3.4 COMMUNITY FOREST MONITORING

Patrick van Laake, Consultant Forestry and Climate Change, Spain
Michael K. McCall, Centro de Investigaciones en Geografía Ambiental, UNAM, México
Margaret Skutsch, Centro de Investigaciones en Geografía Ambiental, UNAM, México

3.4.1 Rationale for community-based inventories.

Forest land in developing countries is increasingly being brought under community management under programs such as Joint Forest Management, Community-based Forest Management, Collaborative Management, etc., more generally called Community Forest Management (CFM). This movement has been stimulated by the recognition in many countries that Forest Departments (FD), which are nominally responsible for management of state-owned forest, do not have the resources to carry out this task effectively. Rural people, whose livelihoods are supplemented by, or even dependent on, a variety of forest products such as firewood and fodder, foods and medicines, have the potential knowledge and human resources to provide effective management capacity to take care of the forest resources when the FD cannot. These actors are not only forest peoples with indigenous entitlements or customary rights to the forest lands, but countless rural communities adjacent to forest areas with accumulated knowledge of them.

The UNFCCC recognizes the special position that 'indigenous and forest peoples' have in REDD+, having repeatedly called for the full and effective participation of indigenous peoples and local communities in REDD+ since the first decision on REDD+ was made by the COP at its 13th session in Bali, December 2007. The interpretation of *full and effective* is left to the individual countries implementing REDD+, but specific reference to monitoring and reporting is made in paragraph 3 of Decision 4/CP.15. In paragraph 72 of Decision 1/CP.16 countries are requested *when developing and implementing their national strategies or action plans, to address, inter alia, the drivers of deforestation and forest degradation, land tenure issues, forest governance issues, gender considerations and the safeguards […], ensuring the full and effective participation of relevant stakeholders, inter alia indigenous peoples and local communities*. This issue is referred to directly in one of the safeguards. Developing countries implementing REDD+ therefore have to *promote and support* (paragraph 2 of Appendix I) this participation and provide information on how this is *addressed and respected* (paragraph 71(d)). There is increasing evidence that communities can be effectively engaged in different aspects of monitoring (Box 3.4.1; Danielsen et al. 2011; Larrazabal et al. 2012; Hawthorne & Boissière 2014).

One component of CFM is to mitigate the over-exploitation which leads to degradation and loss of biomass. The CFM approach is to establish formal systems between communities and FDs in which, usually, communities receive a legalized right to controlled use of forest products from a given parcel of forest, and in return formally agree to protect the forest and manage it collectively. Different approaches to CFM are found in different countries. In Nepal and Tanzania, most of the forest parcels are relatively small, from 25 to 500 hectares, being managed by groups of 10 to 100 households on the basis of agreed off-take of firewood, fodder etc. In Mexico, forest areas may be from 300 to 15,000 hectares and are sometimes managed for timber. In the Amazon, much larger areas may be restituted to indigenous groups, and managed essentially for conservation. The conditions may vary widely - in Mexico for example, the majority of the forest area is legal property of communities, while in most African countries it is the property of the state.

We introduce here the idea that communities involved in CFM can carry out forest surveys as a part of their forest management, when they have a substantive interest in it. Note that this review of community forest monitoring is limited woody biomass, particularly AGB (above ground biomass carbon); it does not deal with soil carbon.
There are a number of reasons within REDD+ programmes why communities may need to be involved in forest surveys:

- For participation in REDD+, it may be a requirement to gather detailed information on carbon stock changes at the community scale, since although forest area change can be measured using remote sensing, changes in biomass density (degradation and forest enhancement) cannot be reliably established without ground level measurements
- Community monitoring may supply valuable information on the drivers of deforestation and degradation and on the impacts of projects and programmes intended to mitigate these.
- Local information on performance with regard to safeguards under REDD+ may be required from communities.
- Data from community-based forest surveys could feed into and densify national level databases, thus supporting and strengthening MRV for REDD+ and other forest reporting systems
- The surveys may also support other forms of monitoring, for example by providing ground level data against which to calibrate remote sensing data; it may be particularly useful in identifying different forest types which are difficult to distinguish in satellite imagery
- Community monitoring may in some cases form the basis for benefit-sharing in REDD+.

The interest for communities to be engaged in forest resource surveys can extend beyond REDD+ issues (see Sect. 3.4.9). In particular, stand out:

- PES (Payment for Environmental Services) projects for other environmental services – notably biodiversity services, usually also require reliable, detailed measurements of environmental indicators at community level.
- Certification schemes, where communities are engaged in certified timber or NTFP production, which require intensive monitoring and verification.
- And importantly, engagement in monitoring may strengthen the communities´ forest management practices, by providing feedback to themselves on management outcomes.

A number of initiatives on community-based monitoring have shown it to be both feasible and beneficial, for example the CCA project which has demonstrated that through well-designed and implemented training programmes and ongoing back-up support, community-based forest monitoring teams can take and record measurements for accurate and precise estimates of forest carbon stock changes (Box 3.4.1). The CCA study suggests that from a climate change perspective, communities should be involved in forest monitoring, because not only will this enrich the data used for estimating carbon stock changes and increase transparency, it will also enhance the sustainability of REDD+ activities, as communities will have a better understanding of what must be done to ensure future REDD+ payments.

