BRIEF No. 48

World Agroforestry Centre

# Improving community-based carbon-stock monitoring: lessons from Batu Majang, East Kalimantan, Indonesia

photo: Subekti Rahayu/World Agroforestry Centre

## Introduction

The Reducing Emissions from Deforestation and Degradation plus conservation (REDD+) mechanism that was introduced under the United Nations Framework Convention on Climate Change has involved reducing emissions from deforestation and forest degradation, conserving forest carbon-stock, enhancing forest carbon-stock, practising sustainable forest management and conserving biodiversity (Brofeldt et al 2014). Communities that surround a forest and interact with it on a daily basis, who well understand the condition of the forest and who receive benefits from it are potential contributors to REDD+ activities.

Batu Majang Village, located in an enclave of a private concession forest in Mahakam Hulu District[1] in East Kalimantan Province, Indonesia, proposed to conserve a patch of about 500 ha of forest as 'customary forest' owing to the environmental services provided by the forest, such as water, timber, medicines and erosion control. This customary forest, thus, also became a strategic area for conserving carbon stock and the biodiversity of indigenous or endemic commercial timber and animal species, such as the hornbill, a cultural and ecological symbol of Kalimantan.

[1] Previously called Kutai Barat District when the work was conducted.

## Highlights

- Community-based carbon stock measurement can be an effective and efficient mode for monitoring carbon stock at plot level. A case study from Batu Majang, East Kalimantan, Indonesia provided a test and lessons.
- Prior to monitoring work, training was provided to the local community: a simple method of biomass estimation was applied.
- The community's work and results were tested against measurements by a professional forester and the results indicated that accuracy of the measurements by the local community improved significantly after the second iteration of training.
- Potential sources of errors were analysed and documented and ways to improve were summarised for more reliable community-based, carbon-stock measurements.

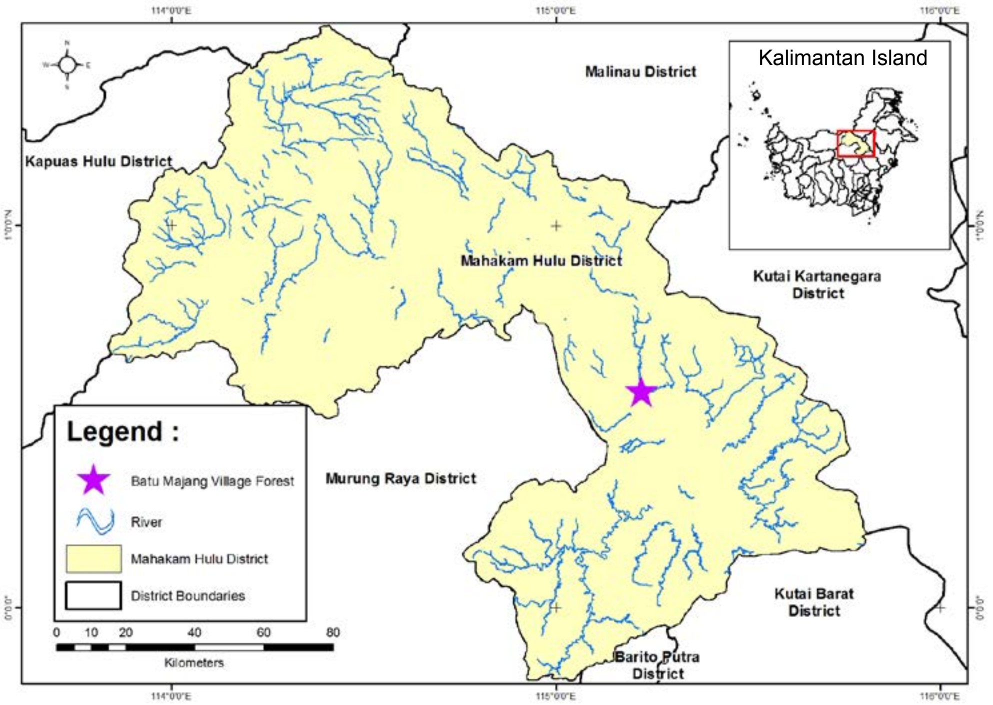



Figure 1. Study site, Batu Majang Village Forest, Mahakam Hulu District

## Community-based carbon stock measurement can be an effective and efficient mode for monitoring carbon stock at plot level. A case study from Batu Majang, Indonesia provided a test and lessons.

