Integrating Participatory Resource Mapping and Geographic Information Systems in Forest Conservation and Natural Resources Management in Cameroon: A Methodological Guide

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1. INTRODUCTION

With reducing forests in the west and central Africa sub-region (Faure, 1989; Ntep, 1999), governments and non-governmental organisations (NGOs) are putting increasing emphasis on permanent forest conservation and management. As a result, throughout the past one and a half decades, there has been an increasing designation of protected areas in Cameroon and Nigeria (EarthTrends, 2001). Some of these protected areas like the Korup National Park (KNP), Cameroon, either have people living inside them or very close to the periphery (Vabi, 1999). Thus, in order to effectively manage the park, the involvement of the local communities in the process is not only considered a modern approach but is seen as indispensable (Barzetti, 1993). One way of assessing the potential to be played by a specific group of communities is by evaluating the extent to which their livelihood strategies are intertwined with the resources in the protected area.

Secondly, with reduced access to permanent forests, livelihood needs at local levels are consequently being derived from semi-managed forest stocks, preferably in the ever-increasing soft edges of permanent forests, loosely referred to as secondary forests (Budowski, 1961, 1970; Gómez-Pompa and Vásques, 1974) and depending on the extent of human-induced management, as agroforests. It is increasingly in these agroforests that resource-poor farmers are being assisted by NGOs (non-governmental organisations), in programmes aimed at the diversification of food and income options such as in the domestication of indigenous fruit and medicinal trees (Leakey and Simons, 1998; Leakey and Tchoundjeu, 2001). Despite existing opportunities for the cultivation and marketing of indigenous trees (Ndoye *et al*., 1997), existing low levels of tree planting by farmers in the region (Degrande *et al*., *in prep*.) is being partly justified by farmers in terms of limited available land livelihood needs. To appraise this situation in a participatory manner, options for tree integration into existing land use systems need to be evaluated in a way that empowers the farmer regarding the true, not imagined, possibilities or limitations of his or her land.

These are the two main issues dealt with in this paper and which are used to illustrate this method of integrating participatory resource mapping and geographic information systems. Given these two issues, two main objectives were developed for the work, viz. using Arcview GIS to:

i. capture, store and manage relevant spatially related data collected through participatory means and in a protected area context, in a retrievable and transformable form, which permits the conservation of its structure including other static features for later use in forest conservation and management.
ii. accurately capture and analyse the spatial disposition of land use possibilities and constraints within the context of tree integration into an agricultural system, with farmers, to enable them to make more precise and informed decisions and choices.

2. Justification of and Background to the Development and Use of the Method.

In the case of the KNP, high-resolution (6m pixels) Synthetic Aperture Radar (SAR) imagery of the park was obtained in 1993 (KNP Management Plan, 2003). After ground truthing, these aerial photographs could have been used to produce maps showing the encroachment of agricultural activities into the park. However, it was considered that communicating and raising the awareness of local people regarding the effects of their activities on protected resources was more crucial in responsibility sharing and in joint management later on. Therefore, a more participatory approach to the analysis of phenomena like encroachment using techniques like participatory resource mapping (see Box 1) was not only a cheaper option, but was believed to be more effective in managing such conflict of interest as opposed to its diagnosis only through the use of sophisticated and expensive aerial photographs.

Box 1: Participatory Resource Mapping (PRM

Participatory Resource Mapping is a tool used by practitioners of participatory methods to acquire a systematic and graphic understanding of the layout of a farmers' landscape and of his/her setting in the village space. This tool permits a picturesque representation of a farmers'/village environment in terms of its make-up, the location of objects or features and their disposition with respect to other related or neighbouring objects. The process evolves with an external facilitator encouraging the farmers to make a graphic representation or drawing of their surroundings, preferably using a familiar object as drawing material, most often on the bare ground. Thereafter, following the objective of the study exercise the farmers are requested to indicate in the drawing of their own environment, relevant physical features, and in the process providing descriptive information that the facilitator records as attribute data. The outcome of this process therefore, is often a map of a farmers' environment covering the themes that reflect the objective of the exercise, and descriptive notes taken by the facilitator, that may comprise, though not exclusively, dates of events, names of farm owners, time taken to walk to points, local names and sightings of wildlife. Not only does the process facilitates a spatial appreciation of a village landscape by an outsider, but it also strengthens the farmer's sense of mastery over his/her environment.

Furthermore, it is standard practice for socio-economic studies to be carried-out as a first step to the involvement of local communities in protected area conservation and management; and in natural resources management in non-permanent forests. While it is largely recognized in protected area management that modern approaches demand the involvement of local communities (Barzetti, 1993), in the case of tree integration within an agricultural context, it is important that, the outcome of the process should not work against other farmer land use strategies or create new problems for the farmer or his/her neighbours (Fujisaka, 1993).

