Combining Mobile GIS and Indigenous Knowledge in Community Managed Forests

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Abstract

For local communities in developing countries to be accredited for their forest management by international carbon funds, they need to supply verifiable data to support their claims. A PDA running ArcPad software and connected to a GPS can supply the necessary technology to do cost effective data collection in community forests that can be verified internationally. Experiments in Tanzania, India and Mali show that communities themselves using this technology can record their indigenous knowledge. This paper highlights the success of local communities in learning and using mobile GIS and the limits of this technology under difficult conditions. From these experiences a suggestion is made on how this technology could be practically implemented in developing countries.

Introduction

The Kyoto protocol is catering for the needs of industry to reduce the reduction of carbon emissions required by international treaties. By planting trees in developing countries the sequestered carbon in growth of these forests can be deducted from national quota. The wider intent of the UNFCCC and the Kyoto protocol of course go beyond this and are considering wider applications of the Clean Development Mechanism in sustainable development.

One direction to take the CDM is to investigate the possibility for local communities in developing countries to benefit from CDM funding directly (Skutsch, 2003). In this line of thinking communities would be rewarded for the additional efforts they take to manage and preserve their forests to prevent degeneration and to increase biodiversity. To make this happen a chain of action from local communities to international funding agencies must be created that is both sustainable and verifiable.

First problem here is that the concept of this idea is not available for discussion under the current Kyoto protocol. Only new forestation and reforestation projects are permitted in the protocol, no existing (community) forest management projects. But the reasons for not allowing these kinds of projects are under discussion and in the light of political and scientific developments (Skutsch, 2003) we could assume that such projects might be allowed in the near future.

Most important in the CDM business is that it is a money business, which business isn't? It is however a funny money business as projects accredited to receive funding have to be (made) almost unprofitable and will receive very little money. Added to that is the fact that the cheaper the project is to maintain, the sooner it is eligible for funding.
In reality it means that carbon accounting of forests needs to be done for a few (as few) dollars per hectare and that this information needs to find its way through national and international

agencies to the funding accountants without (much) added overhead. And if this hard task is accomplished and the carbon is accredited the same should apply to the road the funds take back to the community.

So step one is to have local communities do their own carbon accounting as cheaply as possible. Cheap means so cheap that hired consultants are out of the question. Communities should use their own capacity and indigenous knowledge to quantify the carbon in their forests. That communities have this knowledge (albeit qualitative in many cases) is already known for many years. What however is a problem in this case is the fact that CDM funding would not (and could not) happen for an individual CFM project of the size of a single village forest reserve but only for an accumulated number of projects that amount to several hundreds (thousands) of hectares. To accredit the carbon accounting for a multitude of locally generated data consisting of indigenous species names and measurement techniques is a difficult task and probably one of the reasons that small-scale projects are not allowed for funding. In order to make this possible there should be an interface which can, in a matter of speaking, translate indigenous knowledge to international standards, whatever these may be.

This paper is about the experiences in an ongoing research project to address this situation. To see how local knowledge, GIS technology and International conventions can be joined in a participative effort to enhance sustainable forest management.

About the research setting

The research project under which these experiences have been recorded is called 'Kyoto: Think Global, Act Local': Capacity Building for Local Sustainable Forest Management under international climate change treaties. The project is funded by DGIS (Netherlands Development Cooperation). It is coordinated by the University of Twente in the Netherlands and is executed in 6 countries by 3 partners:

- ICIMOD, Nepal, working in India and Nepal
- University of Dar es Salaam, Tanzania, working in Uganda and Tanzania
- ENDA, Senegal, working in Mali and Senegal.

ITC (Netherlands) is involved in the project to research and increase the capacity of local communities to use high end technology (GIS and GPS) to record their indigenous knowledge.

The project is set in the context of the Kyoto Protocol and the aim of Clean Development Mechanisms (CDM) to reduce global carbon emissions. This makes carbon sequestration via carbon sinks also eligible for funding under LUCF and local communities as well as enterprises are eligible. Conservation of existing carbon sinks, (management of natural forests) are however not yet included.

