

**Community Carbon Forestry (CCF) for REDD
Using CyberTracker for Mapping and Visualising of Community
Forest Management in the Context of REDD.**

K:TGAL (Kyoto: Think Global, Act Local) Report

Graciela Peters-Guarin and Michael K. McCall

ITC

University of Twente, Enschede

and

CIGA

UNAM, Morelia

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Summary

- Field development of applications for mapping community forest carbon.
- Spatial information requirements of mapping community boundaries, relevant community forestry management zones, and biomass / carbon sampling in plots,
- Applying CyberTracker software with Google Earth images and ILWIS GIS.
- Based on practice and experience and procedural developments from community carbon forestry mapping and monitoring in the KTGAL research project [¹], previous field applications in Himalayas and Tanzania.
- Field development in indigenous communities in Michoacán State, Mexico.

I Introduction: Local Participation in Mapping, Measuring and Monitoring Forest Carbon Services

Many constraints are holding back the use of spatial information technologies, especially GIS, for local community mapping, measuring and monitoring forest carbon services. There is the poor availability of user-friendly methodologies which hampers the use of these technologies by laypeople. High-cost specialists from consultancies, universities, government agencies, etc are then required to control the information processes. Moreover, there are very few freeware computer applications available to acquire and manipulate geo-referenced information and databases. Most of the methods available make use of expensive software and mobile devices out of reach of the budgets of communities and local NGOs.

Community members utilising participatory mapping, measuring and participatory GIS for carbon stocks and changes also leads to strong benefits for capacity-building and management and planning initiatives by the communities [²] :

- Skills development and capacity-building with the community;
- Associated with that, increased information and confidence in dealing with the carbon professionals;
- Improved reliable and deeper information on forest conditions, degradation, community forest management, and conflicts identification.
- Obtaining historical information
- Community ownership of the data produced, such as the stock and sequestration data and maps; which gives them at least a better opportunity to control the data;
- Heightened attitudes of community 'ownership' of, and entitlement to, the carbon project itself;
- Using the mapped data and the PGIS method for applying for other payment for environmental services (PES) finance in hydrological services, biodiversity, etc.

¹ KTGAL – 'Kyoto: Think Global Act Local' research programme is based at the University of Twente, Netherlands and has research and community partners in Netherlands (ITC), Nepal (ICIMOD), India (CHEA), Tanzania (Sokoine University), Mali, Senegal, Guinea Bissau (ENDA), Papua New Guinea (Treeness) and Mexico (UNAM). See: Skutsch et al. (2009); www.communitycarbonforestry.org

² Minang & McCall (2006); McCall (2003)

- Good potential for utilising the participatory mapping and PGIS techniques for other community purposes, such as making land claims, resolving land conflicts, and collaborative land use planning.

The positive benefits of this are manifold, aside from the reduced measurement costs, compared with the communities having to pay outsider's fees of professional agents, consultants or researchers.

II KTGAL: Activities towards Local Community Ownership of Mapping, Measuring & Monitoring

Most of the activities related to community carbon forestry (CCF) and carbon monitoring etc. are regarded as a highly-demanding technical activities and therefore in the realm of professionals. The KTGAL project however considers that with adequate training activities such as forest inventories, assessing and measuring of forest resources, tree measuring and quantification of the current carbon stock and its change over time can be performed by the communities.

Local communities' participation in community carbon forestry financing is the main component of what the KTGAL research programme has been developing since 2004 until the present. The objective has been to promote the highest levels of local people's involvement in measuring the initial stock, monitoring, claiming and certifying carbon, etc., in validating community forest management methods, and in obtaining historical biomass and carbon data.

The experience of the programme has been that a 'participatory GIS' system can be implemented in which local communities become conversant with the use of IT for carbon forest data capturing and geo-referencing. When properly trained, local people are able and willing to map their forest (and carbon) reserves rapidly and with precision, locate permanent sampling plots with accuracy, and record measurement data on the trees and other vegetation in these plots. After attending the training, which has been carried out by KTGAL partners in forest communities in several countries in Asia and Africa, the local communities have successfully implemented field assessment under the supervision and technical assistance of local NGOs or forest field staff. (see Zahabu 2008, Karky 2008, Verplanke and Zahabu 2009; Skutsch et al. 2009)

One of the basic premises of the approaches developed by the project is that even people unfamiliar with computers (including illiterates and innumerate) can learn to follow the standard inventory protocols used by professionals if adequate methodologies are made available. The resulting data from the several tested areas has proven to be within the desired levels of precision and reliability similar to that produced by professionals. (Zahabu 2008; Skutsch et al. 2009)

Community Inclusion – Multiple benefits

There are three inter-connected sets of benefits from community involvement in the mapping and monitoring processes.

One of the initial objectives of the project was to greatly reduce the transaction costs of the measurements and monitoring so that it is economically viable for smaller communities (community-managed forests) to become involved in carbon financing. For this, the community members should be as responsible as possible in the actual zonal delineations and the various required measurements. because

obviously their operational costs are massively lower than hired external professionals. The key is to develop the protocols and mechanisms and associated training, so that community members with little formal schooling can perform the measurements and create the necessary geo data (maps, GIS and databases) with sufficient accuracy and reliability to be acceptable in a formal carbon finance mechanism.

The technical option for reduced transactions costs is local people's full participation in sampling and measurement of biomass following the required standard procedures. The specific methodology for forest inventory employed by KTGAL, and in this study, is based on procedures recommended in the IPCC Good Practice Guidelines [³], but structured in such a way that communities can carry out the different steps themselves without difficulty. Intermediary organisations like NGOs will be needed to support some tasks, but such NGOs are already assisting community forest groups in most of these places.

The KTGAL research findings have added considerably to the evidence that land users with no professional training can make adequate, reliable stock assessments. The Scolel Té project in Mexico, for instance, had earlier demonstrated that farmers make their own measurements of stock increases in forests under their protection for which they receive voluntary market payment. (Corbera et al 2009; Bey 2009, Cameroon).

Secondly, it is well established that local communities have extensive and intensive knowledge of ecosystems, tree species distribution, age distributions, plant associations, etc needed for inventories. (REFS) The considerable local or indigenous knowledge extends to the specificities of their forests, forest products, management systems, threats and mitigations. Therefore, the full involvement of local people adds to the accuracy, as well as relevance and applicability of the information gathering.

Thirdly, an expectation, which has been borne out by the results of the KTGAL project in other countries, is that this local community involvement leads to social and institutional strengthening in the community. Skills are developed and, on the whole, retained, new technical knowledge is acquired, and most importantly abilities to deal with strong external agencies governments or NGOs are greatly strengthened. This is confidence –building and empowering for the community.. and in practice, is reflected in the communities using the new geospatial and monitoring skills also for other purposes.

Focus into REDD

Initially the KTGAL Community Carbon Forestry research project was working within the scope of voluntary carbon markets and the idea that 'neo-CDMs might eventually, somehow, accept not just small-scale community forestry but also could include local conservation of existing forest as a carbon sink.

By the time of this research activity (2009). the KTGAL programme was working in the framework of UNFCCC – REDD / REDD+ (Reduced Emissions from Deforestation and Degradation in Developing Countries). The REDD+ concept has added carbon sequestration (due to good forest management) to the avoided deforestation and

³ IPCC (2003) Good Practice Guidance for Land Use, Land Use Change, and Forestry. MacDicken 1997; Weyerhauser 2000.

degradation which were envisaged by the REDD. REDD+ has not yet (as of December 2009) been fully defined in the UNFCCC framework; Table 1 provides the main requirements.

