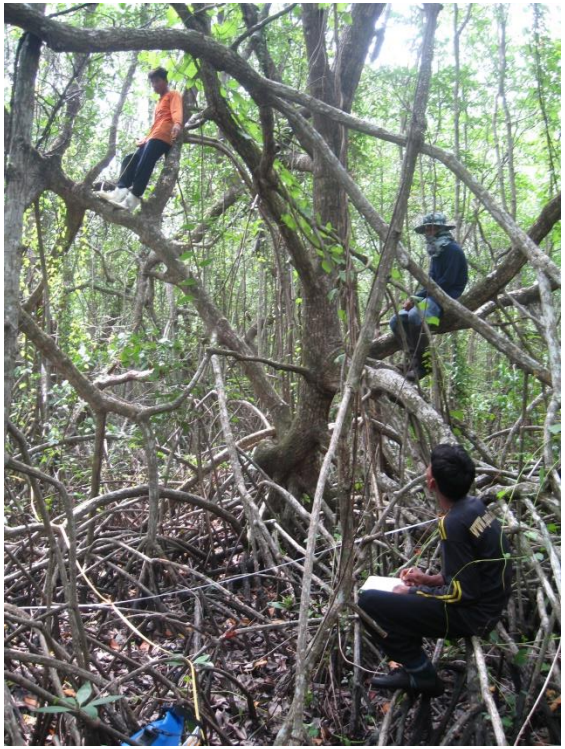
System structure



Overview

- Replicable and Scalable, Transparent, Participatory, Recognizable
- Provides proxy for other goods and services
- Protection of smaller mangrove areas
- Alternative/pre-cursor to carbon crediting
- Aimed at potential financiers
- Existing projects
- Assumes local community organization with standing and capacity