There are significant degrees of intensity or degree of the community involvement in forest monitoring, sometimes summarised as a 'Participation Ladder".
At the minimal level of participation, there is only externally-driven monitoring, professionally executed, and community inputs are limited to their local knowledge about the area. The next level is externally-driven monitoring but with local data collectors who will be recruited to help locate sample sites and collect local data in UNFCCC protocols.

Next there is collaborative monitoring with external data analysis and interpretation, but with some local inputs on content and criteria probably for the social monitoring and safeguards. The fourth level is collaborative monitoring which also engages with local data capture, data interpretation, and local applications of the monitored data (for community purposes). Finally the strongest participation is in autonomous local monitoring, where there is also administrative autonomy and the capacity to change the monitoring systems.

Box 3.4.1 IGES Community Carbon Accounting (CCA) Project

Together with its partners, the Institute for Global Environmental Strategies launched the Community Carbon Accounting (CCA) Project with the intention of developing and testing approaches for engaging communities in forest carbon stock change estimation. With funding from the Ministry of Environment of Japan and the Asia-Pacific Network for Global Change Research, the CCA Project is being implemented at sites in Cambodia, Papua New Guinea (PNG), Indonesia, Laos and Vietnam according to local contexts, opportunities and needs.

The CCA Project provides the following observations for REDD+ project developers and for governments in the process of establishing their national forest monitoring systems (NFMS):

• **Communities can take accurate forest measurements**. With proper training, community teams can take and record forest measurements to provide accurate and precise forest carbon stock estimates that fall well within the range of uncertainty for estimates in similar forest types from professional surveys.

• **Community teams retain the skills they have learnt**. In January 2012, Project partners observed a community forest monitoring team in Cambodia which had received training one year earlier on forest sampling and measurement, and they demonstrated that they had retained the knowledge and skills from this training. Local people who participate in a well-designed training programme can be relied upon for future forest assessments.

• **The training of trainers is critical**. The training of communities on forest measurement is not a simple task. Literacy rates may be low and communities may have received misinformation on issues such as carbon trading. In all Project countries, a structured training of trainers (ToT) was organised to ensure trainers possessed the necessary knowledge on forest carbon accounting and effective techniques for training communities on forest sampling.

• **Communities can do more than is often assumed**. Projects engaging communities in REDD+ should not have rigid views on what communities can and cannot do. Some communities may have members who are competent with and own computers. In such cases, the responsibility for data entry could be given to the community. In participating villages in Jogjakarta Province, Indonesia, the communities were trained in the use of spreadsheets and have taken on the role of data entry using the spreadsheets created for them.

• **The aim should be self-reliant community-based forest monitoring teams**. The aim should be self-reliant teams that can be depended upon for estimation of forest carbon stocks according to pre-determined monitoring intervals. The community forest monitoring teams should thus own the equipment necessary to set up and measure sample plots.

For further information on the CCA Project, see:
http://www.iges.or.jp/en/natural-resource/forest/activity_cca.html

Procedures and protocols for the involvement of local communities in REDD+ activities are within the purview of individual national governments. Political ideologies, land ownership and tenure rights, competing claims on forest resources (e.g. commercial logging operations) all contribute to the variability of conditions that make a single solution impossible. It seems likely that the requirements for large scale data collection, for example for REDD+, will necessitate the involvement of local communities in most countries, if only to reduce the cost of the surveys (see 3.4.5). However, if community monitoring is to be integrated in a formal way into national data systems it is clear that a standard protocol would have to be developed at national level and communities would have to follow this, at least for a minimum of key variables and indicators (CIGA, 2014). Although many manuals for community monitoring are available (see Box 3.4.4), no country has yet developed a national protocol for this. The material presented here is intended to support governments and other agencies who are looking to engage the effective participation of indigenous people and local communities in monitoring and reporting, as requested by the COP through its decisions on REDD+.

3.4.2 How communities can make their own surveys

Forest surveying is usually considered a professional activity requiring specialized forest education. However, it is well established already that local communities have extensive and intimate knowledge of ecosystem properties, tree species distribution, age distribution, plant associations, etc. needed for inventories. There is growing evidence that local people managing their land, even with very little professional training, can make quite adequate and reliable stock assessments (Larrazábal et al 2012; Skutsch (ed.) 2011). In the Scolel Te project in Mexico (Plan Vivo, n.d.), for example, farmers have for many years made their own measurements, both of tree growth in the agroforestry system and of stock increases in forests under their protection, and they receive (voluntary market) payment on the basis of this.

The methodologies for forest surveying that are available in the form of community manuals (Box 3.4.4) are all based on procedures recommended in the IPCC Good Practice Guidance, but structured in such a way that communities can carry out the steps themselves without difficulty. Intermediary organizations (usually NGOs, also district FD agencies or local consultants) will certainly be required to support some of the tasks, especially the training and the maintenance or upgrading of equipment. But such intermediary organizations are often already present and assisting communities in their forest management work. Much of the work in forest surveying, at least regarding above-ground biomass, is simple and easily learned. It can be carried out by people with very little formal education, working in teams. As all the manuals demonstrate, tree measurements are made using standard equipment such as diameter tapes or callipers, and clinometers. What differs between the manuals is the way in which data is recorded. Although data can always be recorded using paper forms, increasingly hand-held computers/PDAs (personal digital assistants), Smartphones or Tablets with in-built GPS functionality are being employed. These can be operated by people with only primary education, with suitable training and appropriate support. The benefit of this technology is that it allows the recording of plot measurement data in the PDA to be combined with the maps, aerial photos or satellite images that are visible on-screen and linked to the geo-positioning from the GPS. Rural communities almost everywhere are familiar with mobile phones, and find the step to PDAs or Smartphones quite easy.