Table 1. Plausible REDD Requirements framework

Measurement of Carbon	Measuring : <ul style="list-style-type: none"> • Reduced deforestation & degradation losses • Increase in carbon stock - sequestration
Scale of functioning	Community scale of measurement. Capability to upscale to region and country
Certification (Validate, Verify)	<ul style="list-style-type: none"> • Costs of verification • Information availability • Monitoring systems
Management Capability	Leadership; participation, resource rules enforcement
Acceptability (Sustainable Development)	Acceptability to states, regions, & local communities
Externalities (EIA / SIA)	Avoiding other damaging effects to environment and society and e.g. equity
Leakage	
Additionality	

(c.f. Angelsen 2008)

The KTGAL research programme [⁴] continues with the research and development focus on:

- (i) Identification, measurement and mapping of biomass carbon by community members, supported by local NGOs,
- (ii) Conservation of natural forest (rather than afforestation & reforestation) because of *avoided* biomass carbon losses from reduced or eliminated deforestation; and *enhanced* carbon sequestration due to the better management by community forests than (usually) in state forests;
- (iii) an emphasis on dealing with forest *degradation*, and not only deforestation, because degradation is usually under-estimated and under-valued in the global climate / carbon discourse;
- (iv) a focus on dry tropical rather than wet tropical forests because of their human social importance (rather than biodiversity), for they affect many more people than does deforestation and degradation in wet tropical forests.
- (v) the communities in the programme are continuing with collaboratively using PGIS to map their community boundaries, forest land claims, and various types of forest stands (quality, productivity, etc.).

⁴ See: Skutsch (2008); Skutsch et al. (2008), Banskota et al. (2005); van Laake et al. (2009); & other KTGAL docs.

III Tasks and Requirements for Mapping, Measuring, Visualising Biomass Carbon – in the REDD+ Context.

For communities to be able to credit and register the carbon sequestered in their forest, accurate and geo-referenced information is required, in relation to the general REDD+ requirements above (Table 1). ^[5]

In this project two levels of information are identified: firstly, a meso or 'landscape' level that involves information at 'community' scale which is meant to establish the initial management scenario (year 0).

The second level concerns a more intensive collection of detailed information at plot level (biomass sample plots), and some information from tree level. Accurate data on the size and location of every measurable tree in a plot are required to monitor and to facilitate the re-measurement process during subsequent years (see Table 2).

Table 2. Information for Community Forest Management and Carbon Sequestration

<p>Level 1: Spatial and other Information for establishing the initial management scenario (year 0)</p> <ul style="list-style-type: none"> • Boundaries of the community, and of its forest areas intended for a carbon payments project. • Community's land claims - if necessary • Community Infrastructure, and relevant land use plans (e.g. for ecotourism) • Community Forestry Management Approaches • Location of activities contributing to forest degradation such as: illegal logging, grazing, marginal agriculture, illegal settlements, urban encroachment • Location of areas potentially affected by hazards (fires, soil erosion, soil & ecosystem degradation, flooding, strong winds, etc) • Conflicts (spatial information about land use, boundaries, etc)
<p>Level 2: Spatial and other Information for forest biomass inventories (year 0 and later)</p> <ul style="list-style-type: none"> • Delimitation of forest ecotype strata (zones) • Location and geo-referencing of the sampling plots for measuring different carbon pools • Geo-reference of trees and other features for future location of the sample plots. • Field measuring and data storing of tree data: DBH (diameter at breast height), tree heights, species, status, etc. in databases

⁵ Some of this information is similarly required for voluntary market carbon payment projects, or even for other PES projects.

For communities, particularly in developing countries, finding most of the information listed in Table 2 available for forest management is not easy. Non-existence, unavailability or inadequacy of spatial information as well as lack of technical knowhow or support from governmental institutions to produce it or handle it are some of the drawbacks usually faced. Therefore in the process of measuring and monitoring their forest resources communities become dependant on external professionals whose services will claim a big share of the economical resources they can claim from the carbon sequestration bonus.

The detailed tasks for Community Carbon Forestry mapping and monitoring are summarised below in Table 3. The specifically mapping and spatial information activities include:

- 1) Map locations of relevant forest areas for carbon project, and other relevant areas and places in the community lands.
- 2) Map community boundaries, if necessary (Use existing surveyed boundaries if possible). Map land and resource claims.
- 3) Identify and Map areas of forest degradation and their causes, areas of deforestation, and other disturbances.
- 4) Identify and Map the different types of community forest management.
(These categories and areas of different forest types and management types are called strata.)
- 5) Map also:
 - a. areas of encroachment, invasion, and zones of conflict with other communities, institutions, or private.
 - b. other areas of particular interest to the community – e.g. zones for eco-tourism development, or for special protection.
 - c. historical land cover and land use changes.
- 6) Carry out pilot surveys in each stratum to determine the number of permanent biomass / carbon sample plots required. Use allometric equations.
- 7) Select and locate the permanent sampling points in the different strata.
- 8) Measure biomass and current carbon stock in the sample plots, (above ground carbon pools including trees, shrubs, litter) based on the sampling frame and measurements. Use suitable allometric equations.
- 9) Prepare monitoring plans including necessary maps, for continued periodic monitoring and measurement of sample points in the future.
- 10) Design and prepare databases for maintaining forest carbon information.
Download data from forest inventory and forward it for registration.
- 11) Support external verification procedures.

Table 3. Detailed Tasks for Community Carbon Forestry Mapping and Monitoring

Task	Who?	Equipment	Description and comments
Pre-Fieldwork Activities in Community			
1. Identify forest inventory team members	Local/Regional NGO in consultation with community leaders		People familiar with the forest and active in its management; at least some must be literate/numerate. Ideally the same people will do the forest inventory work each year so that skills are developed and not lost.

2. Assist communities to develop and prepare project proposals	NGO Local/Regional NGO in consultation with community leaders		Proposals for carbon services payments (voluntary, REDD, PSA projects). This task in collaboration with relevant NGOs.
2. Programme PDA with base map, database, and carbon calculator programme	Trainer Team	PDA, internet	Aerial photos, RS images, anaglyph images (stereo pairs), Google Earth. or any geo-referenced area map of suitable scale that can be scanned and entered into the PDA for use as the base map. Database format can be downloaded from website into PDA, as can be the carbon calculator.
3. Sketch mapping of community forest area and key characteristics	Community Trainer Team	Flip-over. Paper Markers	Sketch mapping on paper or card, etc., without a base map, to elicit important spatial concepts of the community – key locations. a. Map forest degradation and their causes, areas of deforestation, and other disturbances; b. Areas of invasion, and zones of conflict with other communities, institutions, or private. c. Maps of historical land cover and land use changes.
4. Sketch mapping of forest strata.	Community Trainer Team	Flip-over. Paper Markers	Preliminary characterisation of forest strata categories - by forest types and forest management types. Local knowledge of nature of the forest and variations - biophysical characteristics different species mix, and management characteristics (management types, types of degradation etc).
5. Map boundaries of community forest – a definitive geo-referenced map	Community with Trainer Team Short training for practice.	PDA with GIS and GPS	Necessary if boundaries of many community forests are not recorded on formal maps or geo-referenced (but known to local people). PDAs with GPS operated by local people to mark boundaries on a base map or geo-referenced image, e.g. Google Earth. Not necessary if the community boundaries have been surveyed e.g. by land registration office. Forest area calculated. In case of legal disputes over land and resource claims these need to be mapped (geo-referenced) as they may have implications in the carbon claims
6. Identify and map important	Community with Trainer Team	Spatial images – aerial	Preliminary characterisation of forest strata categories - by forest types and forest management types.