Therefore, in the capture and valorisation of information from local communities by integrating PRM and geographic information systems (see Box 2), both in the context of the KNP and in the diversification of indigenous trees, farmer participation was not only a cheaper option but, one that facilitated the incorporation of local perceptions and perspectives into the conception phase of a forest conservation and natural resources management process. Consequently, going down into the villages and using participatory methods and approaches compatible with a computerised information system and communicating with the people who use the forests and land on a daily basis, who know its limits and problems, its diversity and its opportunities, can increasingly be a practical and effective means of acquiring and managing human-centred natural resources management information.

Box 2: Geographic Information Systems (GIS)

A Geographic Information System, or a GIS, is a relational database whose main feature is the use of a common coordinate system for accessing both spatial data (on objects) and descriptive or attribute information defining those objects. The descriptive or *attribute* information can be stored as tables, graphs, or plain text containing information defining the *objects* or features. Because these objects (lines, points, filled-in objects) are stored in real world co-ordinates, when accessing the system spatial objects can appear with their linked attribute data on any part of the globe. This feature makes a GIS ideal for storing information for making and understanding maps. A GIS possesses facilities for quantitative statistical analysis of the data linked by the system to the objects. This feature help make maps interactive and more useful in understanding the relationship between spatial objects and the context in which they exist. Because a GIS is like any other database, its data can be dated and thus a GIS can serve as a useful tool for monitoring change in quantities and relationships, over time and between locations. Of-course, a GIS is completely computer-based, therefore for it to function properly a GIS requires a data capturing and entry system e.g., Global positioning systems, aerial photos, satellite imagery, scanners, etc, a data storage and processing system; data converters, data processors, a computer hard drive, peripheral storage media, digitizers; and a data output system; printers, plotters, projectors, reports, etc.

Beyond personal experience, the opportunities presented by a GIS as an adaptive information system was further recognised in a meeting (Vabi et al., Unpublished Report) of 31 practitioners and trainers of participatory methods and approaches in Cameroon and Financed by the WWF-Cameroon Country programme office. To illustrate the application of a GIS, it was widely agreed in the meeting that one of the most intractable problems with processing data acquired by using participatory methods and approaches was the sheer volume of the information, its hugely qualitative character, and often, the subjectivity of even the experienced practitioner, which could vary with context, time, space or even skill. However, using a GIS to capture and manage spatially linked data provides enough time for thorough and objective analysis because there is a strong likelihood that the GIS will impose a common structure on the data and help make any analysis more systematic. The platform on which such participatory data is captured prior to its introduction into a GIS is the PRM.

3. The Value of PRM and What is Gained by its Integration into a GIS.

In the practice of participatory methods, amongst the most widely used tools are those that encourage the local people to express themselves within the context of their environments and without the inconvenience of language barriers. PRM was recognised in this meeting as an important tool. As it is very often used as the 'entry' tool into the use of participatory methods and approaches by practitioners in a village, especially where spatial analysis of land use is envisaged, it permits more villagers to participate. It also facilitates the identification of resource persons in the village as well as the identification of the more reluctant participants. Finally, during the participatory resource mapping process itself, it is standard practice for most *objects* (farms, plots, trees etc) identified spatially, in the village to be discussed in focussed groups later on while still in the villages. Subsequently, the information thus acquired from the villages is analysed in project offices, presented to, or analysed by professionals other than those who collected it. As the data continues to change hands, unless the information collected is presented each time, completely and accurately, it may not serve the purpose for which it was originally collected, or worse it may be misleading. It is a common criticism (*pers. Comm*. with practitioners) that only part of the data collected during the participatory appraisal exercise in the village is ever used or analysed. Even where it is analysed, traditional forms of data storage, either as texts, or even in a database such as Microsoft Access, do not facilitate quick retrieval and subsequent reference later on, of spatially linked information. Rather than referring to spatial information by using latitude and longitudes coordinates incorporated in text documents, it has proven useful to store and manage spatially linked data in the same form as that in which it was collected. To this end, an appropriate information system like a GIS capable of storing objects in their real-word coordinates, and linked to text information, is crucial.

The situation of improper storage and management of spatially-linked information is a weakness which constrains the value of time-bound spatial information in processes like monitoring and thus requires repetitions of similar studies within very short intervals in same locations, that lead to the common syndrome of 'villager fatigue'. For research data to serve the purpose of demonstrating the value of local knowledge, especially retrospectively, and eventually putting local people in a 'real world' context, it should be in a storable, retrievable, transformable form, and one in which it can be combined and integrated say in a regional, national or international context. A GIS presents such an opportunity. Finally, a lesson learnt from previous experiences, and which has been built into this methodology, integrating Participatory Resource Mapping (PRM) into a Geographic Information System requires good skills in both disciplines.

4. Some Comparable Work in the African Context.

Participatory mapping is not new in Africa as a whole. It remains an integral part of PRA (participatory rural appraisals) and indeed other participatory methods (see Box 1). Mapping and modelling are good techniques to start with because they involve several people, stimulate much discussion and enthusiasm, provide the PRA team with an overview of the area, and deal with non-controversial information (WorldBank, 1996). However, with respect to attempts at integrating participatory resource mapping and GIS, only two similar activities can be cited here.