Some key activities need to be supervised by the intermediaries with understanding of statistical sampling and who can maintain ICT equipment. Many field offices of forestry organization or local NGOs are able to provide such supportive services. To institutionalize community forest surveys, the intermediaries first need to be trained in the methodology. The intermediaries would then train local communities to carry out many of the field survey steps, and they would backup the process at least in the first few years of the survey activities. Certain activities, such as laying out the permanent sample plots, need expertise, but once they are learnt and established, measurements can be made by trained people in the community without assistance. Hence there will be higher costs in the initial years, but these should fall rapidly over time, so long as the trained people remain in the community. See Tables 3.4.1 and 3.4.2 for an overview of the steps involved in this process for the intermediaries and the communities, respectively.

Table 3.4.1.Tasks requiring input from intermediary.

Task	Who?	Equipment	Frequency	Description and comments
1. Identify forest survey team (4 to 7 members)	Intermediary in consultation with community leaders		At start	Need to include people who are familiar with the forest and active in its management; at least some must be literate/numerate. Ideally the same people will do the forest survey work each year so that skills are developed and not lost. [99]
2. Programming PDA with base map, database & C calculator	Intermediary trainers	PDA /smart phone, internet for (geo-locatable) images	Once, at start of work	Aerial photos, satellite images, stereo pairs, Google Earth, or any geo-referenced image /map of suitable scale that can be scanned and entered into the PDA for use as the base map. [100]
3. Map boundaries of community forest	Community, with intermediary assistance	PDA/smart phone with GPS, GIS. Geo-referenced image (e.g. Google Earth)	Once, at start of work	Boundaries of many community forests are known to local people but not recorded on formal maps or geo-referenced. Usually begin with sketch-mapping (without a base map) of the important boundaries, sites and areas for the community, including: forest degradation areas, areas of invasion and zones of conflict, historical land cover and land use changes. Followed by marking onto the geo-referenced images, and then 'walking the boundaries' (and sites) with PDAs and GPS operated by the local team to track and mark the boundaries on the base map.
4. Identify and map any important forest strata	Community with intermediary assistance	PDA/smart phone with GPS, GIS, Geo-referenced image	Once, at start of work	Communities know their forests well. This step is best carried out by first discussing the nature of the forest and confirming what variations there may be within it (different species mix, different levels of degradation, etc.). These can first be sketch-mapped (Task 3); zones can then be mapped by walking their boundaries with the GPS.
5. Pilot survey in each stratum to establish number of	Community with intermediary assistance	Tree tapes or calipers, clinometers		The pilot survey is done with around 15 plots in each stratum. Measuring the trees in these plots could form the training exercise in which the intermediary first introduces the

[99] Attention must be given to ensuring transparency within the community for the whole process. There is always potential for some inequitable distribution of the benefits from the carbon payments, especially if they are cash payments.

[100] The database format can be downloaded from the K:TGAL website (See Box 3.4.4 below) into a PDA, as can the carbon calculator.

sample plots				community forest survey team to measurement methods.
6. Setting out permanent plots on map	Intermediary	Base map, calculator	Once, at start	This requires statistical calculation of number of plots needed, based on the standard error found in the pilot measurements. [101] Plots are distributed systematically and evenly on a transect framework with a random start point.
7. Locating and marking sampling plots in the forest	Community with intermediary assistance	Map of plot locations, compass, GPS, tape measure, marking equipment	Once, at start	Community team stakes out the centres of the plots in the field by use of compass and measuring tape. GPS readings are recorded, and the centre of the plot is permanently marked (with paint or plate on a ventral tree trunk). Each plot is given an identification code and details (identifying features) entered into the PDA
8. Training community team how to measure trees in sample plots	Intermediary		+/- 4 days first time; 1 day for each of the next 3 years	This task could be fulfilled while carrying out task 5. The task involves listing and giving identification codes to the tree species found in the forest. It is expected that the community will be able to function independently in this task after year 4.
9. Identification of suitable allometric equations & programming into the PDA	Intermediary		Once, at start	The program for the PDA contains default allometric equations. [102] If local ones are available, these may be substituted, which will give greater accuracy.
10. Downloading from the PDA of forest inventory data & forwarding to registration	Intermediary			The PDA is programmed [103] to make all necessary calculations and produce an estimate of the mean of the carbon stock in each stratum, with confidence levels (the default precision is set at 10%). These data need to be transferred to more secure databases for year-to-year comparisons and for eventual registration.
11. Maintaining PDA				PDAs require re-charging on a daily basis and minor repairs from time to time. It is anticipated that an intermediary would have several PDAs and would lend these to communities for the forest inventory work (around 10 days per community per year).

Table 3.4.2. Tasks that can be carried out unaided by the community team, after training.