forest strata - preliminary		photos, RS images, anaglyphs (stereopairs), Google Earth	Map the strata based on forest types and forest management previously identified in step 4.
7. Identify and map important forest strata – final version	working with community members, Trainer Team	Mobile GIS for boundary and zonal information . PDA with GPS.	Final characterisation of forest strata categories by forest types and forest management types – geo-referenced. If necessary zones are mapped by walking the boundaries with the GPS. Otherwise the activity will be related to crosschecking the boundaries through geo-referenced points or short transects. Map the strata based on forest types and forest management previously identified in step 4.
8. Pilot survey in each stratum to determine number of sample plots required	Community with Trainer Team	Tree tapes and/or callipers. Hypsometer Sampling programme .	The pilot survey is done with around 15 plots in each stratum. Measuring the trees in these plots, This involves measurement of DBH and height and identifying tree species found in the forest strata. Use of appropriate allometric equations. Enter data into database on iPAQ, (and / or on paper sheets.) Statistical calculation of number of plots needed, based on the standard error found in the pilot measurements.
9. Set out permanent plots on map	Community with Trainer Team	Base map, Calculator.	Plots are distributed systematically on a transect framework with a random start point.
10. Locate and mark sampling plots in the forest	Community with Trainer Team	Map of plot locations, compass, GPS, tape measure, marking equipment (e.g. paint or plaquettes)	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 (e.g. with paint on a ventral tree trunk). Each plot is given an identification code and details (identifying features) are entered into the PDA
11. Measure trees in sample plots	Community with Trainer Team	Tree tapes and/or callipers. Hypsometer s	This involves measurement of DBH and height and identifying tree species. Use of appropriate allometric equations. Measurement of trees and saplings (stems), and of bushes, shrubs, herbs, etc.
12. Identify suitable allometric equations	Trainer Team		The programme for the PDA contains default allometric equations. If local ones are available, these may be substituted, in order to obtain greater accuracy.

and programme these into the PDA			
13. Maintaining the PDAs	Community, NGOs		PDAs require re-charging (probably on a daily basis) and minor repairs from time to time. Assume that the NGOs maintain several PDAs and will lend these to communities for the forest inventory work (around 10 days per community per year).

V Study Area, and Institutional Setting

The paper describes the experience with two pilot communities in Michoacán Mexico. Members of the community with extensive knowledge about their forest were trained to collect data useful for forest management and carbon sequestration by using CyberTracker software installed in an array of iPAQ + GPS and newly-released HTC Smartphones with built-in GPS capacities.

In Mexico the official PES programme is oriented towards individuals or groups of individuals in possession of forest land units and organised in ejidos, communities, associations or NGOs (Muñoz-Piña et al 2008; Corbera et al. 2009; Benneker & McCall 2009, McAfee and Shapiro 2010). Forest environmental services such as hydrological services, soil protection, forest degradation and fire prevention are some of the environmental services the communities aim to provide.

In Mexico better policies for the management and conservation of forest resources are being consolidated by the National Forest Commission (CONAFOR). These policies are aimed to improve the life quality of inhabitants in rural areas by promoting community forestry as a strategy to achieve sustainable forest management, and generate income and jobs. Ejidos and communities need to have a solid organizational foundation that will enable them to implement plans for long-term development.

In this institutional context the Community Forestry Program (PROCYMAF) supports the implementation of this strategy, strengthening the ejidos and self-management processes. Under this scheme communities are encouraged to make sustainable use of their natural resources based on traditional ways of controlling their use and access. The programme also aims to encourage the development of technical and social tools intended to motivate and generate community initiatives and to support their operation.

With the assistance of a local NGO, the Interdisciplinary Group for Adequate Rural Technology (GIRA in Spanish) which works for sustainable development and community-based natural resource management, two communities whose forest units are located in the west-central part of the Michoacán State were selected for the KTGal project (see Figure 1).



Figure 1. Study area

The community of San Juan Bautista is in the municipality of Uruapan. In S. Juan the government has handed nearly 270 ha. of forest to this urban community for its management. Of this area, about 260 ha. (93%) is covered by pine forest. Because of the urban character of the community, the forest is mainly intended for providing environmental services and ecotourism to the whole city.

The second community is located in Taretan Municipality. The ejido has 2620 hectares of which around 1385 ha. (52%) is covered with forest of pines and oak trees. In this case the local community uses the forest for environmental services (water provision mainly), ecotourism and grazing.

After reviewing the data requirements in tables 2 and 3 it was found that for both communities the following information was required if CCF projects were going to be established:

1. Mapping and location of community infrastructure in forest areas
2. Mapping of activities contributing to forest degradation
3. Conflict mapping: Illegal selling of community land, crops, boundaries, private Infrastructure, illegal settling and urban encroaching
4. Acquisition of information for forest inventories: Delimitation and participatory mapping of forest strata
5. Field collection of geo-referenced data on DBH and tree height and storage in digital databases.

The use of Google Earth and CyberTracker

The approach used in Mexico was intended for community PGIS stock assessment and monitoring biomass carbon specifically by using freeware to further cut the

transaction costs, and to be community use-friendly. Therefore, Google Earth and CyberTracker software were used in place of expensive and more complicated satellite imagery and GIS software.

Google Earth is a virtual globe, map and geographic information program that allows to zoom in to see highly detailed aerial photos or satellite images of any place on the planet earth. The programme was originally called EarthViewer 3D, and was created by Keyhole, Inc, a company acquired by Google in 2004. The programme, a free software, maps the Earth by the superimposition of images obtained from satellite imagery, aerial photography and GIS 3D globe. It is available as Google Earth, a free version with limited functionality and Google Earth Pro which is intended for commercial use. Google Earth includes numerous layers of professional and community submissions to assist the user in zooming to see interesting places. The search feature is as easy to use as is Google search and incredibly intelligent in locating places around the globe. The degree of resolution of the images available varies throughout the globe, but most land is covered in at least 15 meters of resolution. Google Earth allows users to search for addresses for some countries, enter coordinates, or simply use the mouse to browse to a location. (Wikipedia).

The CyberTracker field data capture equipment consist of a Palm OS handheld computer (PDA) connected via cable or Bluetooth to a GPS unit. lately Its use in Smartphones with a built in GPS antenna are being implemented. CyberTracker was originally developed for wildlife monitoring in Southern Africa [6]. The software allows the design of screens that facilitate collection of field data in a systematic way. The data entry can be programmed to be done by clicking on icons or text following a predefined sequence (Beyers 2004). Its salient advantages are that the software was originally designed to be especially user-friendly for people unfamiliar with computers, even illiterates or innumerates. The interface is relatively straightforward to use, as its front end has been designed for ease of understanding, e.g. with a wide range of existing icons, thus relatively little need for programming skills (see Figure 2).

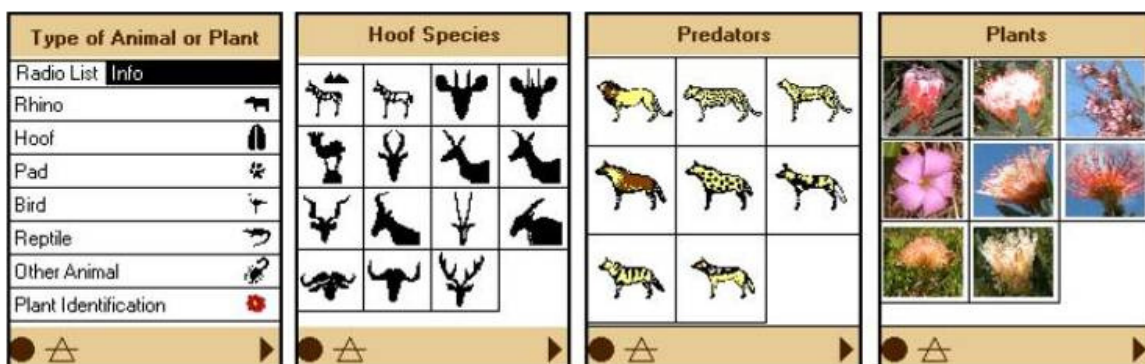


Figure 2. Icon-based screens designed for wildlife data capture (source: Cybertracker.org).

Later on the data can be transferred easily to a PC (windows-based) using the 'hotsync' function of the Palm OS. The transferred field data can be visualised and queried in the desktop version of the programme under the *Reports* mode. The design and programming of sequences is done under the *Applications* mode.

⁶ Developed by Louis Liebenberg www.cybertracker.org

CyberTracker is open source for further development and free to obtain. When combined with free satellite imagery from Google Earth as an open source free GIS software, (we use ILWIS [⁷]), there are considerable financial advantages over relying on expensive (Ikonos, SPOT) or low resolution (e.g. Landsat) remote sensing products and on standard GIS software such as ArcPad (ArcView).