Kyoto eligibility for 'Natural Forest Management by Local Communities' is dependent on accurate and cheap carbon baseline measurements in natural forests (reduced transaction costs) and effective local monitoring of fixed carbon changes, acceptable to UNFCCC. Both these require appropriate local-level geo-information and a national & regional carbon policy to apply at local level (adaptation). It sets local institutional pre-requisites for the sustainable natural forest management, and effective measuring and monitoring.

The primary research objective therefore is to identify a potential methodology for geo-information management to enable effective measurement and monitoring of carbon stocks. In the light of the above it means that this will be investigated taking into account:

- Kyoto conditionalities: measurement of *carbon additionality*, *investment additionality*, *permanence*, *carbon leakage*, and: *sustainable local development & livelihood impacts.*
- Local measurement techniques must be robust, sufficiently accurate, cost-effective, locally acceptable & integrated, UNFCC-acceptable & Kyoto-eligible,
- Dovetail local monitoring of sinks with promoting sustainable local development, livelihoods, and empowerment impacts.
- Potential to integrate with transfer funds for: new multi-lateral environmental (BioCarbon Fund, Community Development CF) biodiversity & Red Book protection, watershed management payments, etc.

As it is unlikely in the short run that communities themselves will be able to deal with all the data requirements that surround these kinds of issues, the first year goal of the project was to show that involvement of community groups in the definition of sustainability indicators, and in the classification and measurement of forest types and conditions using PRA type methods for forest volumetric measurements and assessments on development indicators, short cut or could replace some of the procedures that have to be carried out in formulating climate projects. Also to show that such short cuts will considerably reduce project transaction costs. In the long run we may be in a position to push the process much further, with a view to involving the communities much more deeply in the project formulation and monitoring, in line with the idea that communities themselves could in the long run become the owners and initiators of such climate projects (Skutsch, 2003).

The part of the research described here deals with the participatory use of GIS technology. The first year of this project was mainly used to establish what is currently practically possible with using hands-on PPGIS while anticipating future developments. Both the technical and the participatory aspects were under investigation.

The first step was to assemble a portable GIS unit that could perform the basic steps of field data recording. The second step was to let local communities evaluate this unit. By letting the communities do a “participatory technology evaluation” problems with the GIS unit could be observed and recorded. This second step would provide the necessary input to adapt and improve the unit so it could be used by the communities in coming project years. The evaluation gave a useful insight into the capacity of local communities to work with these tools.

About the hardware and software

Evaluation of iPAQs

In this project, PDA technology was chosen as the platform for mobile GIS. PDA with a Windows CE operating system (HP iPAQ pocket PC) gives users the opportunity to work with familiar MS Windows software albeit in a simpler form. The pocket PC’s used and tested are not seen as possible end-products. They are tested in different configurations to understand their capabilities as field equipment and to see to what extent modifications are required to make them suitable for fieldwork. Ruggedized editions already exist but are avoided from a cost perspective. Technological developments follow each other very rapidly and it is judged more sensible to explore cheaper configurations with the same capabilities (but less rugged) first. When the testing phase is over a configuration that meets all requirements will be selected.

Evaluation of GPSes

All field equipment configurations require a GPS to directly register the location of any recordings made. Commercially available GPSes have many common characteristics but still they still differ largely in their options. Most GPSes however offer the same number of simultaneously received channels (12) and also have similar data acquisition intervals (1 second). Some GPSes can only be operated from the PDA but most can operate independently. Both cases were tested as both seemed to offer their advantages. The more "black box" a GPS is with fewer possibilities to operate it, the less can be done wrong with it. A "stand-alone" GPS can be monitored and be used as backup when the PDA is not functioning.