Task	Equipment	Frequency	Description and comments
Measure dbh (and height, if required by local allometric equations) of all	Tree tapes or calipers, clinometers	Periodically, e.g. annually	During the first year, fairly complete supervision by the intermediary is advisable, but in subsequent years a short refresher training will be sufficient, see

[101] A tailor-made program for this is downloadable from the K:TGAL website and can be operated on a PDA

[102] From the K:TGAL website.

[103] Ditto.

trees of given minimum diameter in sample plots			above, Task 8.
Enter data into database (on paper sheets and/or on PDA)	Recording sheets/PDA or smart phone	After every survey	In some cases communities appear to find it easier to use pre-designed paper forms to record tree data in the field, although direct entry of data into the PDA is certainly possible and reduces chance of transcribing error.
Submit data to the National Forest Monitoring System	PDA, smart phone, or work station with internet connection	After every survey	If the National Forest Monitoring System is set up to receive data directly from the communities through a web-interface, transfer of data can be automated to reduce effort and error. A submission of data may trigger a set of responses, such as verification by a local FD office, generation of a report, or allocation of benefits.

Box 3.4.2 Limitations of data collection at the community level

As noted in the introduction, there are good reasons to include communities in the collection of data for REDD+. Such involvement supports ownership and commitment; together with (legal) recognition and receiving a just share of the benefits, communities are then strengthened as sustainable managers and custodians of the forest. Community involvement is the most cost-efficient mechanism to collect large volumes of basic data on the ground. (McCall 2011; Knowles et al 2010).

There are limitations however to the types of data that communities can reliably collect. The data are best limited to a set of basic forest properties, (though these data alone are not sufficient to compute above-ground biomass (see 3.4.3)

- Social/ geographical information – community and forest boundaries and claims, conflict areas, forest management types. Initial stage and periodic updating, say every five years.
- Type of forest, species identification, with common names (which should also be translated to scientific nomenclature). Initial and Periodic.
- Tree count. Annual.
- dbh measurement. Annual.
-

Measurements by community members are not always of consistently high quality over time, between stands, or between observers. Aside from occasional external verifications, data quality assessment in a given community can be augmented by jointly analyzing the data from many communities in a single ecological zone or forest type or forest management type.

If a community is producing data divergent from those of other communities, then the causes need investigation. They may be due to (see: Chave et al. 2004):

- errors in the tree measurement procedures;
- sampling uncertainty related to the size of the study plot;
- representativeness of the network of plots in the forest landscape, related to the stratification of the forest (e.g. forest belongs to another ecological zone);
- effectiveness of intervention (improved forest management) is different.

If the equipment (PDAs equipped with mobile GIS software, Smartphones, Tablets, GPS, measuring tapes, tree tapes, callipers, clinometers, etc.) is allocated as the property of the intermediaries, it can be used efficiently by many community forest groups in an area. An intermediary with three or PDAs / Tablets could service 12 or more communities per year (for cost estimates see Section 3.4.5). Appropriate methodology has been developed by several organisations and agencies, notably the K:TGAL project (see Box 3.4.3).

Communities need to be assisted in establishing the sampling plots. Marking the centre of the permanent plots with paint or plates on tree trunks, increases the reliability of the survey and reduces the standard error by ensuring that the same areas are measured each year. This can introduce bias, in that it identifies precisely where the measurements are being made, which could lead forest users to better protect those areas against degradation, e.g. by limiting the collection of firewood or poles or cattle grazing in those places. However this problem is not unique to community surveying, it would be the same with external surveyors. Locating the plots with a GPS is an alternative, but in densely forested areas the signal may be weak, giving a coarse determination of position.

Box 3.4.3 The *Kyoto: Think Global, Act Local* collaborative research project

The *Kyoto: Think Global, Act Local* (K:TGAL) research project was a joint endeavour of research institutes and NGOs in seven countries in Asia and Africa, led by the University of Twente with the support of ITC, in The Netherlands, from 2003 to 2009.

The K:TGAL project has prepared manuals intended for the training of intermediary staff in participatory forest inventory. It uses standard tree measuring equipment and PDAs for recording the data. It is assumed most staff would have had at least some intermediate (middle school) education, and that they are familiar with digital, but it is not a requirement that they have much forestry experience. The manuals can be downloaded from the K:TGAL website (www.communitycarbonforestry.org, under Resources and Publications, Community measuring monitoring and mapping) together with other supporting information. An updated version for use with Smartphones can be accessed at https://redd.ciga.unam.mx (under Publications, manuals)

Box 3.4.4 Manuals for guiding community forest monitoring

MacDicken, K.G. (1997) A Guide to Monitoring Carbon Storage in Forestry And Agroforestry Projects. Winrock International. http://www.winrock.org/ecosystems/files/carbon.pdf

Theron, L.-J. (2009) Carbon Stock Quantification. Training and Field Manual. Stellenbosch: Peace Parks Foundation, Climate Change Programme www.peaceparks.org

Verplanke, J.J. and E. Zahabu (2009) A Field Guide for Assessing and Monitoring Reduced Forest Degradation and Carbon Sequestration by Local Communities. www.communitycarbonforestry.org

Bhishma, P.S. et al. (2010) Forest Carbon Stock Measurement Guidelines for Measuring Carbon Stocks in Community-Managed Forests. Asia Network for Sustainable Agriculture and Bioresources (ANSAB), Kathmandu, Nepal. www.forestrynepal.org/publications/book/4772

Honorio Coronado, Eurídice N.; and Baker, Timothy R. (2010) Manual para el Monitoreo del Ciclo del Carbono en Bosques Amazónicos. Lima: Instituto de Investigaciones de la Amazonia Peruana / Universidad de Leeds. (54 p.) http://www.rainfor.org/upload/ManualsSpanish/Honorio_Baker2010%20Manual%20carbono.pdf

Peters-Guarin, G. and McCall, M.K. (2010) Community Carbon Forestry (CCF) for REDD. Using CyberTracker for Mapping and Visualising of Community Forest Management in the Context of REDD. KT-GAL.