CyberTracker was used to provide support for the field mapping steps in the inventory above (Table 3) –: mapping the community and forest boundaries, and mapping the forest strata in the field. It also provides menus and screen templates to ease the process of data acquisition on the pilot and permanent sample plots, carbon pools and on the community forest management systems and types and sources of degradation, which are essential to the REDD approach

In Mexico the project also experimented with using Smartphones [⁸], as an alternative to the use of GPS + iPAQ. The Smartphone has an in-built GPS, very large storage with a chip for images and software, web-accessibility for uploading & downloading, camera and video capability for adding photos, other functionalities, and is simpler to handle. We contend that as the technology develops and the scale economies of volume production emerge, Smartphones should lead to lower costs, as well as to greater simplicity and ease of use (especially by young people) in rural communities. This leads to the production of much needed geo-information at local level at very low cost and simultaneously to expand local employment opportunities related to carbon measuring.

VI Technical Procedures for Community Carbon Forestry Mapping and Monitoring Tasks,

As shown in Tables 2 and 3 the geo-information that communities should acquire, at least for the first stage of the project, is relatively straightforward to obtain. It requires basically the use of a device that facilitates the acquisition of geo-referenced points (i.e. a GPS), a database that can be used to assign identifiers or labels to the information been collected and moreover time for tracking along the infrastructure, forest units, transects and plots to be mapped.

The process of working with the CyberTracker + Google Earth arrangement involves four main stages:

A preliminary step is to download the Google Earth or Google Earth Pro⁶ images from the Web as source material for the forest maps. The most recent version of CyberTracker allows direct access to the most up-to-date Google image for the place where the geo-referenced information is to be collected. The image can be saved and used as a map at any scale selected by the user (see figure 2). It can also be exported as an image in Bitmap or JPG formats.

Then there is a technical stage where the databases aimed at collecting different types of data have to be designed. In this stage the community can start to be integrated in the process by, for instance, schematising and testing the sequence in

⁷ ILWIS 3.6 Open. .52°North, Münster, Germany, and, ITC, Enschede Netherlands.
http://52north.org/index.php?option=com_content&view=category&layout=blog&id=33&Itemid=67

⁸ e.g. HTS DiamondTouch <http://www.htc.com/nl/product/touchdiamond/specification.html>

which information is going to be captured in the field and deciding on the icons to be used for assisting (easing) the data capture process.

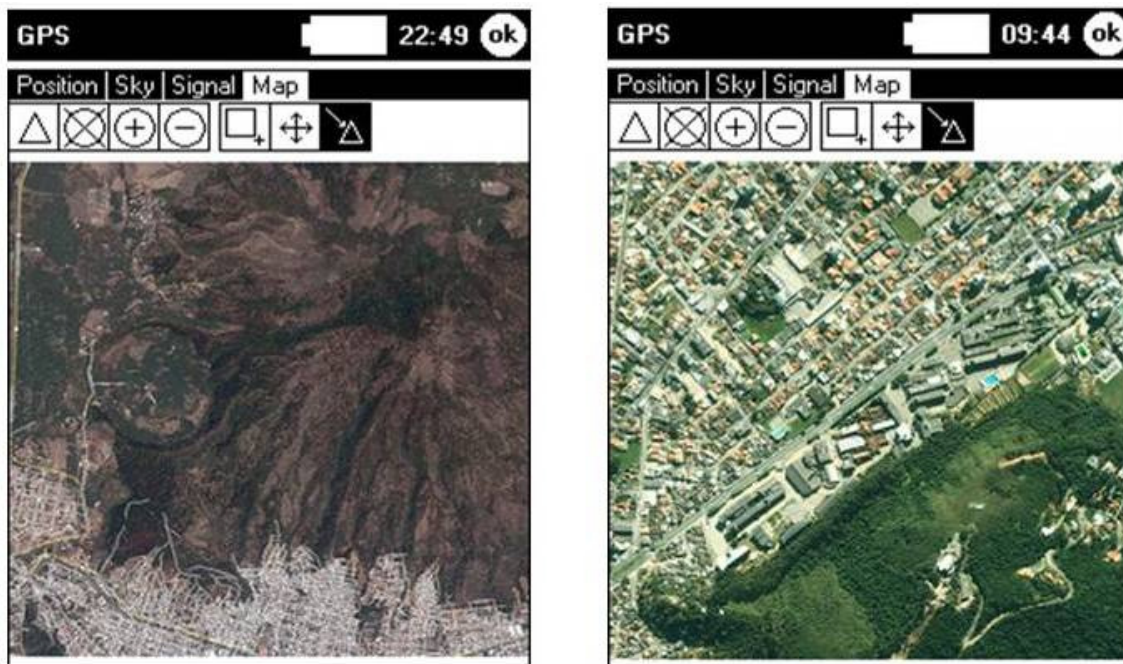
In the third stage, the data capture is oriented towards the direct manipulation, on the field, of the sequences designed for geo-referencing, collecting, editing and storing the forest management data. After adequate training, this stage is supposed to be under the direct responsibility of the communities involved.

The final stage consists of the downloading, systematisation and analysis of the spatial data in a GIS setting and the non-spatial data in a database (external to CyberTracker) such as Excel, Access etc.

Stage 1: Using Google Earth

The method designed initially involved downloading firstly Google Earth or Google Earth Pro [⁹] images from the Web whenever possible, as source or background material for the forest maps. Once found, the images were downloaded and geo-referenced according to the specifications of CyberTracker. [¹⁰]

The image can be saved as a fieldwork map at the scale the user considers useful for the mapping task (see figure 3). This map then becomes part of the application (or data capture sequence) in CyberTracker and it is therefore downloaded to the mobile device in order to be used as a background image for location and geo-referencing of the fieldwork campaigns. The fieldwork map can be also exported as an image in Bitmap or JPG formats; nevertheless for further processes in a GIS the image needs to undergo geo-referencing processes.



⁹ Google Earth 5.0, Google Earth Pro. <http://earth.google.com/>

¹⁰ Note that this step however is no longer necessary as new improvements (November 2009) in CyberTracker now make it possible to provide an up-to-date Google image for the place where the geo-referenced information is to be collected.

Figure 3: Field maps derived from Google images and integrated into CyberTracker applications for data capture

Stage 2. Developing CyberTracker Sequences

The second step consisted in developing the applications for forest and carbon mapping taking advantage of the user-friendly interface and icons of CyberTracker. Some of the advantages of using CyberTracker were related to the relatively straightforward use of its interface where, for instance, questions and queries can be easily replaced by icons as shown in Figure 2.

The collection of data in CyberTracker is usually done by following a 'sequence' of screens. Therefore the type of information expected to be collected in the field need to be previously known in order to design the applications according to the 'logic' sequence that a person will follow during fieldwork campaigns. The familiarity of communities with forest management is therefore highly valuable as they can assist the process of coherently designing the data capture tools which will facilitate and speed the process.

CyberTracker allows that in a single screen different type of data can be collected. By making use of *Data Controls* elements such as panels, memos, drop list of objects, text editors, numbers etc can be incorporated in a single screen in order to capture as much data as required from a single object (a tree for instance). In addition, if location a individual trees is required (for instance for further monitoring) a data control can be added so that coordinates for every particular tree can be also captured and stored (see figure 4)

Figure 4: Combination of different data controls in a CyberTracker screen/sequence in order to maximise the CFM data capture process

CyberTracker also has checking and editing features, which allows to supervise if all the information required has been properly captured or that no records have been missed. This feature is active in the sequences while working on the PDA or Smartphone, therefore it mostly useful during fieldwork. As can be seen from Figure

5 the date and time of data input are shown as well as the records for each individual tree as requested in the screens for data capture (i.e. those shown in Figure 4).

In order to check if the data was entered correctly or for data was missed one just have to move backward and forward between records pressing the arrows. Once a mistake or missing data is detected the record can be edited by tapping the *Edit* box, subsequently the corresponding data capture screen will be displayed and the new data can be input or corrected.