Recommended set-up based on experiences

The older iPAQ 3970, was a very good piece of equipment that unfortunately is no longer for sale. Its successor the 5550 has been equipped with more functionality that increases its worth but it is also one of the first PDAs to offer so much functionality and with that its system is somewhat sensitive to bugs and errors. It does however remain a good piece of equipment. ROM upgrades which are released every now and then do fix most of the problems. The HP 1940 has a different processor which performs like the 5550 although it is slower and this makes for more efficient power consumption. It is very small and extremely light (screen is slightly smaller). It has a few new hardware problems that need to be checked and compared to the other systems.

The 5550 with Garmin or Navman remains the most tested system and because of its portability the Navman is preferred in the field. In Senegal the environmental conditions are suitable for the Navman as signal obstructions are little. If problems remain as they are in the steep Indian mountains it might be recommendable to use a Garmin or BT GPS there instead of the Navman. Canopy and tree density in Tanzania might also require this option. As the cable connection with the Garmin is considered very fragile I am hesitant to recommend this option. The NAVMAN has as additional benefit that it cannot be tampered with. As it has no buttons it cannot be misused. The GPSmart BT GPS is also tested extensively. This might become a suitable alternative to the Garmin and become part of the final outfit (Garmin might also offer Bluetooth (BT) technology soon). Same can be said about the 1940. It has different problems than the 55xx and 39xx series which need to be evaluated more but it is a very small and light system. Together with a BT GPS it is a very nice combination of performance and portability.

Tablet PC

The main problem with the iPAQ sets is the size of the screen. To operate it with one or two people is not a problem but it is difficult to simultaneously look at the screen with more than two people. Because of the participatory nature of the projects and the research this is a problem. To investigate whether this problem can be solved a Tablet PC (10.4" screen) will be used in the field to see if this improves the participatory work. Such a set-up does however cost twice as much as an iPAQ set-up so a balance must be made between them. There is no doubt that the Tablet PC will make (iPAQ) training easier. The (HP) TC1100 Tablet PC is one of the few tablet PC's on the market with a detachable screen, which makes it very portable.
It operates ArcPAD on a much bigger screen of course but it can also run the full ArcGIS programme (or ERDAS) making it a mobile GIS-lab. This means that the full database for a

project can be kept and appended in the field (if necessary). It also will offer easier operation as there are much more applications available to make it user friendly. Main drawback is that the screen has no backlight, which makes it less visible outside in the sun. Newer models will certainly include this feature.

Software

The ArcPAD 6.0.2 software has proven to be useful and many of the bugs that have been reported during project experiments were mainly due to either hardware compatibility or data preparation. The main drawback that has surfaced is the elaborate number of steps that need to be taken in order to be able to edit layers (add data). This means that people without a reasonable understanding of the programme cannot operate it without guidance. It must be seen whether a user interface (macro) can be created that does all the necessary set-up that the programme requires.

The tablet PC offers more versatility as it can operate more different software. Using ArcGIS directly gives the opportunity to have an active link with the project database. Any work done is directly updating the database as the software uses the same DBMS as MS Access and thus can be connected to such a database.

Experiences with local communities

Over the past 10 years many experiences have been made with local communities and their ability to understand GIS and GPS technology and maps to assist in local level planning (e.g. McKinnon, 1999). Many of these experiments investigated the understanding or applicability of the methodology and technology. The complexity and portability of the technology has until now prevented actual hands on participation by local communities. Research has been done by taking a GIS to remote communities (Gonzales, 2000) using truck batteries as PC power supplies and a trained operator to perform the necessary actions. The Graphical User Interfaces (GUI) that are nowadays available on commercially available portable computers offer the ability to even illiterate people to make use of (mobile) computers without the direct assistance of experts. These technological advances will probably improve the integration of GIS in communities (Harris and Weiner, 1998b; McCall, 2003)

A part of the research done in this project has been to investigate which parts of the standard GUI that a GIS offers require more or less training for users that are not educated in computer operation. A question to be answered was which parts of the GUI can remain unaltered and to what extent can the interface be modified.