Walker et al. (2011) A Field Guide for Forest Biomass and Carbon Estimation. Woods Hole Research Center, Woods Hole, MA, USA. www.whrc.org/resources/fieldguides/index.html

Hairiah, K. Dewi, S., Agus, F., Velarde, S., Ekadinata, A., Rahayu S., and van Noordwijk, M. (2011) Manual: Measuring Carbon Stocks Across Land Use Systems. World Agroforestry Centre http://www.worldagroforestry.org/sea/Publications/files/manual/MN0050-11/MN0050-11-1.PDF

Edwards, Karen; Henry Scheyvens; Jim Stephenson; and Taiji Fujisaki (2014) Community-Based Forest Biomass Monitoring. Training of Trainers Manual. Hayama, Kanagawa: Institute for Global Environmental Strategies (IGES) (216p.) http://pub.iges.or.jp/modules/envirolib/view.php?docid=4999.

SNV Vietnam and German Federal Ministry for Environment, Nature Conservation and Nuclear Safety http://www.snvworld.org/en/redd/publications/participatory-carbon-monitoring-manual-for-local-people.

CIGA-UNAM (2014) Manual for Community Technicians, Version 5. http://redd.unam.mx (Go to: Publications, Manuals)

3.4.3 Additional data requirements for biomass carbon

The communities may be in a good position to collect basic data from the forest, such as tree species, tree count and dbh, but these alone are not sufficient to compute above-ground biomass. It is necessary to have a parallel process to complement the basic data and be able to ascertain the quality of the locally-collected data.
The additional data required depend on the local conditions and prior information. For instance, locally relevant allometric equations are needed to calculate above-ground biomass and these equations require input parameters like tree height, tree branch height, or wood density. Such parameters can be collected using traditional forest inventory techniques, such as those described in sections 2.3 and 3.3. Even if no additional parameters are required beyond dbh, it is important to have a parallel process to sample measure dbh and tree counts with high accuracy, in order to validate the data input from communities. Standard statistical techniques can then be applied to establish whether the data received from communities are reliable.

3.4.4 Reliability and accuracy

Although some express doubts whether communities will be able to provide reliable, good quality data, the evidence is that they can. In the K:TGAL project, independent professional forest companies carried out surveys in three of the project sites in order to test the reliability of the communities' estimates of carbon stock. In every case, there was no more than 5% difference in the estimate of mean carbon stocks between the professionals and the community.

It is recommended that communities make annual measurements, even though official reporting periods in REDD+ may be longer than this. There are a number of reasons:

- This would maintain community involvement and sustain interest, and would provide a continuity of practice in the monitoring tools and procedures,
- It is an important mechanism to assess the quality of the data collection process - errors of measurement in a particular year may be more easily detected and eliminated. Annual measurement provides a robust approach to inventory.
- It can provide more timely insights into the effectiveness of REDD+ interventions.
- If forests are measured annually, communities will be more aware of changes in the forest.
- Annual fluctuations due to weather changes are common, over a longer trajectory those would to some extent be smoothed out.
- It is feasible that national REDD+ programs will have to offer annual incentives for participation in monitoring activities, rather than carbon payments at the end of a multi-year reporting period, - communities are unlikely to accept long waiting periods for payments.

The confidence level used in determining the number of sample plots is a major factor in the cost of carrying out forest surveys. A confidence level of 95% rather than 90% requires many more sample plots (i.e. more work by communities in making measurements). On the other hand, less uncertainty in the assessment of above-ground biomass will most likely lead to more confident estimates of emission reduction or removals and thus higher payments or other benefits; see Section 2.5 for more details.

The number of sampling plots required to achieve a given confidence level and maximum error is calculated following a pilot sampling survey. The statistical methods for this are clearly explained in the manuals and in the IPCC Good Practice Guide. A protocol regarding the level of confidence required is one of many parameters that need to be determined at national level, for standard application in all community monitoring within a country's REDD+ programme.

3.4.5 Costs and payments

The K:TGAL project estimated costs of community forest inventory as ranging between $1 and $4 per hectare per year (2005-2009 period), including day wages for the community members involved and the intermediary, and a factor for 'rental' of the equipment (PDA, GPS, etc.). The costs in the first year are higher than this, given the substantial inputs by the intermediary in training community members and establishment of the sampling plots. Average costs are much lower in large, homogeneous forests owing to economies of scale. The equivalent costs if professional organizations were to be employed instead of communities are two to three times higher than this. (Skutsch et al. 2011; also see: Knowles et al. 2010)

Emission reductions and enhanced removals may be credited over longer time intervals (e.g. 5 years), but local communities will need to be paid annually or even more frequently to maintain their commitment to the process. How payments are made, and on what basis, are questions which the government REDD+ agency must decide.