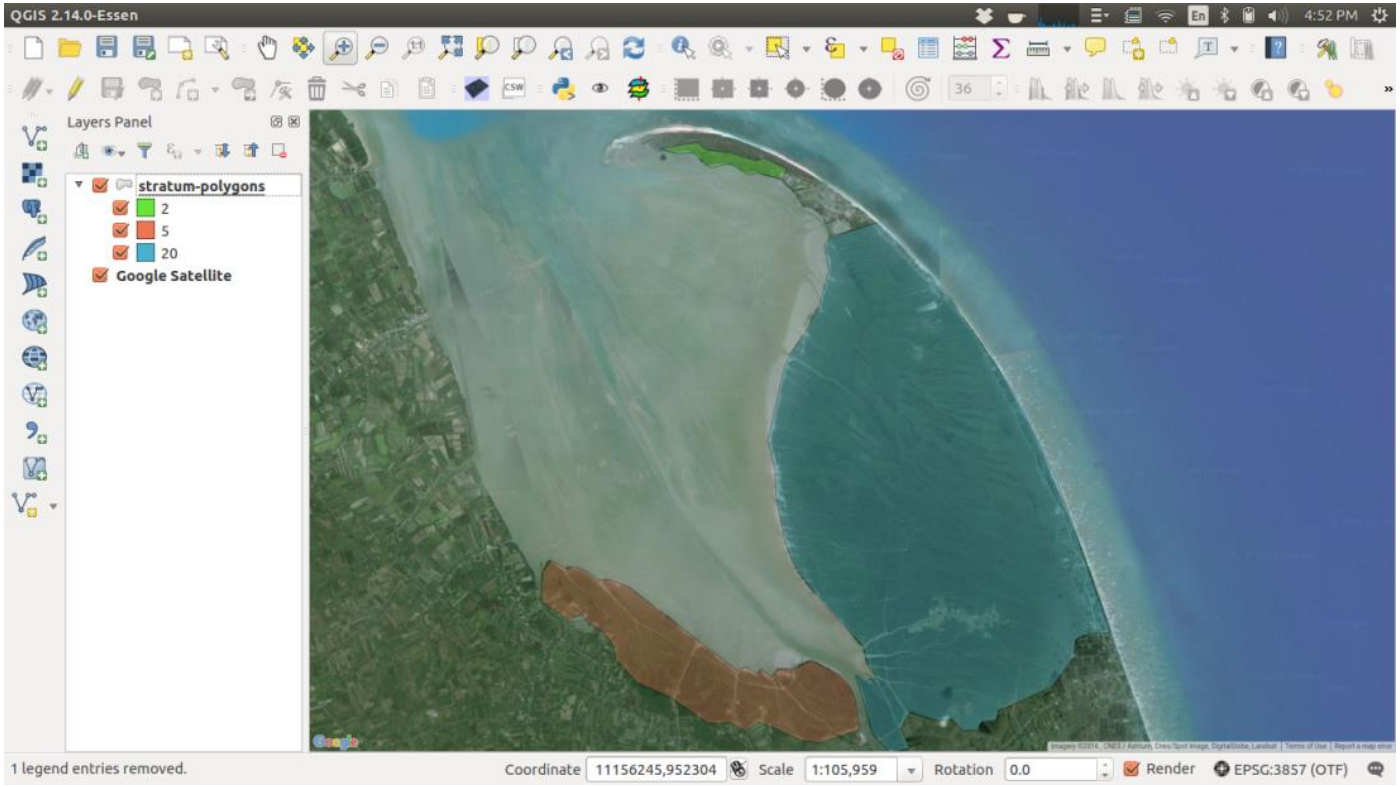
Carbon estimation and monitoring



1. Project area mapping
    i. Perimeter walk
    ii. Create polygon/s in QGIS
2. Carbon stock estimation
    i. Sample point selection
    ii. Basal area measurement
3. Mangrove monitoring
    i. Photo point monitoring
    ii. Analysis of high resolution satellite imagery
    iii. Patrolling and physical examination

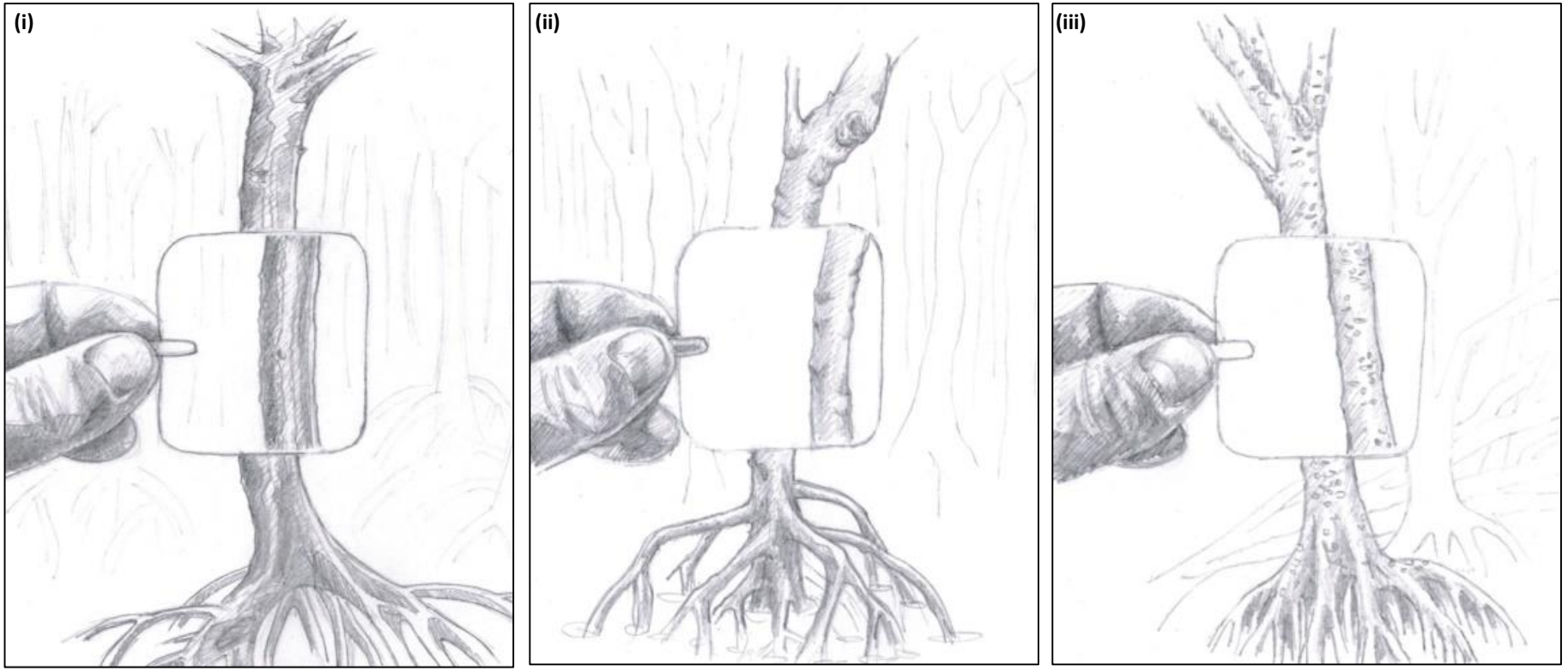
Project area mapping

GPS/phone and QGIS to delineate project area:



Carbon stock estimation

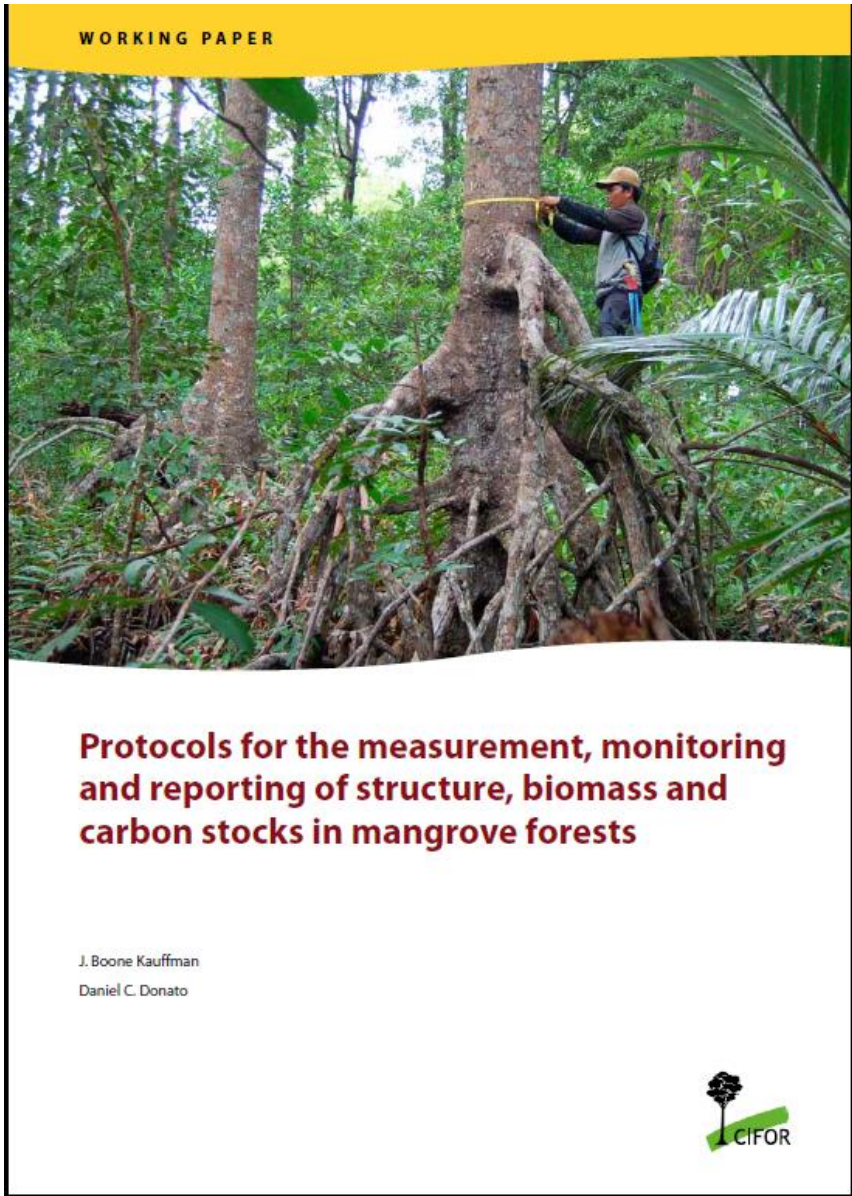
- Biomass and soil organic carbon stock estimated from latitude and mean basal area (and location)



Carbon stock estimation

Based on regression analysis of published data and validation using SWAMP methodology:

- Bukoski, J.J., Broadhead, J.S., Donato, D.C., Murdiyarso, D, Gregoire, T.G. 2016. The Use of Mixed Effects Models for Obtaining Low-Cost Ecosystem Carbon Stock Estimates in Mangroves of the Asia-Pacific. PLoS ONE.