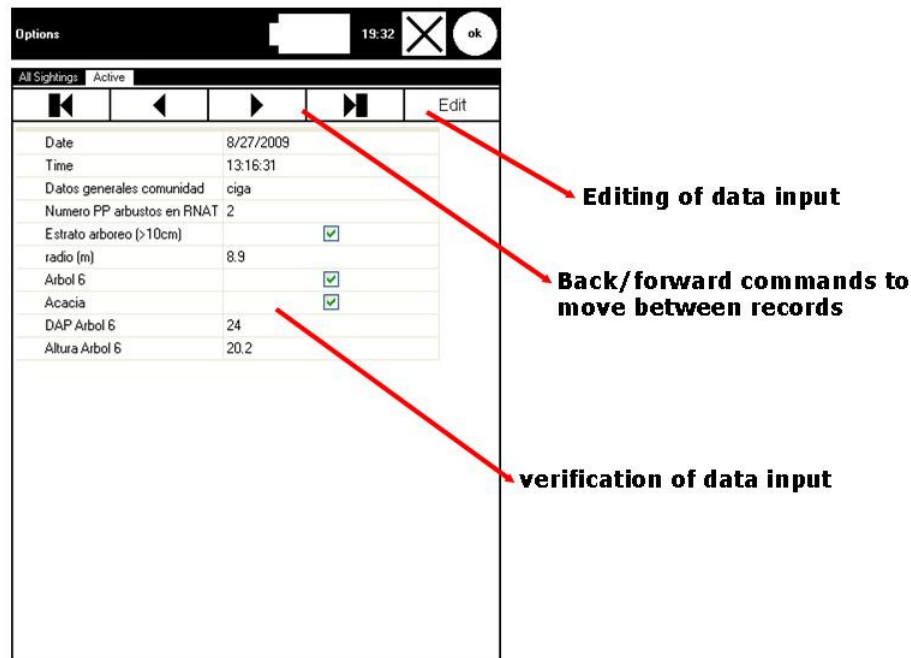


Figure 5. CyberTracker feature for checking/editing data during fieldwork

By making use of some of the characteristics explained above two main types of 'applications' or 'sequences' were designed in CyberTracker: one group of applications was intended for mapping purposes and geo-referencing of infrastructure and boundaries of different features; which can be categorised as 'vector' type data. The other group was meant to capture mostly 'point' data related to centre of sampling plots, beginning, end and direction of sampling transects, individual trees etc. The design of the applications was based on simple queries and icons which minimize writing and reading in order to make them appropriate for people with basic literate and numerate skills.

During the test the iPAQ and GPS were mostly manipulated by the trainees. A researcher accompanied them to support in case of technical problems with the gadgets.

Initially the applications were tested on San Juan Bautista which proved to be an ideal case as, under the PES system, the community has implemented a series of management strategies that have not been documented (in spatial terms). Furthermore there are a series of 'especial' situations that can hinder community carbon forestry activities such as, illegal encroaching, overlapping boundaries with

nearby communities and construction of private infrastructure (i.e. communication antennas) which the community needed to make 'visible'.

This type of sequences were used to map roads, pathways, fire breaks, and other elements that were helpful on the one hand for supporting the team in mapping of the different forest strata and on the other hand for community planning, ecotourism and environmental services among others.

An example of the sequence developed for mapping community infrastructure and forest boundaries is presented in Figure 6.

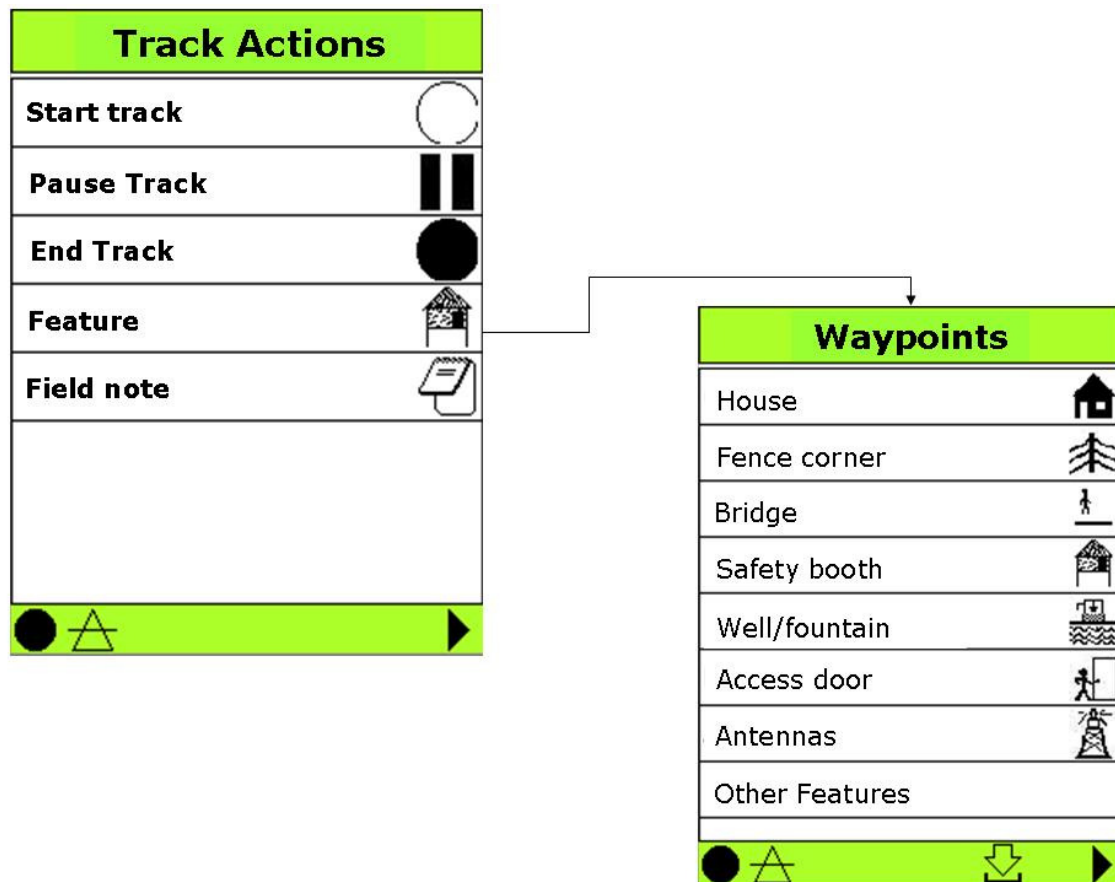


Figure 6. Sequences and icons adapted for mapping community infrastructure

While transecting and geo-referencing features with CyberTracker it is possible to check the performance of the GPS, i.e. to determine if the signal is strong enough amidst dense forest canopy. This can be done by tapping on the Triangle placed usually at the bottom left of the screens. A series of screen will then pop up from where several data about location and satellite signal can be read (see Figure 7)