Essentially there are three options:
A. Communities implement REDD+ activities to reduce deforestation and forest degradation, and as a condition of their participation, they are required to survey the forest regularly to assess the amount of biomass. Benefits are made over to them based on the amount of emission reductions or enhancement removals they achieve. In this option, monitoring is an implantation or transaction cost which has to be carried by the community itself. The national REDD+ agency is likely to be strongly insistent on external verification with this option, because, in effect, the communities themselves are providing the data from which their carbon payments will be determined.
B. Communities engaging in REDD+ activities are required to make regular surveys but they are paid for this activity, independently from any benefits they may receive for carbon performance. In this option, there is no link with emission reductions or enhanced removals – payment is made for the survey services rendered.
C. Surveys at community level are managed by the staff of a government REDD+ agency, or say, an NGO, which may hire local community labour to carry out this work.

3.4.6 Options for external, independent assessment of locally-collected biomass data

National governments will need an independent mechanism to verify the data monitored by local communities, particularly if benefit distribution is based on these data. One of the options is statistical analysis, as briefly explained above, but at larger scales remote sensing is an obvious choice; see Sections 2.2 and 2.3. In order to enable independent assessments, forest specialists should make complete inventories at the time of establishing the sampling protocol for community REDD+ projects. A proper stratification of the forest, with due consideration for those properties of the forest that are easily detected on satellite imagery, will be of prime importance, as will the detailed description of the forest structure.

The data that are being collected by the communities can be correlated to satellite imagery using a number of techniques.
The first one looks at the (assumed) homogeneity of the strata in the forest, while the second one establishes the correlation between biomass as measured in the forest and reflectance recorded in the satellite image:

- Assuming that the stratification of the forest has led to homogenous units, the reflectance characteristics of the pixels in the stratum should also be similar at the time the stratification is made (i.e. it has a uniform look in the imagery). At a later stage, when some management intervention has been implemented and the communities are collecting data, a new image can be analysed for its uniformity. If the uniformity is no longer present, or weaker than before, it may be that part of the forest was deforested or some communities are not managing the forest as they should. Note that the reflectance itself may have changed if the biomass has changed, either through continued but reduced degradation or because of forest enhancement. Homogeneity, and thus uniformity in the satellite image, may also increase if the forest is more uniformly degraded or enhanced; this may be avoided by applying a more strict stratification initially.
- Using a standard image analysis technique, the biomass assessment made by the communities can be correlated to the reflectance in the satellite image. In open woodlands and forest types that have a distinct seasonal dynamic (e.g. leaf shedding in the dry season) the assessment (and its timing) has to be compatible with the measurements made by the local community. Outliers in the correlation indicate some issue with the data collection process (or deficient stratification). When widely implemented, the sheer volume of locally-collected data, probably even when a detailed stratification of the forest is made, makes it possible to use only a (random) sample of the local data.

3.4.7 Community Monitoring of Safeguards in REDD+

As the goals and politics of REDD+ have developed, more non-carbon measures and indicators are being drawn in, notably the concepts of safeguards. (Though even before that, the objective of ‘sustainable management of forests was already included in MRV discourse). REDD+ policies and directives call for additional environmental and social-economic information on CFM. Some are directly connected to the biomass surveys which form the core of this chapter, and some are more akin to social and institutional surveys. Much of this information can be provided by measurements and monitoring by community members.

The full gamut of safeguards runs from: environmental and biodiversity, to objectives of policy compatibility, good governance, human rights and social equity, and calls for stakeholder participation and respect for the rights (and the knowledge) of indigenous peoples and local communities. See Table 3.4.3; Chhatre et al. 2012)

Table 3.4.3 Safeguarding Environmental and Social issues in REDD+.

SAFEGUARDS (Stated in Decisions 1/CP.16, appendices)	**COMMUNITY SURVEY TOOLS & METHODS**
i. ***Policy objectives:*** consistency with national forest programmes and international conventions and agreements,	Policy impact surveys deployed by communities – Indicators in specific forest management zones
ii. Governance: effective and transparent forest governance structures	Surveys of awareness of, and participation in, governance
iii. Human rights objectives: participation especially indigenous peoples and forest local communities. Use of local specialised knowledge	Surveys of participation in forest management activities, and, in decision-making. Tracking use of local/ indigenous forest & management knowledge
iv. Socio-economic objectives: social benefits, related to benefit-sharing.	Social surveys, expenditure surveys, etc. for categories of forest users
v. ***Biodiversity objectives:*** conservation of natural forest,	Field observations, camera traps, sound recordings, species identification, etc. by

	community members during forest activities.
vi. Environmental objectives: environmental benefits, risks reversals of REDD+ and emissions displacement – change of land use/land cover, leakage	Observations, volunteered information, recording protocols

adapted from Muchemi et al. (2014)

Under REDD+, countries will develop indicators for safeguards, and they will be required to report on how safeguards are being addressed and respected. Monitoring for safeguards is an activity which can be carried out by communities alongside their forest measurements. This would require the development of protocols and survey methods which the communities could self-apply. There is considerable evidence that communities are able to make simple biodiversity measurements, based on key species (Danielsen et al. 2009; 2011). If communities survey annually their forest and also make safeguard assessments, this information can feed back to national governments and enable fine-tuning of policy choices.