Biomass carbon stock estimation

- Biomass carbon in metric tonnes per hectare
  - $= \beta_0 + \beta_1 \times \text{Basal area} + \beta_2 \times (\text{Basal area} \times \text{Latitude}) + \beta_3$
- Root-mean-square-error:
  - Fixed effects model: ±37.7 Mt C/ha (28.2%)
  - Mixed effects model: ±24.6 Mt C/ha (18.4%)
- Mean biomass carbon stock from model data:
  - 133.8 Mt C/ha
- Higher uncertainty but much lower cost

Soil carbon stock estimation

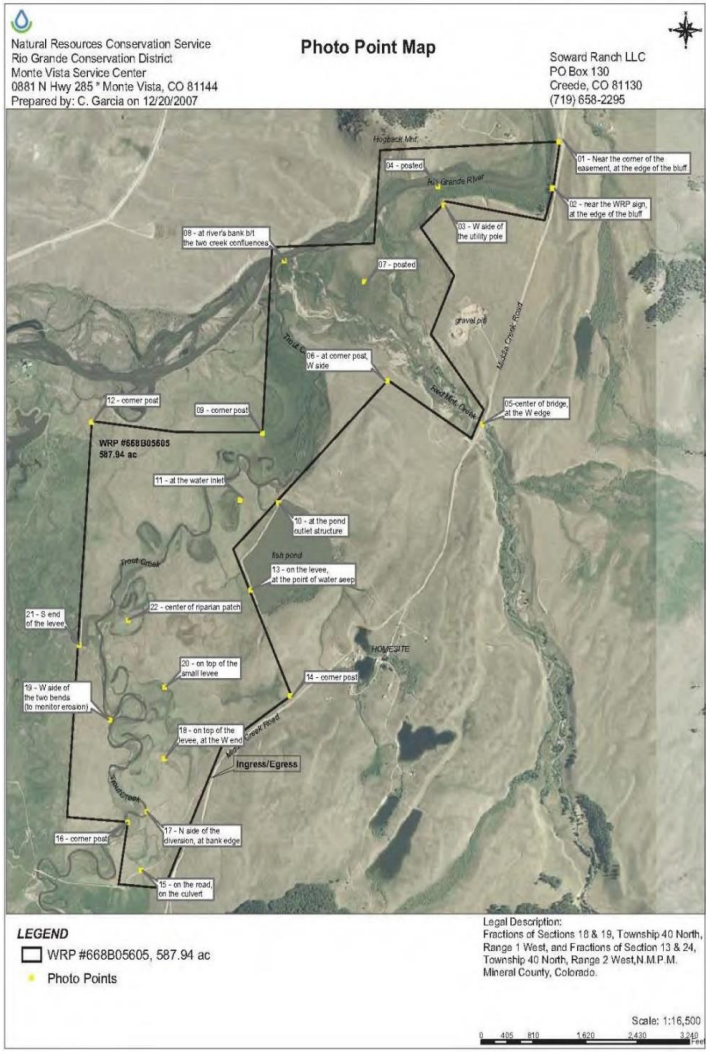
- Soil carbon stock in milligrams per cubic centimeter
  - $= \beta_0 + \beta_1 \times \log_e(\text{Latitude}) + \beta_2 \times \log_e(\text{Basal area}) + \beta_3$
  - multiply by soil depth in centimeters and then by 0.1 to give metric tonnes per hectare
  - (Soil depth measurements are taken at sampling plots)
- Root-mean-square-error:
  - Fixed effects model: ±13.4 mg C/cm3 (38.6%)
  - Mixed effects model: ±4.9 mg C/cm3 (18.4%)
- Mean soil organic carbon density from model data
  - 34.6 mg C/cm^3 (346 tonnes/ha to depth of 1m)
- Total 479 t/ha, low compared to CIFOR study

Mangrove monitoring

1. Photo point monitoring
2. Satellite image analysis
3. Global Forest Watch auto alerts
4. Mangrove patrolling
5. Monitoring of seedlings (restoration only)
6. Reporting