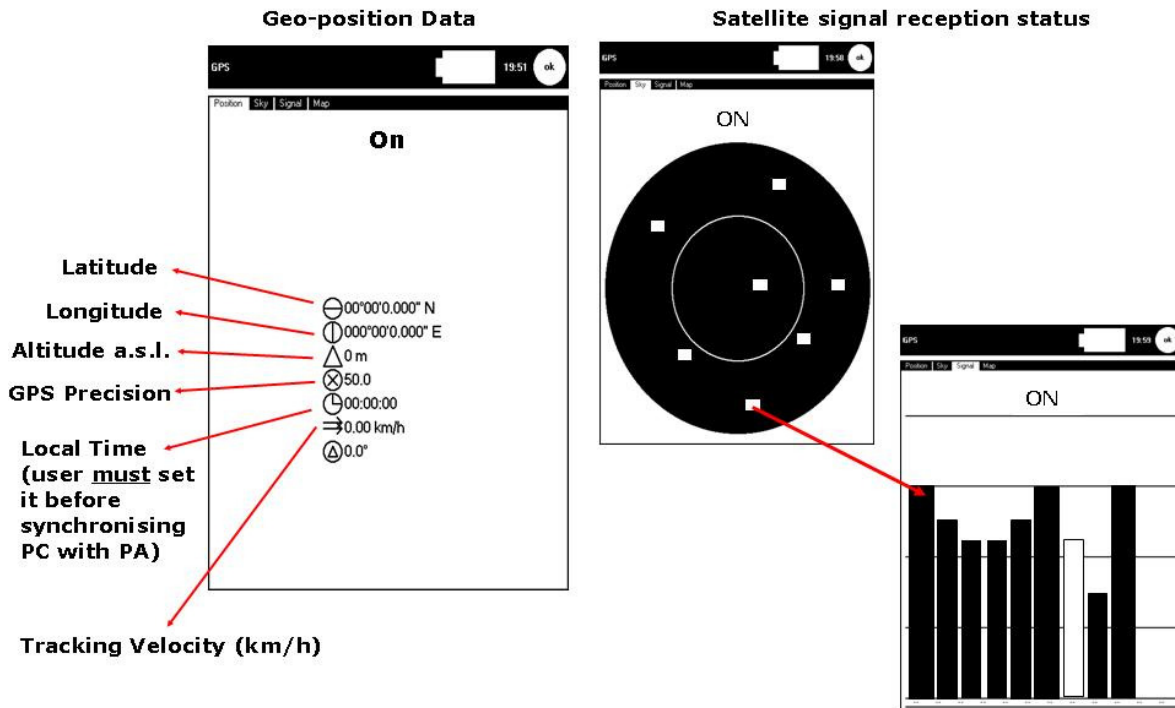


Figure 7. Geo-position and satellite status control features in CyberTracker.

Aside from the geographical coordinates the position screen provides important data such as the GPS precision. The variations in precision depend on several factors, for instance the quality of the GPS used, number of satellites available, the cloud cover, canopy cover and the openness of the place in which the measurements are taken. Nevertheless the precision managed inside the forest was always less than 2 m. which was considered good enough for the purposes of the work being done. In the case of measuring boundaries between communities however, measuring precision may become an issue. However as CyberTracker also stores the precision with which the data was taken, this information can be added as metadata to the maps.

Stage 3. Tracking in CyberTracker

The *Track Actions* sequence became one of the most useful applications of CyberTracker as it allowed collecting series of GPS points with variable time intervals which could be set depending on the means of transportation used. For instance while recording from a 4X4 SUV vehicle the time could be set at 1 second in order to track down all the features in the road (i.e. bends). For walking transects the time recorder was set at 5-10 seconds, in order to obtain a similar level of detail. The longer interval between measurements helped to save battery power and therefore assist longer data-capture journeys (see Figure 8).



Figure 8: Use of CyberTracker tracking capacities for geo-referencing CFM infrastructure (left: in vehicle) (right: on foot)

CyberTracker can be very efficient in directly recording geo-referenced information. Nevertheless, it should be taken into account that this programme is not meant to be a GIS software (such as ArcPad) and therefore its capacity for manipulating and visualising spatial data according to certain user-defined parameters is very weak.

For instance, several of the trails depicted in Figure 9 correspond to fire breaks. However this difference cannot be directly visualised in CyberTracker. From the information management point of view this case may have several implications. On the one hand the community needs to differentiate the fire breaks from the roads as both fulfil different aims and require different maintenance activities. Regarding the road they wanted to differentiate segments layered with different materials (dirt, cobblestone etc), or different purposes, for instance segments that can become part of eco-touristic routes etc. On the other hand it is also important to know the individual length of the firebreaks as the community needs to demonstrate they have extended these features in order to claim/justify governmental assistance under the Mexican institutional PES programmes. During the present project the need for differentiating features was solved by using proper GIS software (ILWIS). Nevertheless it is possible that by means of the continuous improvement of the CyberTracker software some of these issues will be progressively tackled.

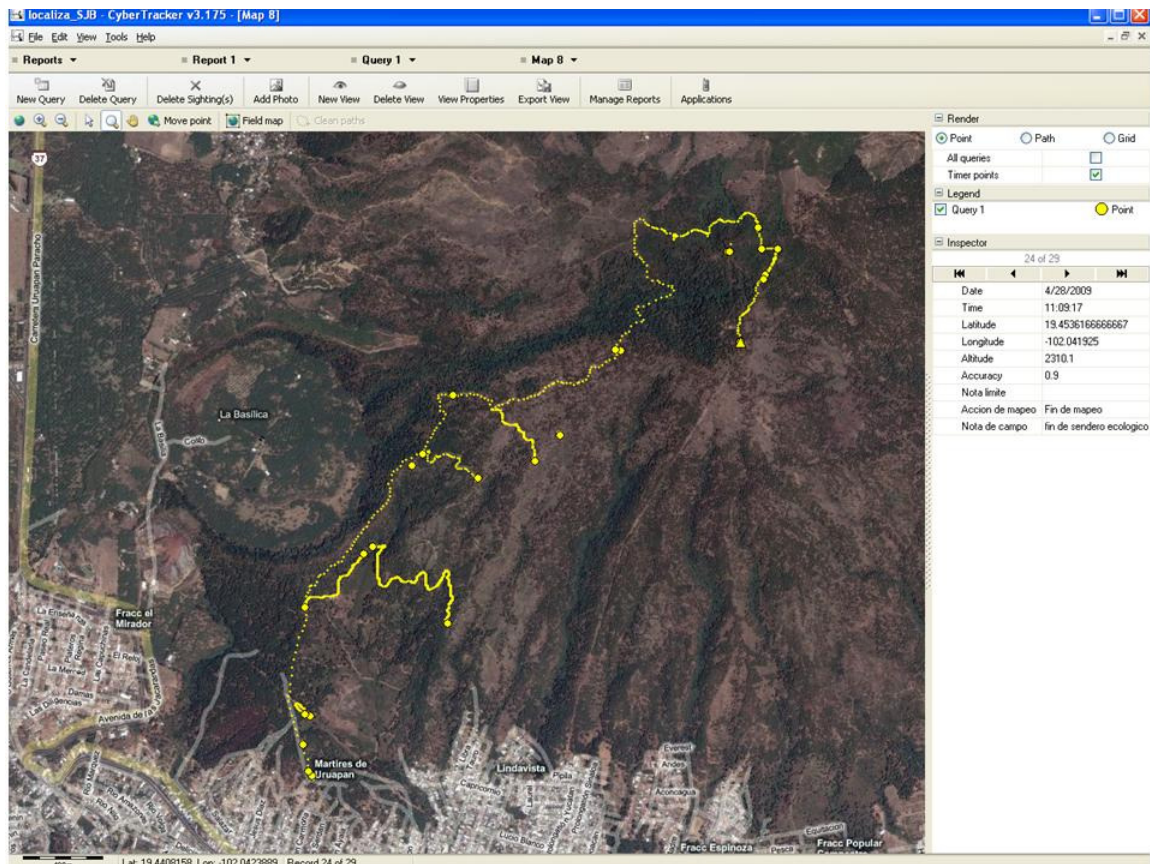


Figure 9. Unclassified geo-referenced CFM infrastructure using CyberTracker.

Stage 4. Using GIS and a database programme

Because most of the classification procedures cannot be carried out in CyberTracker, further processing needs to be carried out in a suitable GIS. In our case the project decided to use the open source software ILWIS® which is known for its capabilities for manipulating point and vector type data.

To be able to work in ILWIS the GPS points needed to be first exported from CyberTracker as an ESRI shape file (.shp). In this case two options were available:

- A. Export View as an ESRI shape file in which case just those GPS points that correspond to start/end of tracking and identified waypoints are converted.
- B. Export View as an ESRI shape (integrated tracks) in which all the intermediate GPS measurements (which constitute the track) are converted too.

Once the shape files were ready they could be directly imported to ILWIS. In this case what was obtained was a series of undifferentiated geo-referenced points (GPS measurements). As the intention was to obtain a map where point and vector elements were clearly differentiated, procedure A was followed for waypoints corresponding to community infrastructure (i.e. entrance gates, community centre, milestones). Once in ILWIS a point map was created where each waypoint had a unique identifier assessed by means of a Class Domain.

Roads and other linear elements had to follow procedure B in order to obtain the whole trail for the roads and fire breaks. In this case there was a need to create a vector map with *Class Domain* that assigns the corresponding category to each segment of the track. The final map presented for validation to the community is presented in Figure 10, showing the pilot and permanent sample plots, the carbon pools, and the community forest management systems and types and sources of degradation – all of which are essential to the REDD approach.