Firstly, a participatory mapping training workshop jointly organized by the German-funded Mount Cameroon Project (MCP) in Buea, Cameroon and the Central Africa Programme for the Environment (CARPE). These training workshops and mapping exercises were held in 1998 and 1999 respectively and the reports are available from: (http://carpe.umd.edu/products/PDF_files/Report-MtCameroonProjectCARPE1999.pdf). The main objectives of the exercise were to empower local communities to better manage and benefit from natural resources by involving them in the actual mapping of their own resources. Another aim of this mapping process was to contribute to land use planning and resource management plans to be developed by the MCP, Buea in Collaboration with the government. An important aspect of this MCP-CARPE collaborative project was the aspect of recognition of the products by the State. Perhaps that was so because the main outputs of the process were 'large scale participatory maps in hard and digital copies. Firstly, this experience differs from that reported in this article in terms of objectives. Rather than the production of legal maps, the methodology in this article has as main objective to use an information system to provide advocacy for local communities in forest conservation, through the transcription of their livelihood activities into a 'real-world' context accessible to higher-level decision-makers. Secondly, generating information which links people and object, and which raises awareness of such relationships was another key objective of the methodology in this article. Furthermore, from a logistical perspective the MCP-CARPE project was huge and involved significant costs, in both human and material terms, to implement. The project described in this article is much less complex. In-fact, in the case of trees diversification, the methodology discussed in this article can be so cheaply employed that monitoring the evolution of a single farm or farmer is possible at very low cost. Finally, although the MCP-CARPE experience potentially has longer-term value, it did not seem clear if the system or approach was specifically designed to provide a platform for monitoring. Even so, due to the immense logistical constraint it can serve monitoring purposes though very expensively.

Secondly, a comparable experience worth citing was the subject of an international training course on Participatory Environmental Appraisal in GIS-supported Environmental Analysis held at the Norton, Zimbabwe, at the Institute of Public Administration (ZIPAM), in 1998. The course was financed by the Federal Ministry for Economic Cooperation and Development, on behalf of the Government of Germany. This experience was the foundation on which this methodology was developed. The evolution of this methodology that now seems different from the experience in Norton, Zimbabwe is normal and expected. In Norton the principle was still a concept and the reality was that previous attempts at integrating participatory methods and GIS were too discipline driven – meaning that, the GIS specialists possessed few participatory skills, while the experts on participatory methods possessed few GIS skills. One lesson which has been incorporated in this methodology is that mastery of both disciplines is essential for effective practice of the methodology

5. METHODOLOGY

5.1: Preparing the integration of a Participatory Resource Map into a GIS.

A 1:200,000 paper map of Cameroon was used. The tic marks (coordinate intersection points) of the humid forest lowland areas on the map were marked-out using a black pencil. These relevant sections were then scanned-in and saved as *bmp* black and white (could also be in colour) images on the hard drive of a 128 MB personal computer. Overlapping adjacent sections of the map were scanned such that the tic marks whose coordinates had been copied-out showed off clearly on the preview screen prior to saving. Thereafter, each scanned map section was imported into a professional version of TNT*mips* (TNT Products, Version 6.0, October 1998) application software. (Version 6.0, 1988) Geo-referencing was done progressively by entering the coordinates of at least four tic marks per image as the ground control points for real world geo-referencing. Once this process is completed these scanned maps fit into the map of Cameroon which then becomes part of the map of the world and part of the GIS in TNT*mips*. Alternatively, it is also possible to download prior geo-referenced relevant digital maps of any part of the world from the Internet[1] for some countries. This can make scanning and geo-referencing unnecessary. The use of TNT*mips* for geo-referencing of the Cameroon base-map was a question of choice by the author. Other *Arcview* compatible software like IMAGEWARP, Arcview Spatial Analyst, etc., may also be used for geo-referencing of scanned images of a topographic map of scale 1:200 000 or lower. After geo-referencing, the images can be exported to a regular GIS application software such as *Arcview* GIS version 3.2a.

In *Arcview* GIS 3.2a, the geo-referenced map of Cameroon is brought into the *View* by selecting *Image data source*. Areas in which the participatory mapping work was to be carried-out, were then zoomed-in and enlarged. Features such as footpaths, roads passable by vehicle, villages, streams and rivers, mountain ranges and other physical features on these areas were digitised on-screen using the mouse, as separate *themes.* After all the roads and footpaths have been digitised as lines; houses, and other structures as points; the village territory, parks and forest reserves as *polygons*, the scanned-in images of the background topographic map was then removed from the *View* leaving only the newly digitised *vector objects* on the screen. These *vector objects* would constitute the main physical features or 'landmarks' of the land use system or resource in which the PRM exercise was to take place. They would show the main physical features of the locality and the entire output is referred-to as a *frame* on to which participatorily generated information will be transcribed*.* These *frames* were then printed out as simple maps on a large enough paper size (poster format or AO recommended). A4 (smaller) maps can also be used, but the bigger the maps the easier the transcription process will be.