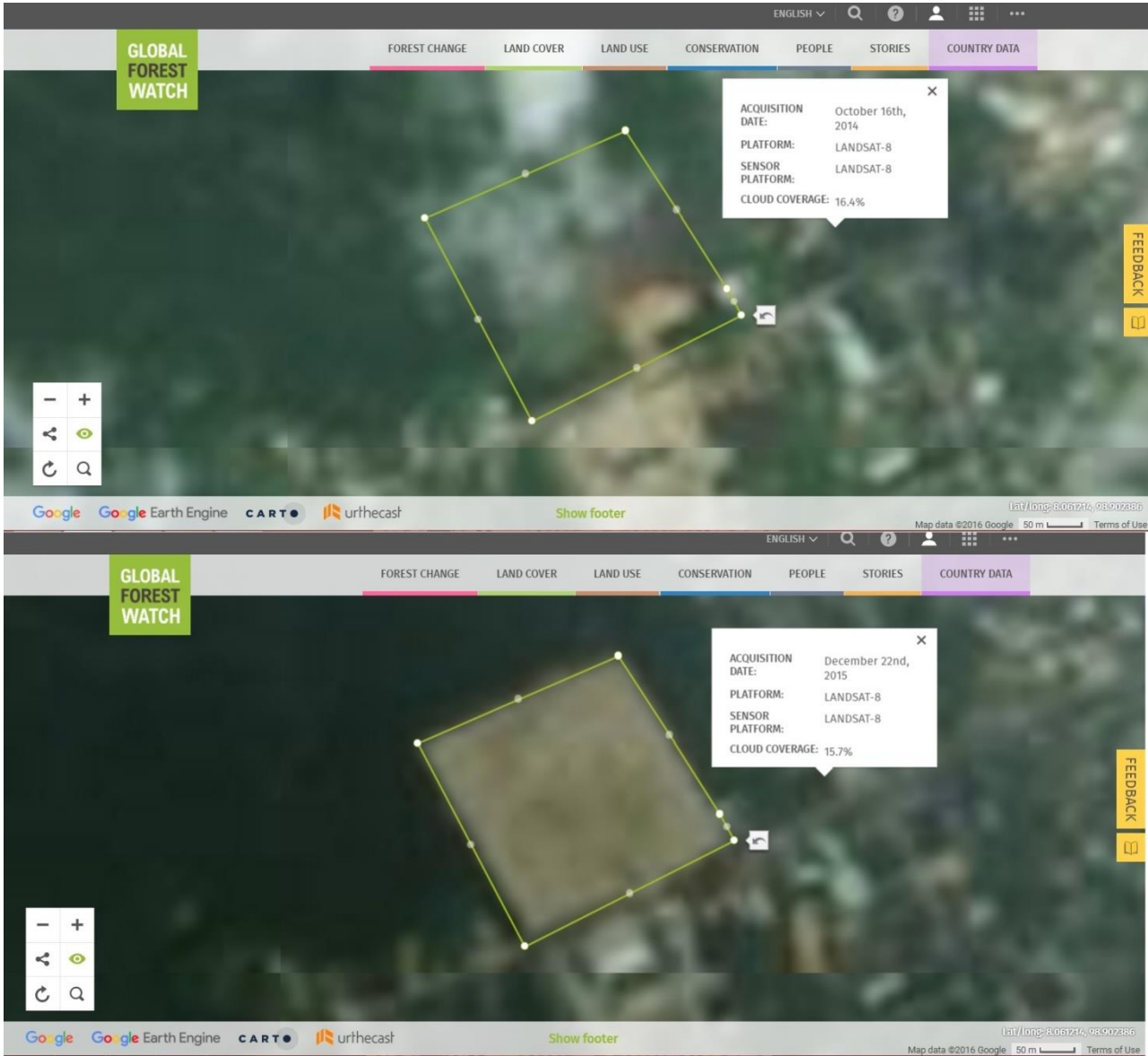
Photo point monitoring

- Photography of a point of interest at regular intervals from the same location



Satellite image analysis

Krabi,
October 2014 and
December 2015



Mangrove patrolling

- Undertaken by community members to prevent and detect encroachment
- Encroachment details included in monitoring reports

Monitoring of restored mangrove sites

1. Seedlings counted at randomly selected points using 5.6 metre string (100m^2)
2. Measure seedling height
3. Note seedling condition and probable cause of death

Reporting

1. Project area map (at the start of project, with updates as necessary)
2. Biomass and carbon stock estimation (at the start of project)
3. Photo point monitoring map, photos and analysis (at project start and 6-month intervals)
4. Satellite images and analysis (at project start and 6-month intervals)
5. Results of physical monitoring of recently restored mangroves (monthly for 3 months then every 3 months up to 2 years)

Mangrove mapping exercise

1. Walk perimeters of selected strata
   i. Three groups, three strata
   ii. Use GPS and/or phone apps
2. Upload tracks to QGIS
3. Create area boundary (polygons layer)
4. Calculate area of each stratum