The ArcPad 6.0 programme used offers several possibilities to adapt or tailor the interface with pre-formatted toolbars and forms for data entry. Based on the experiences in 3 project areas the first steps are now taken with the local counterparts to develop an interface that is suitable for all project locations.

Tanzania

The first project location is situated in the East Usambara Mountains in Northern Tanzania. The Handei Village Forest Reserve (VFR) is managed by a Village Forest Committee and lies about 4 km from the village. It has an area of about 160 ha. It is part of the Amani Biosphere reserve which consists of thirteen villages working together with nature conservationists in a collaborative sustainable management programme. Although the establishment of the VFR is not

one of the most successful examples of community forest management (CFM) (Zulu, 2004) the site was chosen for its convenience. The communities in Amani are familiar with scientific research parties in the area and the total biosphere reserve could become a cooperative of many small “CDM” projects.
The purpose of the exercise was to do the experiment with local people who have no experience with the envisioned methodology or technology. Through this, strengths and weaknesses of the methodology and technology might be discovered.
Six people from the village participated in the exercise. Two participants were women and the levels of education of the villagers varied from standard 7 (4 participants) to standard 4 (1) and no formal education (1). All were members of either the village government or the village forest committee.

The participatory technology evaluation was performed to learn about the ability of the villagers to use a mobile GIS unit (a GPS as an integrated system with an iPAQ) to find points enter relevant forestry data and to draw boundaries around the reserve.

Training was given with the help of 3 interpreters who also had technical knowledge of forestry. Three sets of computers were used, so in principle two villagers worked with one professional in a team.

None of the villagers had ever seen a computer much less used one. Concepts such as ‘open file’ and ‘save file’ were unknown to them. Nevertheless they quite quickly grasped how to operate the IPAQ (on/off, entering words and numbers with stylus, moving from one programme to another with the stylus). As some of these operations require rather complicated sequences of moves which are difficult to explain and unnecessary as far as the exercise was concerned this was partly prepared for them. Within 4 hours each of the teams had grasped the basics of locating a point using the GPS system and had found the 4 pre-planned points that appeared on the screen. They understood that ‘no fix’ occurred sometimes because the GPS could not receive enough signals from the satellites. They also made a circuit around a plot of trees, watching the polygon develop on the screen, and (with help) entered data describing this plot on a pre designed form on the IPAQ (name of plot, slope angle, crown cover, etc.

The principal things learnt from this exercise were:

The villages did not have a lot of difficulty with the operation of the IPAQ. They are able to understand which icon to press for certain operations, to restart the machine when it blacks out to save its battery, to enter data with the stylus,
The villagers were able to follow the ‘compass’ of the GPS on the screen to retrieve a point in the field. The graphic display of this feature within ArcPad is apparently very suitable and straightforward to understand its use. This is very encouraging, particularly the fact that the villagers were all totally absorbed by the exercise for more than 3 hours and very evidently were enjoying it enormously.
It is more of a challenge to explain the basic functions and features of a computer (the well known “conventions” of terminology and symbology to computer users) to people that are unfamiliar to the concept of computers.
A lot of button pressing is necessary to get to the starting point of the GPS exercise, which is difficult to achieve for someone unfamiliar with the equipment. Ideally we need a tailor made user interface that enables direct operation of the necessary software and on which only the functions that are needed are present. Many of these demands can already be met by the flexibility of ArcPad.

Data entry with the stylus went much better than expected. The standard form for entering details (dbh, height, species etc) had been installed on the iPAQ with entry fields for numerical data and pull down menus for qualitative data (the latter still in English, but this can easily be done in local language). However the use of the tap keyboard with letter and numbers was easily understood, also how to use the pull down menus.

The only visual aid available for the exercise was a digital topographical map (scale 1:50,000) as a backdrop for the GIS programme. This enabled the villagers to orient themselves in the field. As map scale is often a problem when working in a small area there can be doubts on the usefulness of this additional data. The local community does not need any geographical reference to orient themselves in the field. It does however provide a check on recorded data. The fact that the entered data becomes directly visible on screen is however a benefit. Progress becomes visible as well as spatial patterns.
What would help is some graphical explanation on how the GPS receiver works. This could be of help to mitigate some of the field problems experienced as it is good for people understand why they need to hold the machine in such “awkward” positions to receive signals.