5.2 Whole Village Participatory Resource Mapping

While in the village the participatory resources mapping process was carried-out as normal involving a representative sample of the entire village population. The main interviewing technique here was semi-structured group discussions. (See box 1). During the exercise three resource persons were identified on the basis of the level of their participation and/or extent of their knowledge of the village landscape and of the natural resources management issues being discussed in the process. After the exercise, the map constructed by the entire village was copied-out, exactly like the original one, on to a large sheet of khaki brown paper. An appointment was then made with the identified, resource persons for the following day.

5.3 Ground–truthing of Participatorily Mapped Information and Building-up of Village/community Database.

Using open-ended questioning in this focussed group semi-structured interviewing process, the features on the map 'drawn on the bare ground by the villagers and copied onto the brown paper were now verified using the three resource persons, and transcribed on the *frames* previously printed-out from the GIS. Feature by feature, the objects were, identified, verified on the khaki brown sheet of paper showing the village map and transcribed onto the geo-referenced *frame*. The work with the resource persons sometimes required the verification of the location and description of certain features previously identified in the 'whole village' mapping session. Subsequent agreement is thus achieved by analysing and vetting some of the information supplied by the village vis-à-vis what exists in the 'real-world'. To this end all modifications where made and incorporated in the *frames*. During this exercise the location of water points, the village limits, bridges/culverts, animal sightings, hunters' huts, last farms, farm or protected area boundaries, spaces in farms, wetlands, productive farms,

[1] See the following resources: *http://www.fao.org/forestry/fo/fra/download.jsp*; *http://www.globalforestwatch.org/english/datawarehouse/index.asp*

unproductive farms, were taken using a handheld Global Positioning System (*Garmin* GPS12CX, see *http://gpsdb.com/index.shtml) (*see Box 3).

Box 3: Global Positioning System (GPS)

A Global Positioning System (GPS) is an electronic device of variable shape and size, capable of providing the latitude and longitude reading of any point on the surface of the earth. It achieves this effectively by computing and triangulating the coordinates of that point by downloading relevant data from 2 or more satellites in outer space. This way the latitude and longitude coordinates can be converted into *Decimal degrees* in Microsoft EXCEL using a simple formula (Seconds/60+Minutes)/60+Degrees. This is now exported into Arcview by saving as a *dbf IV file* in MS EXCEL. In Arcview the data is integrated into a *View* by *adding an event theme*. It can be fully incorporated as a point *object* in Arcview by converting it into a *Shape file.* In this way the location of objects taken by a GPS during a participatory mapping process can be easily incorporated into a spatial database of a community.

This consultative work with the resource persons on making the information on the *frame* reflect the participatorily gathered information was completed in a day per village in the case of the Korup National Park which was a one-off survey and ten weeks in the case of the trees diversification site which required more detail and thus many trips. On this map *(frame*), the village and its territory, all houses, streams, footpaths, main roads, limits, landmarks, farms, wetlands, productive farms, unproductive farms etc, including *attribute* or descriptive data were indicated.

5.4 Integrating the participatorily collected information into a GIS and building-up of electronic database in Arcview GIS 3.2a.

This map was then taken back to the office and all the features were entered into the GIS by directly digitising on-screen on to the section from which the community area base maps (*frames*) had been printed-out. After this process, the finished map was taken back to the village and openly discussed with a gender balanced and enlarged group of resource persons that included the three original resource persons. No major modifications where made and the villagers were very excited at being able to see their village as part a bigger picture and in the case of the National Park within the context of its management zones.

In the case of the analysis of farming systems at the ICRAF sites, as already pointed out, it was a gradual but more long-term process. Here, over a period of Ten weeks repeated visits were made to the houses of village participants each time staff where in the field, and household members were asked to progressively map-out the location and type of farms, water points, quality and type; fallow lands, previous crop, ownership and age; animal sightings, species and frequency; forest product, species, collection periods and tenure; village limits; forest use by whom, household demography and made comments.

In both the conservation and the tree diversification and integration contexts, the data in the GIS was organised at Ethnic group level, then family group (group of villages), then village level, and finally at household. At village level, the data was progressively taken down for each household or point, and entered into the GIS as text and figures in tables. In the GIS all the descriptive or *attribute* data was linked to the household-point data (*objects*), like farms, its ownership, size, crop, length of cultivation, crop sequence, type and mix. At household level information included demographic factors like births over past 12 months, deaths over same period, in-out migrations, educational levels, household size, number and quality of houses. Non-spatial information like institutional affiliations, decision making bodies, socio-cultural peculiarities linked the village and the communities at higher level in tables making it possible to sort by using simple queries.

6. Sample Data Output and Analysis

To illustrate the potential usefulness of the system, sample data acquired from the trees diversification and domestication research site in central Cameroon will be used. This is because being more smaller scale farms can be identified and discussed within the context of the entire landscape. The principle within the Korup National Park process was identical in principle.