3.4.8 Mobile IT for community surveys

Technological potential lies in the ubiquity of mobile IT devices and apps which have greatly increased functionalities, at lower cost, and are increasingly easy to handle.

Hardware: Rugged Tablets and Smartphones with large memory for storing the necessary imagery or maps and software, with GPS capability of sufficient precision, camera and video, and with internet connectivity for downloading images and uploading data are replacing the PDA set-ups. The prime advantages are ease of use, convenience of supply and repair, and especially to benefit from the familiarity of ordinary people with mobile phones – very easy for young community members to 'upgrade' to a Smartphone. Currently, costs of Smartphones are high – but dropping fast, and not prohibitive. A common business plan is that the local intermediaries or brokers would be the resource holders of Smartphones in the near future, until unit prices drop further.

Imagery: Geo-referenced images as bases for mapping community forest boundaries and strata, and plots, etc., are easily available at very low cost or free, from Google Earth or Virtual Earth or other virtual globes (Peters-Guarin and McCall 2011). The cost of LIDAR which could provide very high precision imagery is also dropping.
There is big potential in the use of UAVs / drones for communities (or intermediaries) to acquire their own dedicated imagery from a range of air-borne sensors, and have their own capacity for real-time monitoring of forest threats, fires, invasions, etc. There are obvious challenges of current costs, skills and maintenance, and of privacy, safety and security, but the trend is already apparent (Paneque-Gálvez et al. 2014).

Apps: Apps with very user-friendly interface between users and the devices (PDAs, Tablets, Smartphones) are being adapted for forest and tree measurement with simplified data recording and clear sequential instructions. In 2014 these are CyberTracker (South Africa, Mexico) and Sapelli (UK), both with special attention to non-literate users by using icons, Plataforma eREDD (Mexico), Google's ODK (Open Data Kit) and GeoODK, and Poimapper (Finland). Most of them, e.g. CT, Sapelli, and ODK, work well offline without network connectivity.

Table 3.4.4 (Potential) Mobile IT Platforms and Survey Tools.

Tool	Description, Features	License Type	IT Skills Required	Egs of Users	OS Mobile devices Data storage
CyberTracker	Software originally	Freeware	Computer	CIGA-REDD	CT desktop,

http://cybertracker.org/	for game tracking. Has developed into global monitoring tool, 1000's users. User-friendly icon-driven interface for mobile devices.	Open Source	skills & basic knowledge databases – for initial design – not for operating	UNAM, Mexico 'Manual for Community Technicians' http://redd.ciga.unam.mx/files/CommunityManual.pdf	Windows, Apple MacOSX; Android Smartphones, Samsung Galaxy Camera, Tablets Windows Mobile PDA. Private database, desktop
Google OpenDataKit http://opendatakit.org/	Set of tools designed to facilitate mobile data collection. Data collection forms Collect data on Mobile device Aggregate data on server	Freeware Open Source	Computer skills & basic knowledge databases – for initial design.	Global Canopy Programme, Guyana, Brazil	Android. Private database, desktop, or Cloud
GeoODK www.geoodk.com	Developed from ODK. 'Formhub' for database management. GeoTrace (walk around area)	Freeware Open Source	Online and offline mapping components	University of Maryland / IIASA. Not yet community carbon monitoring	Android. Private database, desktop, or Cloud
Plataforma eREDD+	Local NRM activities. Online/offline mobile and historic data collection, data storage, analysis and visualisation. Normalised databases for: biomass, RIL-C, water quality, &biodiversity.	Testing phase. Freeware	Basic computer skills	Alianza Mexico REDD+;Fortalecimiento REDD+; Coperación Sur Sur; Proyecto LAIF	WEB Platform: SQL Server/Windows. NET/IIS Android devices. Data Analysis Tool: DAR OLAP Geographic Analysis Tool: Geo Server
Sapelli http://www.ucl.ac.uk/excites/software/sapelli	Mobile data collection and sharing platform. Sapelli Collector pictorial decision trees icon-driven interfaces. Sapelli Data Sender forward SMS messages Sapelli Maps	Sapelli Launcher replaces Android UI with text-free app. launcher interface.		UCL Extreme Citizen Science (ExCiteS) Central Africa	Cloud storage – Amazon Server & Dropbox
Poimapper http://poimapper.com/	Allows mobile users to collect, share, and visualize geographically tagged data in real-time.	Copyright. Free version for single user. Price; reductions for NGOs	Support from developing team needed.	Mostly in Health applications. No users identified in community forest mngt.	Android Cloud or private database storage.

Sources: Adapted from: Larrazabal et al. (2012); WWF/USGS/GCP (2014); websites

3.4.9 Conclusions – Drivers and principles of community monitoring

Local Community Interests in Community-based forest monitoring –
'What's in it for the community?'
Although the immediate external driver for community monitoring in this context is the support of local REDD+ activities, there are a range of reasons why communities may be disposed to be involved in such surveys. Local studies and literature identify many specific reasons why communities are already involved in monitoring their local forest conditions and changes, or have a serious potential interest in doing so.