Not only was it clear that villagers could catch on very quickly both to techniques of forest measurement and to using a highly complex computer, which was a primary objective; we got a lot of feedback on teething problems of the computer system and also insights into what needs to be measured in the forest. Some of these changes were be made before the next participatory technology evaluation session, which took place in India.

India

The second “participatory technology evaluation” was done in the Village Dhaili, 90 km from Nainital, Uttaranchar, India on the foot slopes of the Himalayas . About 15 villagers (from 3 villages) participated in the PTE. The level of education seemed to be higher than in Tanzania. This PTE was also different in its institutional setting. The participants consisted of the local community and the national counterpart that would deal with the technical support who were not present in the evaluation in Tanzania.
The villagers had been thoroughly briefed by the counterpart on the outline of the project and “carbon issues” and had been introduced to the basic concepts of GPS. This preparation was noted as very valuable. Basic instructions were quite easily understood and the questions raised by the villagers provided useful input.

During the PTE the villagers were divided into 3 groups that were guided by 3 technical assistants from the local counterpart. Through this set-up the villagers again quickly learned the basic operations with the iPAQs. Especially on basic computer operations (start-up and opening files) and the data input they showed fast progress. The training venue was situated conveniently on a roof terrace that, with excellent weather conditions, made a fine GPS testing location. The three groups could easily try all GPS related functions within ArcPad under these conditions.
After the groups felt confident enough with the equipment a small forest survey was done to test the equipment on-site. Sampling strategies for these forests exist already locally and altogether this could suit quick measurement of carbon parameters.

High on the slopes in the forest there was little problem to get GPS signals with the Navman GPS. An external antenna that was constructed after the Tanzania experience did not provide significantly better signals although it did prevent some errors occurring during data entry.

On the lower parts of the slopes, the high canopy density (which is fairly constant) and the increasing topography provided serious signal acquisition problems for the Navman, similar to earlier experiences.
For the training graphics were used to illustrate the different concepts of GIS and GPS. The illustrations made for this training were very useful to illustrate the accuracy of GPS and signal acquisition and the concept of geographical coordinates.
The external antenna proved its functionality but with high canopy cover its use is limited to preventing errors during data entry.
Different than in the Tanzania experiment an ASTER satellite image was used as a background layer in ArcPad to see if this would prove as useful as a topographical map. The villagers however could not easily reference themselves on the false colour picture. The iPAQ screen is too small to get sufficient detail and overview at the scale of the project. Possibly when testing the use of a bigger screen (tablet PC or laptop) this can still be incorporated. For iPAQs one needs high-resolution images, Ikonos or preferably Aerial Photographs to be of use. Using digitised topo-sheets or existing map layers as background layers is thus far to be recommended.

Senegal

The workshop in Mali was redirected to Senegal, close to Dakar. The participating group did not consist of villagers of the planned project area. The participants were the local technical staff that would be responsible for training the local communities in Mali and Senegal and the project counterpart who is responsible for the institutional and policy aspects for that region. The PTE was therefore more a “training of trainers”, devoted to familiarizing the staff of the different organizations with the methodology and the technology .

The workshop was very active and all participants were deeply engaged in coming to grips with the methodology and technology. It was evident from the beginning that there were effectively two groups: those who have no experience of GIS/GPS, and who needed some practical hours to learn to operate the system, and those who are experienced with GIS and quickly understood the operation of the system. This second group therefore was separated at some point to understand better the technical details of the PDA’s and software.

The only way to learn is by doing. A simple manual to accompany the system, with worked examples to help staff become familiar and confident with the operation of the technology was apparently needed.
There is however a difference between integrating the methodology/databases and operating the machines with respect to the training or capabilities of the local staff. The operation of the PDA’s is running more smoothly partly because the local staff is familiar with “jamming” computers. The outfits also have become less error prone since the first workshop in Tanzania because of software and ROM upgrades.