Figure I[2], shows a scanned copy of the PRM prepared by the villagers and copied on to a brown sheet of paper. Figure II, shows the results of the transcription of the information from the participatory process onto a *frame*, which is later on integrated into a GIS. Figure III illustrates the data structure in the GIS: its arrangement and its relational character.

During and after the focussed discussions with the farmers, it was generally agreed that cocoa farms are prime sites for tree integration. Figure IV shows the results of a systematic mapping and analysis of 10% of the village population. Important reasons for selecting cocoa farms was that these were more secure and thus long-term ownership of fruits is unlikely to be a problem. Older farms also tended to be in the middle of the village, and integrating trees in them was seen by the farmers as a form of rehabilitation of the 'old town'. From the output in Figure IV their reasons can be further be substantiated as cocoa farms tended to concentrate more towards the centre of the village territory – obviously a less disputed portion of the land. On the other hand, food crop fields often considered in the same category as fallow fields, are used by farmers in acquiring new farmland. Thus, there is a concentration of these types of farms in the 'frontier' sections of the village territory. There were much less trees earmarked for the eastern section of the village territory. As Figure IV will indicate this area is reserved for food crops as it is considered generally more fertile.
The location of farms belonging to single families tended to be dispersed all over the village landscape. Through mapping farmers saw increasing possibilities for land use and tree integration, as certain portions of their lands (between fields especially) could not be classified readily. They were familiar with land ownership even by those not taking part in the study. Once they realised that a piece of land could not be attributed to any category although its ownership was known, such land came under scrutiny by the farmer as a possible site for trees diversification and integration. Such sites included old cocoa farms, old fallow fields, unfarmed portions of sloping land, wetlands and home garden: sections not normally considered in day-to-day agriculture.

The data analysis processes included temporal data (see Figure III), and thus is used in monitoring. To develop an insight into farmer decision-making process especially at farm level, analysis was carried-out in the farm, within its limited context and also within the context of the landscape. This way the farmer saw his/her farm evolving with the landscape. For instance, the farmers were able to appreciate that should the trend continue, where trees were being integrated largely in cocoa farms (Figure IV), the landscape of the future is likely to be made up of clumps of trees. Such fragmented forest has implications for plant/animal species survival because it creates corridors and affects forest continuity (Hudson, 1991). Influencing woodland continuity can only be done at landscape level and with external contributions.

[2] Figures I, II, III and IV are provided in a separate file in view of their size. This is available from the http://www.ejisdc.org website under Volume 14, Paper 2, Figures.pdf.

7. Some Achievements of the Process

Within the Conservation and management Context of the Korup National park

The use of the techniques within the context of the Korup National Park was focussed on evaluating the extent of community use of park's resources. The work concentrated on villages within three kilometres of the park limits. The findings of this work are reported in VABI (1999) and more details would be found in (Mbile *et al*. in preparation). The capture of the spatial data indicating the extent of use of parks resources were subsequently presented in management planning follow-up workshops (Vabi, 2000). These information convinced the panel to adopt a community conservation strategy (Vabi, 2000), with an entire section under 'Management Programmes', dedicated to the involvement of these villages within three kilometres of the park boundary in long-term management.

Secondly, although the process of the development of the current Korup National Park Management plan started as early as 1986 (Cloutier & Dufresne, 1986), it was not until 2000 that the first draft was produced by Malte Sommerlatte (WWF-CPO Wildlife Consultant). This draft and the final copy (Dunn, 2002) relied significantly on data produced in 1998/99, that included GIS-enhanced participatory resource maps of human use zones inside and within three kilometres of the park boundary, stored and managed in a GIS. The advocacy value of the results of the study as a direct result of the methodology needs no emphasis. This site was actually the testing ground for this methodology.

Within the context of trees diversification in a farmer-managed farming system in central Cameroon

Much of the potential value of the process in the village on the outskirts of Yaounde, Centre Province of Cameroon, has been discussed under sample data output and analysis. However some points that can bring out additional value of the process need mentioning. Abondo village is located in the vegetation 'transition' zone, commonly described as peri-forest or peri-savannah. The population of the village, approximately 800 persons with a density of 25 persons per square kilometre (Nfoumou, 2002), considered medium-high in Cameroon. Despite existing opportunities for the cultivation and marketing of indigenous trees (Ndoye, 1985), existing low levels of tree planting by farmers in the region (Schreckenberg, 2002) is being partly justified by farmers in terms of limited available land livelihood needs.

After participatorily mapping the locations and dispositions of especially cocoa farms, farmers were able by themselves to locate possible points of tree integration in the different fields (Figure III). It was even possible to estimate numbers of trees per system. Between 2000 and the end of 2001 one thousand seven hundred trees comprising eight different species were planted (ICRAF west/central Africa, 2001/2002 Annual Report). When the PRM developed progressively by the farmers was resituated in the villages new integration sites were identified.