The community may already be involved in other PES programmes or future opportunities – e.g. PES for hydrological services, erosion control, biodiversity services, endangered species, pollenisation, landscape aesthetics, etc. Surveying and monitoring change in forest resources can be linked with a more comprehensive approach to environmental service provision, for compensation from off-site beneficiaries. Management of forest and of territory in general by local communities is undertaken in a holistic manner; it is not a disarticulated management of individual resources or service provision. Thus, when communities choose to take up the programmes and procedures of forest monitoring, they can relatively easily transfer the monitoring procedures and skills to a 'community portfolio' of environmental services. The data conventions, frequency and scale of monitoring are of course specific to the environmental service claimed (carbon, biodiversity, hydrological provision); but the experience developed in forest monitoring for carbon can be transferred to other environmental services.

Similarly, many communities are involved in FSC or other Certification of forest products and forest landscapes, and, whether certified or not, many communities are engaged with specific forest products which are already economically valuable to the community, e.g. NTFPs, honey, medicinal plants, bamboo production. Along the same lines, rural communities are increasingly looking towards eco-tourism opportunities, and thus need to monitor and advertise the positive status of the landscape.

Frequently the most significant driver at the local level is political-cultural – the monitoring of the community territory and its forest areas in connection with, and complementary to, claims for customary territorial rights and the community's entitlement to lands and land resources. And equally, for making claims for lands which have been alienated or are being invaded. A deep-rooted component of this, especially for indigenous peoples, is the protection and conservation of sacred places and sacred landscapes, natural or constructed.

Mixed interests – both internal and external

Another driver, which relates to both internal and external interests, is to monitor the stresses affecting local forest management or NRM in general – deforestation and degradation locations and causes, damage to NTFPs, natural hazards - notably forest fires, pollution sources, forest pests and diseases, or in other resources, etc. This information on the outcomes and drivers of deforestation and degradation is vital for evaluating national public policies and programmes.

For effective environmental planning the government needs data on the nature of drivers at local level and on the effectiveness of measures that are undertaken. Communities can supply data on these alongside their other measurements in the forest, thus assisting national REDD+ agencies in their assessments of policy effectiveness under different conditions. Although many countries appear to be opting for PES-type incentives under REDD+, the details of how these are implemented make a considerable difference to their effectiveness. Depending on the types of forest (humid tropical, dry tropical, temperate), the specific threats of deforestation, and the population pressure, different policies and incentive plans are necessary. Some policies may be more effective in targeting degradation and forest enhancement, while others may focus on deforestation.

Community monitoring might also provide a basis for whatever REDD+ benefit distribution system is selected by countries. In principle, communities could be awarded benefits for any decreases they achieve in rates of deforestation and degradation, and any increases in stocks. In practice, this may be very difficult to achieve (Balderas Torres and Skutsch, 2012), since it is unlikely that deforestation/ degradation baselines will be created for each and every community participating within a national REDD+ programme. However, forest enhancements can easily be measured by communities directly meaning that that in principle they could be rewarded for any enhancement of stock (sequestration) they achieve, based on the monitoring surveys carried out.

Links to national MRV
It is also suggested that community-monitored data could be integrated with national level forest data systems, providing more detailed ´densified´ data for areas where communities are active in managing and monitoring forests, gradually raising the reliability of overall national MRV systems (Pratihast et al 2011, 2013; Skutsch et al 2014). Moreover community assessments of forest cover type may provide important inputs to remotely sensed data on forest cover change (Vergara-Asenjo et al 2014).

FPIC – free, prior, informed consent.

Community forest monitoring is, by definition, a community participatory activity, and therefore is subject to the same political, ethical, and moral principles as any interactive process between powerful external forces and less powerful peripheral local peoples. In any case, FPIC ('free, prior, and informed consent') is a specified requirement of any REDD+ project or activity, as demanded by UN-REDD (ONU-REDD 2013; UN-REDD 2011, 2012). This is as valid for the processes of community involvement in surveying and monitoring as it is for any part of a REDD+ community project. FPIC requirements are highly demanding, very complicated and time-consuming to implement; rarely are they fully adhered to. Nevertheless, they must be recognised and operationalised as far as possible.

'Free' refers to the process (of agreement to participate in monitoring) being self-directed by the community from whom consent is being sought, unencumbered by coercion, expectations or timelines externally imposed. 'Prior' implies that time is provided to access and understand the information on the monitoring activities. Information must be provided before activities are initiated, and for instance, decision-making timelines of local/ indigenous peoples must be respected. 'Informed' refers to the information that should be provided prior to seeking consent and during the consent process. Information about the community monitoring activities and outputs should be accessible, clear, accurate, transparent, in appropriate language, covering positive and negative aspects, and any consequences if the people withhold their consent. It should reach even remote communities, women and the marginalized, and be on-going.

'Consent' refers to decisions being made by local communities reached through customary decision-making processes. The collective right to give or withhold consent applies to "all projects, activities, legislative and administrative measures and policies that directly impact the lands, territories, resources, and livelihoods of indigenous peoples and other local communities", and thus includes monitoring activities.
A significant aspect of 'consent' is the question of 'ownership' of the products of the participatory monitoring – the survey results, forest and carbon measurements, maps and any other data.

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