Maintenance of trees as part of conserving aboveground carbon stock needs monitoring that can be applied efficiently, sustainably and reliably. Involving communities in carbon-stock monitoring is considered an effective approach owing to the proximity of community dwellings to the forest in question and residents' understanding of forest and weather conditions. For community-based monitoring, a simple and cost-effective method should be developed and training conducted prior to monitoring, with evaluation of the results and the community's reliability. Tests of the reliability of community monitoring of carbon stock were conducted in Batu Majang by evaluating results relative to those of a professional forester.

## Prior to monitoring work, training was provided to the local community in which a simple method of biomass estimation was applied.

Training in community-based, carbon-stock monitoring, which included learning to operate a geographic position recorder, was conducted in Batu Majang Village in two iterations in 2011 and 2013. In the first iteration, focus-group discussions were held with the community to collect information about the condition of the customary forest, plot samples were designed and people selected to be involved in the monitoring. Most of the participants in the first iteration had experience of conducting a tree survey through their casual work in the concession.

For community-based monitoring, only one of five carbon pools was used: aboveground carbon-stock of tree biomass. Trees of more than 10 cm diameter at breast height (DBH) were measured in each plot and marked using fluorescent tape. Wood hardness and the local name of each tree were noted in circular plots of 9 m diameter (for trees 10–30 cm DBH) and 15 m diameter (for trees more than 30 cm DBH). The plots were in circular shape and were marked by drawing four ropes from a selected tree as centre point with the length being the radius of the circular plot.

Sixty-five (65) plots in the customary forest were identified for monitoring on a map with coordinate positions. Trained community members undertook initial measurements then a professional forester re-measured in the same plot and with the same method.

Tree biomass was estimated based on an allometric equation developed by Chave et al (2005) using DBH and wood density as variable calculations. Three categories of wood hardness were used to estimate carbon stock based on average values of density of soft (0.42 g $cm^{-3}$), medium (0.67 g $cm^{-3}$) and hard (0.95 g $cm^{-3}$) wood (http://db.worldagroforestry.org/wd). Carbon content of 46% biomass was used to estimate carbon stock (Hairiah et al 2011).

The second iteration of measurement was conducted and improvements were incorporated. The plot area was improved by adding four more ropes from the centre points, hence, eight ropes drawn to eight directions (Figure 2). Most of the community members involved in the second iteration were new to the method.

Figure 2. Drawing four ropes to mark the area for the first iteration (above); and eight ropes for the second iteration (below). (photo: Subekti Rahayu)

## The community's work and results were tested against measurements by a professional forester and the results indicated that accuracy of the measurements by the local community improved significantly after the second iteration of training.

The average values of carbon stock of the 65 plots measured by the community in the first iteration were significantly lower than those of the professional forester: 238 MgC $ha^{-1}$ and 293 MgC $ha^{-1}$, respectively. In the second iteration, the average values of carbon stock measured by the community increased significantly, close to those measured by the professional forester: 304 MgC $ha^{-1}$ and 288 MgC $ha^{-1}$, respectively (Figure 3).