This year (2003) another two thousand trees of *Irvingia wombolu vermosen* will be planted in Abondo and three other neighbouring villages that have joined the programme. This sudden realisation of possibilities for tree integration by farmers in their landscapes cannot be due only to the accurate integration and enhancing of a village PRM. Nevertheless, by involving them in the process, they are able to visualise accurately that trees would not occupy as much space as previously thought, and that the trees can actually be used to address real problems of land management and tenure. By also keeping and managing that data in the system we can monitor the likely transformation of the landscape as a direct result of the farmers' tree planting activities.

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Figures I, II, III and IV for Mbile et al. (2003)

SAMPLE OUTPUTS OF THE PROCESS:

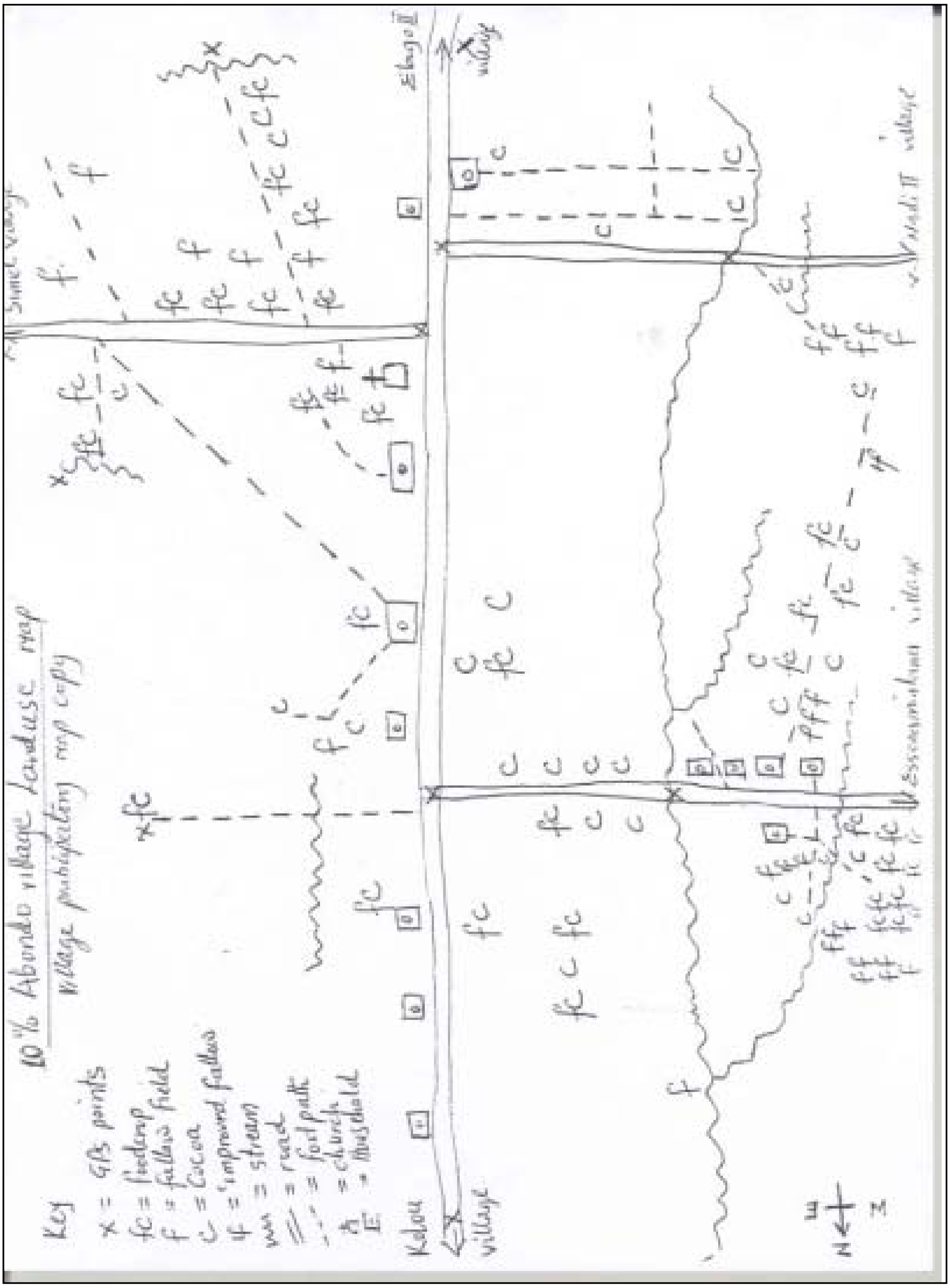


Figure I: Exact copy of village participatory resource map in the trees diversification context (PRM)