One major difference in this workshop was the higher level of education/training of the participants. This required a different approach in explaining the tools and their possibilities. For one it took more time to explain different issues, as the number of questions generated was much larger. The experiences so far in all three regions do show the different approaches needed and the different requirements for the involved “levels” of participants in the project.

Institutional aspects: a possible way for this to work

The results from this research up to now are much in line with more generalized statements about the proper use of participatory geo-information approaches and tools in spatial planning (e.g. McCall 2003).

In applying 'good governance' in geo-information systems, certain criteria and conditions are paramount. For the GI approaches and tools to strengthen good government, they should:

- support 'accountability' expressed in terms of 'transparency' and 'visibility' of decisions – mobile P-GIS does this, so long as there is a representative group involved. In all project areas this is the case.
- promote 'participation' of the disadvantaged and less articulate, and usually, of women as a particular group – as above, mobile GIS is supporting this in this project. Team members come from various backgrounds and levels of education, both men and women.
- support 'respect for local knowledge' and indigenous spatial knowledge which lies at the heart of this project – mobile GIS makes explicit use of local people's knowledge of spatial boundaries, resource conditions, indigenous zoning principles, etc.
- provide for 'equity' in terms of local manageability of the tools – mobile GIS has not yet achieved this, but the technology is becoming increasingly user-friendly as has been experienced in this project. Also from an institutional point of view this objective can already be envisioned.
- competence, i.e. the capacity to acquire and understand and use the actual information that has real meaning for the local people – given that it is their own resource and responsibility the local communities involved here are well aware of the implications of this P-GIS approach. They understand that mastering this tool to the level of their capacity can assist the management of resources but more importantly they see it as a window of opportunity to have a wider impact on their communal livelihoods.

The technical solution for this issue will present itself in due course given the current rate of developments in computer technology. This projects main goal therefore is not to figure out an ideal configuration in the short run but rather to find a way in which the approach can be institutionalised at different levels.

The three broad levels that we are dealing with are local, national and international. For the aims of this project to be achieved there need to be institutions functioning at all three levels and in between them. These are institutions dealing with one framework for CDM or carbon related issues. Assumptions therefore must be made to the future establishment of such a framework. Given the recent developments under the Kyoto protocol this seems more and more likely.

The top level international institutions will be the bodies that preside over the framework (protocols) and the accrediting agencies that validate any data. Together with the local level institutions, being the managing bodies of the CFM projects and their participants, these are most easy to define.

It is more difficult to define who will be institutions at national level and linking between levels. From local to national level an institution must be established that can liase with the national institutions regarding carbon issues. Probably they could be one and the same but it is more likely to be a well networked NGO. Ideally this NGO would also be able to link (with) the national level (institutions) with the international level. Ideally because the less institutions involved the cheaper the process probably can stay. In India and Senegal two NGOs are already able to play the role of liaison between local and national level. In Tanzania an institution at this intermediate level has not yet materialised.

In all project countries at least the participatory management has been institutionalised from national level. Local forest committees have mandates for action and their efforts are acknowledged. Part of the institutionalisation between local and national level will be to be able to coordinate as many participatory “CDM” projects as there to be accepted as one accreditation request. As least as much effort needs to be put in creating a mechanism for dispersing any funds obtained back to the participants. Much of these institutional aspects are therefore dealing with national laws and regulations.

Conclusion

Based on the first year of experiences it can be said that local communities can learn without much difficulty to use mobile GIS to make inventories of their natural resources.
The technological developments indicate that portable computers in the near future could enable people with limited formal education to record and quantify the indigenous knowledge of their natural resources.
If the institutional settings at local, national and international level could accommodate the accreditation of local knowledge that is recorded through mobile GIS, giving them international recognition for their efforts, it will add to the sustainable development of local communities and their resources.

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