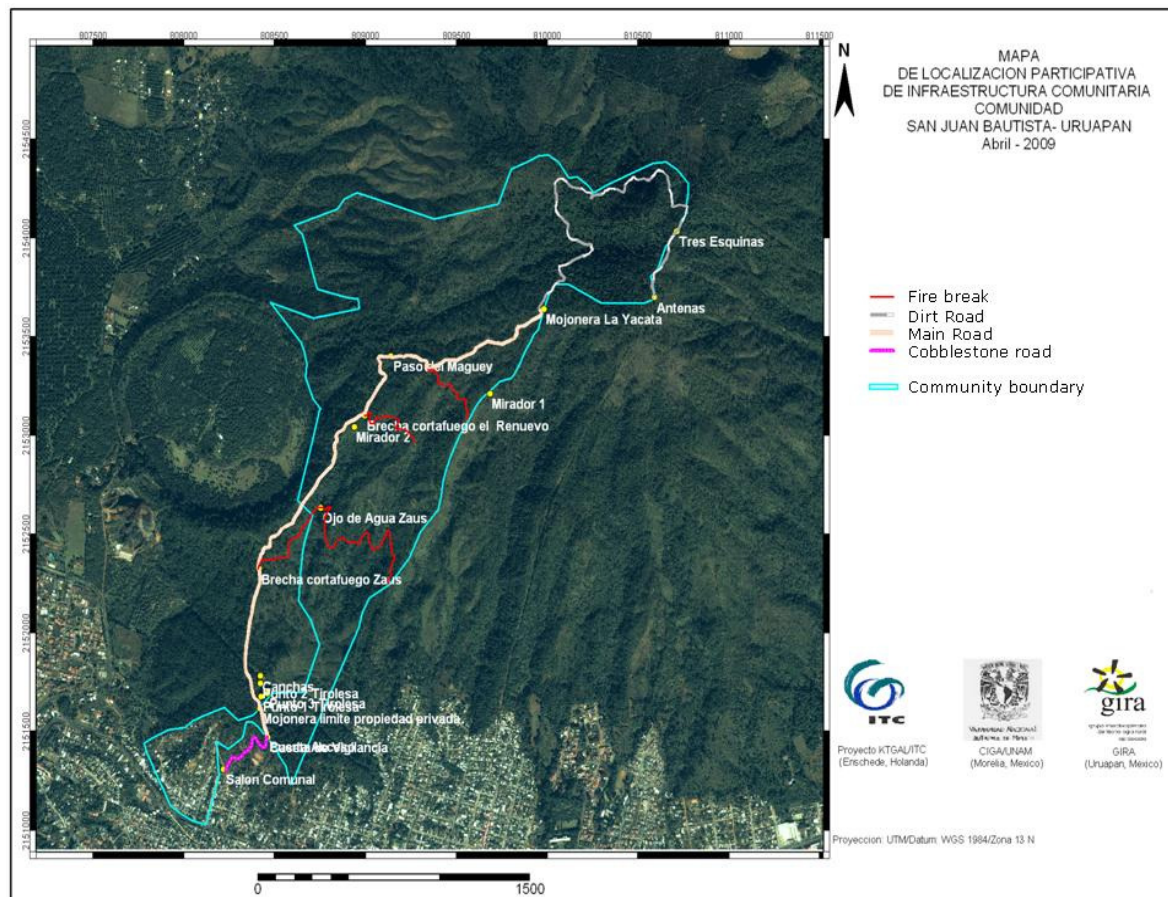


Figure 10. Final map of CFM and community infrastructure for San Juan Bautista obtained after geo-referencing and processing using CyberTracker and ILWIS GIS.

Regarding the non-spatial data, CyberTracker works mainly as a database (with some geo-referencing capacities). The information needed for forest inventory such as plot number, tree identification, and tree features (DBH, height etc) were collected during fieldwork by means of screens like the ones shown in Figure 4 need to be downloaded (via hot/Active sync) to the PC. In CyberTracker the download happens automatically once the PDA is connected to PC. Once downloaded the data can be visualised and manipulated under the *Reports* mode, where it is displayed in a table-like format with sightings differentiated by date and time of data capture (see Figure 11).

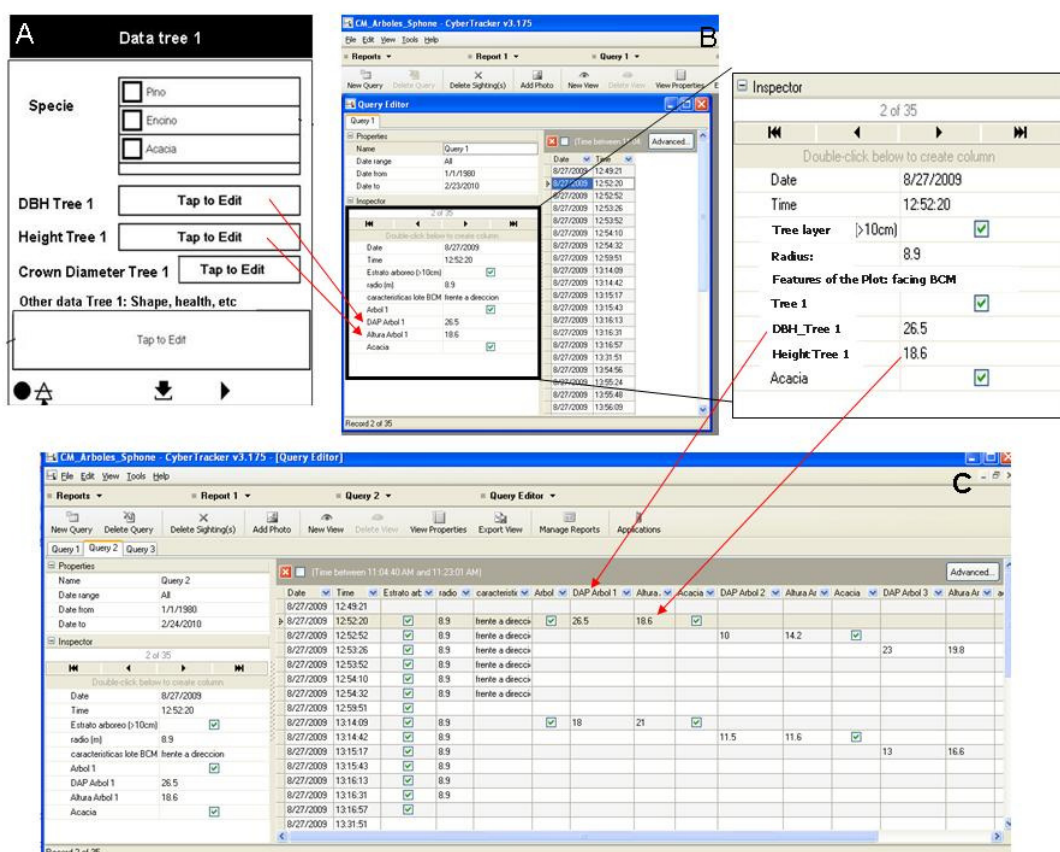


Figure 11. Structure for non-spatial data captured using CyberTracker. Screen for forest inventory data (A); Sightings downloaded in PC and visualised under Reports mode (B); Data query filtered and organised in column-like structure ready to be exported to other database formats (C).