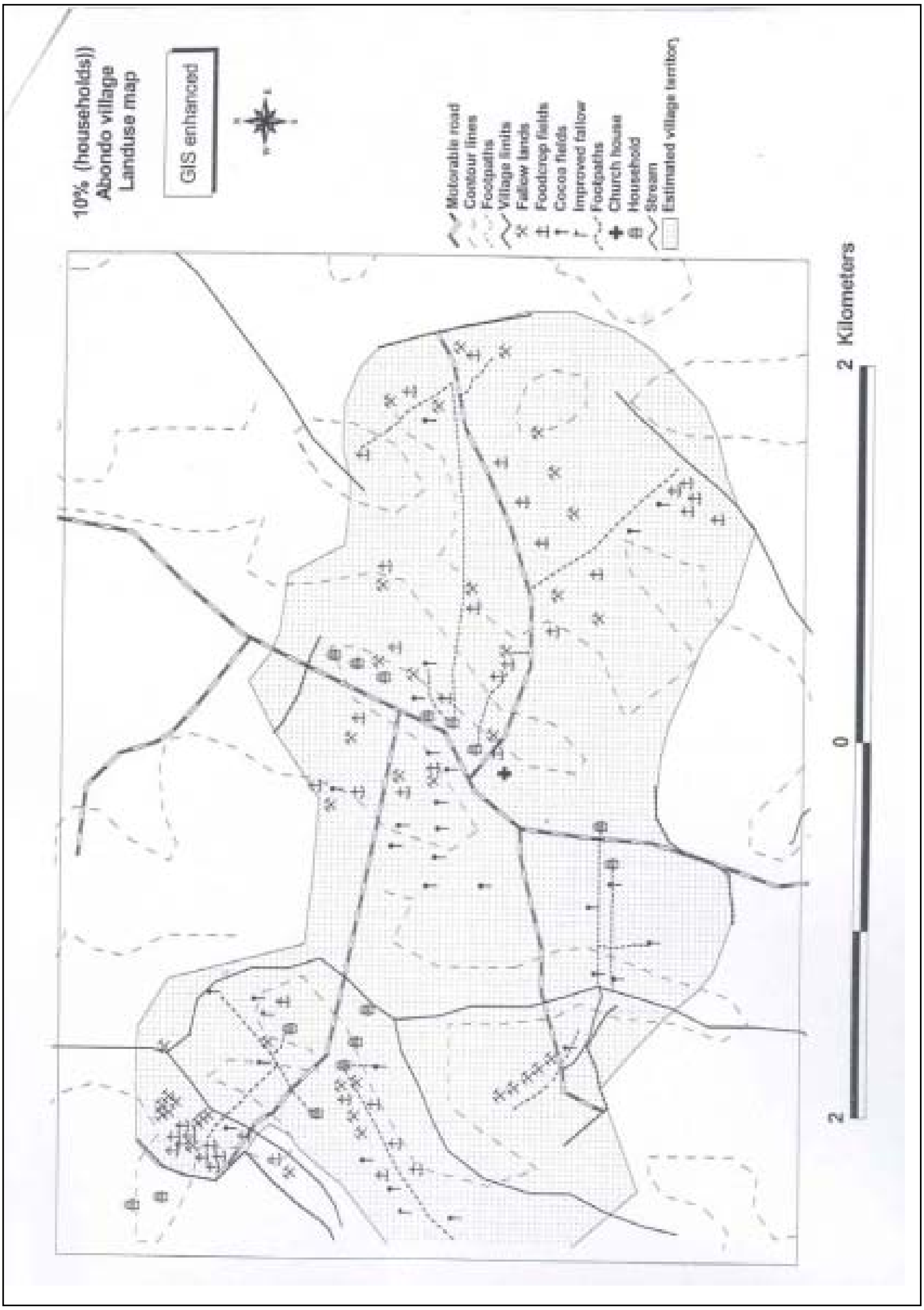
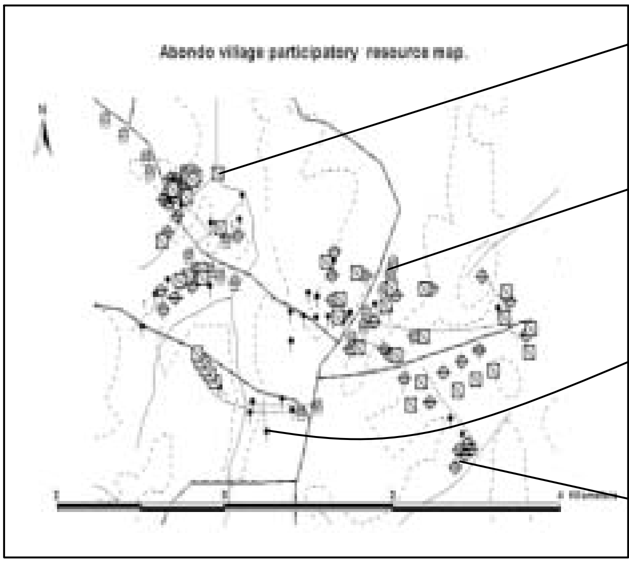


Figure II: The *frame* of the PRM in the trees diversification context ready to be integrated into the GIS.