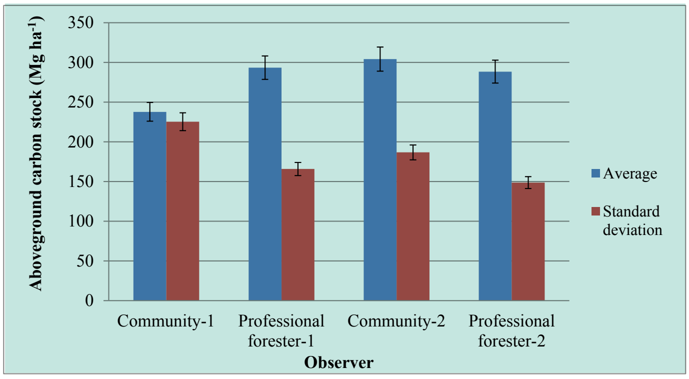
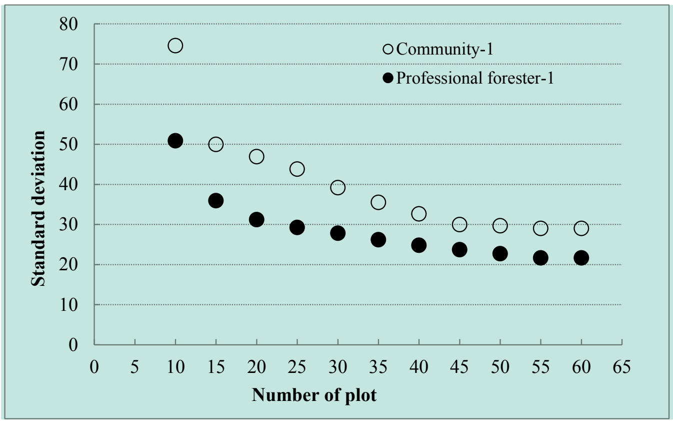



Figure 3. Average values and standard deviations of carbon stock measured by the community and professional forester in the first and second iterations



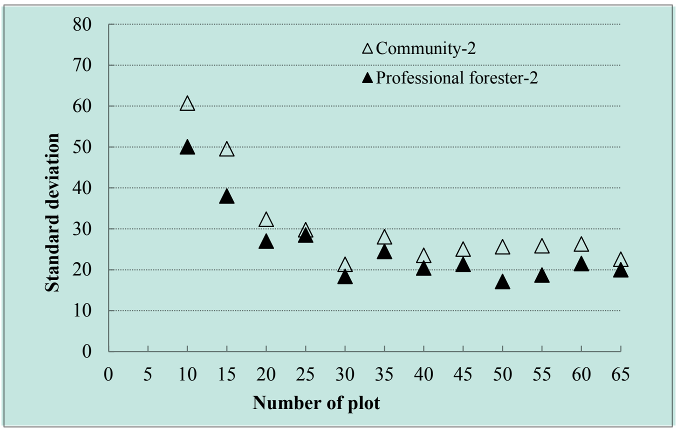




Figure 4. Average standard errors of random values of carbon stock at plot level during the first iteration (above); and second iteration (below)

This exercise showed that carbon-stock values measured by the professional forester were relatively consistent between the first and second iterations while there was a substantial discrepancy between the first and second iterations of the community.

For the second iteration, the average aboveground carbon stock and standard deviation of the community's measurements were close to that of the professional forester.

The minimum number of plots required by the community to reach the same standard error as the professional forester was also evidence of reliability in the measurement.

Average standard errors of random values from 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60 and 65 plots were applied in this analysis. In the first iteration, the community needed 45 plots to reach the same standard error as that achieved from 25 plots by the professional forester (Figure 4, above). Additional plots up to 65 did not ensure the same accuracy but had the effect of narrowing the distance of standard error by about 10.

In the second iteration, the community improved their accuracy and decreased the number of plots needed to reach the same standard error as that of the professional forester: from 45 to 30 plots. An additional number of plots up to 6 obtained the same standard error as the professional forester (Figure 4, below). This showed that in the second iteration, standard deviation was lower and closer to that of the professional forester's result.

## Potential sources of errors were analysed and documented and ways to improve were summarised for more reliable community-based, carbon-stock measurements.

Coverage area of each plot was the major factor identified as a potential source of error during the first iteration, which was improved in the second iteration. Using only four ropes drawn from the centre point as a means to mark the plot size was not sufficient, resulting in smaller coverage area and, thus, a lower number of trees recorded. On average, the number of trees recorded in each plot by the community was 77% of the number recorded by the professional forester. In the second iteration, eight ropes were drawn from the centre point, providing a more accurate delineation of the circular plots towards the boundaries. As a result, the community's monitoring increased the number of trees recorded up to 96% of the professional forester's count.