The data can be displayed in Queries under a column format (by double-clicking each record on the left panel) or using some of the filters available in the programme (i.e. year, time of capture, etc) or created by the user. These views (Queries) containing the data in column format can be then exported like 'coma separated values' or to other data-base like programmes such as Excel (see Figure 12).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
	Date	Time	Tree Layer (>10cm)	radius (m)	Features Plot	DBH Tree 1	Height Tree 1	Acacia	DBH Tree 2	Height Tree 2	Acacia	DBH Tree 3	Height Tree 3	Acacia	DBH Tree 4	Height Tree 4
1	8/27/2009	12:49:21	True	8.9	frente a direccion	26.5	18.6	True								
2	8/27/2009	12:52:20	True	8.9	frente a direccion				10	14.2	True					
3	8/27/2009	12:52:52	True	8.9	frente a direccion							23	19.8	True		
4	8/27/2009	12:53:26	True	8.9	frente a direccion										29.5	20.2
5	8/27/2009	12:53:52	True	8.9	frente a direccion											
6	8/27/2009	12:54:10	True	8.9	frente a direccion											
7	8/27/2009	12:54:32	True	8.9	frente a direccion											
8	8/27/2009	12:54:51	True													
9																
10																

Figure 12. Forest Inventory Database per plot in Excel.

Once the information is available in other relational database programmes it can be manipulated according to the user's parameters for further monitoring and reporting of carbon sequestration; for instance singles sheets can be created to contain the data for all the trees in a plot, or individual sheets can be created per tree per plot.

Hardware and software Summary

As mentioned the project made use of a combination of freeware for CFM. The basic software and hardware required for data capture and management is presented in Table 4

Table 4. Hardware and software requirements for community capture of CFM data

FREWARE	APPLICATION	HARDWARE AND SOFTWARE REQUIREMENTS
CyberTracker	Design of applications (sequences) for geo-referencing and field data capture	<p>CyberTracker requires Microsoft Windows 2000/XP/2003/Vista PC or laptop for design of applications, downloading and processing of data. Palm OS, PocketPC and Windows Mobile Devices</p> <p>Smartphones with touch screen support</p> <p>Any GPS that can output NMEA sentences (serial text protocol that GPS devices use to communicate with other computers). TSIP (Trimble) is also supported.</p> <p>In general, most serial and Bluetooth GPS devices work (cybertracker.org).</p>
Google Earth Images	For mapping and monitoring CFM activities	PC or laptop with internet access
ILWIS Open®	For mapping and processing spatial information	PC or laptop

For Field Data Collection, we recommend: SD cards to make back-up of data in the field and Removable batteries to ensure that you do not run out of battery power

The project tested the use and performance of different Devices for data collection in order to determine their practical use during field campaigns. Table 5 presents the comparison between the performances of a PDA+GPS sets and Smartphone.

Table 5. Performance of gadgets for Data Capture (for a two hour session)

Feature/Device	iPAQ + GPS	Smartphone
Battery consumption	15 %	60% (mostly because of the use of built-in GPS)
Full charging time	About 4 hours	½ hour
Time between initiation and GPS connection (cold start)	Around 3 minutes	Until 15 minutes, afterwards it may take 1 or 2 minutes to reconnect to the satellite signal
Average precision for GPS readings	0.8 – 1 metre	2-3 metres
Ease of use	Clear, bright screen; simple controls	Smaller screen, fiddly controls, but similarity to cellphone layout makes it familiar to use
Cost	\$600-1000	\$ 800-1300

VII Technical Issues - Problems, Adapted Solutions etc

During fieldwork, some initial difficulties were found regarding the use of the small keyboard (Smartphone) and digital keyboard + pen (iPAQ) to introduce some of the data. These difficulties however eased with time and practice as volunteers became familiar with the use of the different gadgets.

Some problems found were related to the geo-position procedure. When working with PDA+GPS it is recommended to always switch on first the GPS before initiating the data capture with CyberTracker in order to ease the process of synchronisation between the two gadgets, and avoid that the PDA does not recognise the GPS. In this case a simple reboot (with the GPS Switched ON) will solve the problem.

It should be noted that, if allowed to completely run out of battery, most PDAs lose all data and/or additional software installed. Therefore it is necessary to include a backup module or save the data in an external/removable memory card. It is also highly recommended to make safety backups daily, particularly during extensive fieldwork campaigns.

During fieldwork it is not possible to add/edit/change the screens directly on the PDA, As mentioned, this stage has to be done previously in a PC, therefore running pilot sessions to fine-tune the sequences is highly advisable. Nowadays it can also be possible to modify the sequences in the field provided that there is a laptop with CyberTracker in which the editing and reloading of sequences to the PDA can be done.

Difficulties in the post-processing of data acquired using CyberTracker were related to the fact that CyberTracker is not GIS software. Therefore it is necessary to consider that if geo-referenced information is to be used in subsequent steps, processing in a GIS (i.e. ILWIS, ARCGIS) needs to be carried out.

The manipulation of information on Excel is another issue, as the process to organise the data in the format required for the user may take time. Nevertheless the creation of sheets for every plot or tree is a 'one-time' step in which the sightings of successive years can be directly organised and compared.

VIII Working with People – Experiences with the Participatory Approach

The entrance to the two communities was done through a local NGO. The Interdisciplinary Group for Appropriate Rural Technology (GIRA is a local organisation working with several communities in Michoacán in the implementation of rural planning processes and environmental service programmes. The fact that they have been previously working in the area helped the Kyoto team to speed the process of rapport building and to clearly manage the objectives of the project without creating false expectations among the communities.

In both areas two adult men, with medium and high level education made part of the teams. They were chosen by each community to volunteer on the Community Forest Management and Carbon Sequestration test, mostly because they could allocate time for the training. In this respect it should be mentioned that the research sought participation from different groups in the community. Some of the targeted groups were women and especially young people. By taking advantage of the youngsters' familiarity with IT gadgets such as mobiles and smartphones the project aimed to foster their interest in the management of the forest in relation to their community.

Alas, one of the main obstacles to include both the youngsters and middle-aged men and women in the test was the need to allocate certain amount of time for the initial training and later on for the data acquisition campaigns, particularly tree measurements. It was found that in both communities the young study for the most part of the year and most adults are busy working or with home duties during the day. Therefore the aim of having volunteers from these groups was not fulfilled

In practical terms the project found that very likely, these are particular issues for volunteering for CFM and CS in the Michoacán context. In areas such as Chiapas and Oaxaca, indigenous communities are still linked to forest management for their livelihood and use of forest resources; therefore fuller participation of communities required for the implementation of CFM or CCF projects for the voluntary market (i.e. Scolel Té) has been achieved (Corbera et al. 2009)

In the study area however communities do not derive economic or direct benefits from their community forest, and therefore performing administrative issues or collaborating in institutional programmes is mostly done on a voluntary and free-time basis.

Nevertheless it is expected that once communities are able to access the voluntary market the level of participation in CCF activities will increase, as these projects will imply direct benefits in monetary terms for the whole community. Having one or two members already trained in the methodology required for carbon measurement will therefore make them more capable of both access the market and increase their revenues.

IX Conclusions

The contribution of local communities in the acquisition of data useful for activities related to forest management and carbon sequestration has been hampered by the poor availability of friendly methodologies and the fact that these issues are seen as an affair for technicians and experts. This project has demonstrated the potential for using CyberTracker for mapping and visualising of Community Forest management in the context of REDD. The experience in Mexico demonstrated that handling new technologies and software is not an obstacle for a deeper involvement of local communities as long as learning by means of user-friendly tools and methods is provided.

The information collected is crucial to determine year 0 scenarios, location of different forest management practices, activities contributing to forest degradation, and carbon sequestration (strata, transects, sampling plots, etc.), the geo-referencing of sampling plots, trees and other features ease the process of carbon sequestration measuring and future monitoring

The methodology for community forest management and carbon sequestration data collection during fieldwork is easy to apply at community level and requires a minimum time of training and people's familiarisation with the gadgets and software (CyberTracker) applications. This approach based on freeware allowed participants, who were not familiar with computer use, to collect basic information. These participatory procedures increased people's expectations of ownership of the data, as well as greatly reducing the cost of information management required for accessing carbon sequestration benefits, as the need for the participation of experts is largely removed.

The use of friendly software such as CyberTracker has demonstrated the potential to involve local communities' knowledge as they contribute to the design of screen sequences (applications), as well as the choice of icons and queries to facilitate and speed the process of data capture.

Finally, the spatial and non-spatial information produced can be used to support other types of community projects and activities such as land use planning, PES schemes (payments for environmental services), ecotourism, socioeconomic programmes, and the like.

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