Example of Fallow fields attribute table

HHID	FFID	PC	FFS	FA	Date	IFM	Pos.
001	FF01	Maize	1ha	3yrs	011002	Yes	L/L

Example of household attribute table

HHID	Head	Sex	Size	F	Date	M	Pos.
001	Mbi	M	10	5	011002	5	L/L

Example of cocoa field attribute

HHID	CFID	Type	Size	Date	P/s	Pos.
001	CF01	Cocoa	1ha	011002	10t	L/L

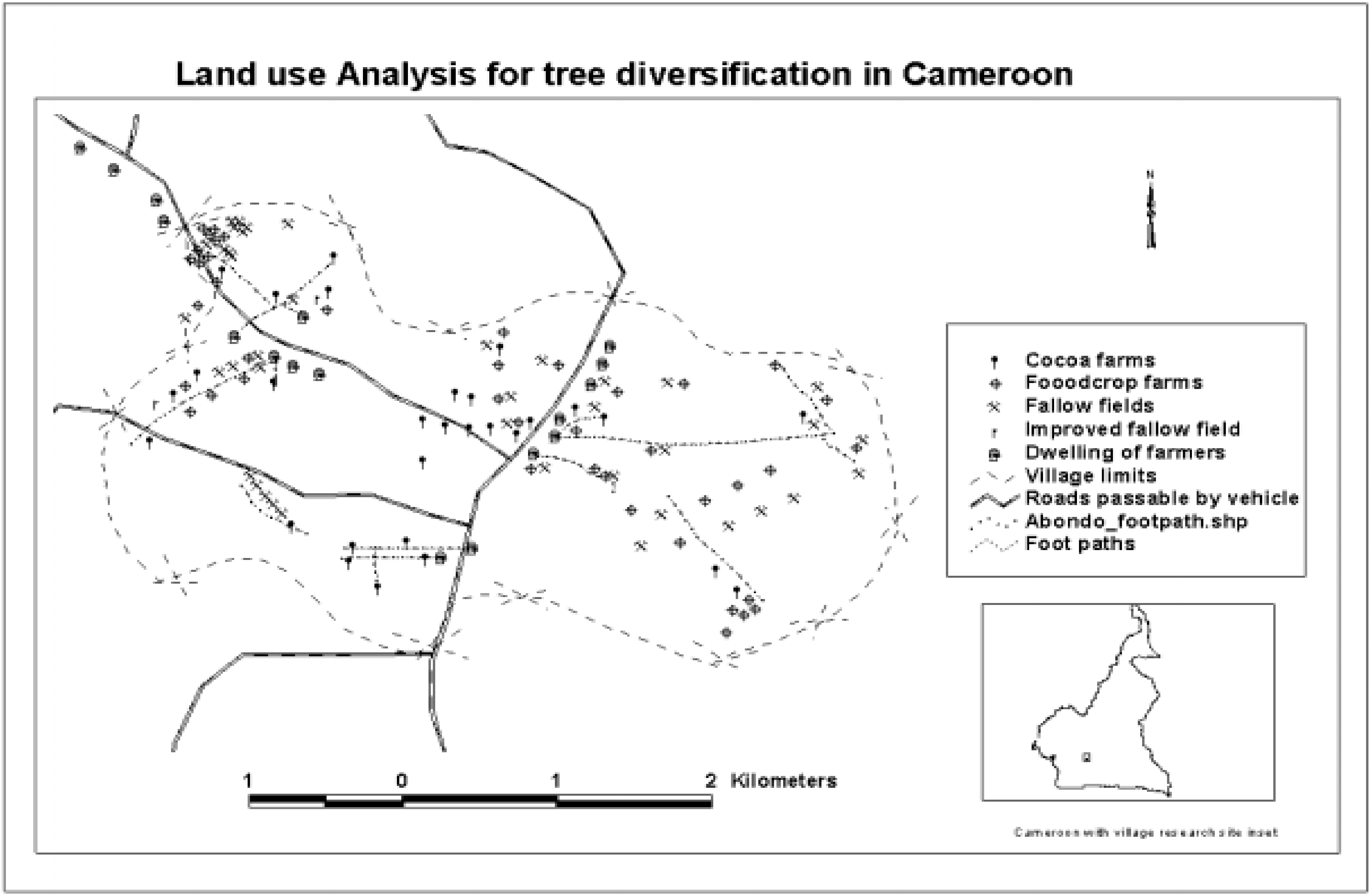
Example of foodcrop field attribute

HHID	FCID	Type	Size	Date	P/s	Pos.
001	CF01	Maize	1ha	011002	3b	L/L

Household identification numbers serve as the link between tables

HHID = Household identification number; FFID = Fallow field identification number; FFS=Fallowfield size; Fallow age; IFM=Improved fallow management; CFID Cocoa field identification number; P/s=Production per season; Pos. = Geographical Position; L/L = Latitude and Longitude.

Figure III: PRM relational data structure in the GIS.


Land use Analysis for tree diversification in Cameroon
Cocoa farms
Fooodcrop farms
Fallow fields
Improved fallow field
Dwelling of farmers
Village limits
Roads passable by vehicle
Abondo_footpath.shp
Foot paths
1
0
1
2 Kilometers