There were also minor factors that influenced the accuracy of the community's carbon-stock measurement.

1. *Mis-measurement*. Measuring the diameter of big trees at times requires more than one person. The community simplified the method by measuring the girth (Figure 5, right) but did not document the method properly nor advise of the change, which then affected the biomass calculation. In cases such as this, ensuring that the community follow the procedures exactly and take notes whenever necessary is a must.


**Figure 5. Suggested method for diameter measurement for a big tree (left); simplified method by measuring girth, as was commonly applied by community members (right). (photo: Subekti Rahayu)**

2. *Wood-hardness perception*. The community recorded 49% of total measured trees as medium wood-hardness whereas the professional forester recorded 42%. For hard wood, the community recorded 40% but the professional forester noted 49%. For some species, mostly non-commercial timber, the community found it difficult to decide on categorization as medium or hard. In high-density forest with big trees more than 60 cm DBH making up about 30% of total observed trees, this mistake undoubtedly affected the biomass calculation. Differentiating wood-hardness into two classes (hard and soft) instead of three classes (hard, medium and soft) will be easier for the community as they can easily distinguish between hard and soft wood.

The frequency of training did not necessarily influence the measurement results. From the two iterations, we concluded that almost all community members only received training once but could still carry out the tasks. Six of the 12 people involved in the first iteration had some experience with tree surveys but only three of the 12 in the second iteration. The improvement in the second iteration was mainly due to the improved method in marking plot area and size. Adding the number of ropes and drawing them in eight directions improved the measurement results significantly, reduced the number of missed trees and produced similar carbon-stock values to those of the professional forester.

The forest in Batu Majang had relatively uniform canopy cover and density; to obtain accuracy similar to that of the professional forester the community needed at least 45 plots. We presume that for more varied forests and tree density, a higher number of plots would be needed.

Lessons from Batu Majang show that providing a simple method in combination with clear guidelines is the best approach for community-based carbon-stock monitoring. Experience also shows that providing a second round of training, based on evaluation of the method and analysis of possible sources of errors, proved to be sufficient for improving capacity of the community.

### Primary source

The methods and results presented in this brief were published in Brofeldt et al (2014).

## References


- Brofeldt S, Theilade I, Burgess ND, Danielsen F, Poulsen MK, Adrian T, Bang TN, Budiman A, Jensen J, Jensen AE, Kurniawan Y, Laegaard SBL, Mingxu Z, van Noordwijk M, Rahayu S, Rutishauser E, Schmidt-Vogt D, Warta Z, Widayati A. 2014. Community monitoring of carbon stocks for REDD+: does accuracy and cost change over time? Forest 5:1834–1854. DOI 10.3390/f5081834.
- Chave J, Adalo C, Brown S, Cairns MA, Chambers JQ, Eamus D, Folster H, Framord F, Higuchi N, Kira T, Lescure JP, Nelson BW, Ogawa H, Piug H, Riera B, Yakamura T. 2005. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia 145:87–99. DOI 10.1007/s00442-005-0100-x.
- Hairiah K, Ekadinata A, Sari RR, Rahayu S. 2011. Pengukuran cadangan karbon dari tingkat lahan ke bentang lahan. Measuring carbon at plot and landscape levels. 2nd edition. Bogor, Indonesia: World Agroforestry Centre (ICRAF) Southeast Asia Regional Program.



### Correct citation

Rahayu S and Widayati A. 2014. *Improving community-based carbon-stock monitoring: lessons from Batu Majang, East Kalimantan, Indonesia*. Brief 48. Bogor, Indonesia. World Agroforestry Centre (ICRAF) Southeast Asia Regional Program.



for further information please contact:
Subekti Rahayu (s.rahayu@cgiar.org),

**World Agroforestry Centre**
**ICRAF Southeast Asia Regional Program**
Jl. CIFOR, Situ Gede, Sindang Barang, Bogor 16115
PO Box 161, Bogor 16001, Indonesia
Tel: +62 251 8625415; Fax: +62 251 8625416
www.worldagroforestry.org/regions/southeast_asia
blog.worldagroforestry.org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