Participatory Mapping of Village Territories

Malinau, East Kalimantan

January-December 2000

Some lessons in 'Adaptive Use and Management of Geographic Data'

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Introduction[1]

As part of CIFOR's research activities in the Bulungan Research Forest, the Adaptive Co-Management (ACM) program aims to understand how the interests of different stakeholders in a forest area can be coordinated to strengthen forest management. Since local communities tend to be at a disadvantage in negotiations over forest use and distribution of benefits, despite their long history of ownership, the program focuses on how to improve the capacities of these groups for such negotiations.

The Upper Malinau area is the focus of the study. This provides overlap with the Inhutani II concession where other CIFOR research is being conducted. The 'Upper Malinau' is defined as the 27 villages located between Sentaban and Long Jalan. The 27 villages share the same principle watershed, fall into three shared concessions, and are considered the most disadvantaged in the Malinau watershed. Considerable tensions have emerged with development in the area of mining, logging and plantations.

The participatory action research that CIFOR-ACM is implementing, is to work towards coordination of forest use through agreements that combines interests within and among communities, through agreements between community and local timber, mining or oil palm companies; and through agreements between community and government.

From the beginning, the communities showed tremendous interest in mapping, in part because many were involved in compensation settlements with companies and neighbouring communities and they saw the maps as a way of avoiding escalating conflict. The context of reformation in Indonesia since 1998 has increased local people's interests in making claims to forest lands. It was decided to focus on research about how agreements are made concerning village boundaries.

To this end the following activities were undertaken:

- Coordinating a **training in participatory mapping** for the four villages of Long Loreh (the original focus of the work) in late 1998 together with the NGO SHK (*Konsortium Sistem Hutan Kemasyarakatan-Kaltim*). This proved to be of such high interest to the communities that it was decided to expand the work to the upper watershed.
- Conducting **informal village surveys** in February, April and August 1999 to assess issues in each of the 27 villages and to introduce CIFOR.
- Facilitating a large **multi-stakeholder workshop** for planning CIFOR's collaboration with communities in November 1999 (called 'Building a Research Agenda together'), combined with a mapping training.

[1] See Wollenberg *et al*., 2000. Action research on negotiating conflict and community empowerment in forest areas. Progress Report to ITTO, CIFOR, Bogor.

In January 2000, a **facilitation team** was formed, consisting of the CIFOR staff Njau Anau, Pajar Gumelar, Godwin Limberg and Made Sudana, and the local participants Salmon Afarisi, Sargius Anye, Abia Ape, Ramses Iwan, Piang and Nyoman Wigunaya. I joined this team to provide mapping and survey training, to give technical backstopping and eventually to prepare the maps. At the same time, I provided a link between the field team and CIFOR headquarters in Bogor where the final maps would be prepared, as well as a link with the 'Multi-disciplinary Landscape Assessment survey' that was going on at the same time and in which I participated.

The facilitation team prepared a report of activities in the year 2000, under the title '*Pemetaan Partisipatif sebagai Alat Menyelesaikan Konflik. Studi Kasus Desa-Desa Daerah Aliran Sungai Malinau*[2] which focuses on the negotiation and decision making process that took place in each of the villages during the mapping period (April-July 2000). The current report, however, provides a chronological overview of the process from the standpoint of a mapmaker and is meant as future reference for the data created.

Information of the Malinau area available at CIFOR by the end of 1999

- Several INHUTANI- II maps, which had poor georeference (we knew that from the Reduced Impact Logging work in the area) and only covered a small part of the whole Malinau watershed area.
- Several 1:250,000 thematic maps with little detail and often outdated (e.g. topography, land cover, land use, TGHK, geology, soil).
- Satellite images: 1991 with few clouds, but many cover changes have occurred since then; the 1997 image is more cloudy, especially around Long Loreh where a lot of CIFOR activities are concentrated. Neither of the images had been georeferenced yet.
- **Planned**: a contour and river layer to be produced for the whole Bulungan research forest by outside company, based on Radar imagery.

[2] 'Participatory Village Mapping as a Tool in Conflict Resolution'. A Case Study of Villages in the Malinau Watershed.

The preparation of community maps

Before the workshop 'Building a Research Agenda together' in Long Loreh (November 1999) large line maps of the whole Malinau river were prepared at scale 1:50,000, including major tributaries e.g. Sentaban, Setulang, Seturan and Ran. These maps were drawn on the basis of a 1991 Landsat TM image.[3] During the workshop people received three days of training in mapping techniques and were given one of the line large maps to take back to each village, where they added tributaries as well as mountain peaks, with their names. A few villages drew symbols in specific places where certain natural resources occurred,[4] and one village went as far as to sketch areas for 'protected forest' and 'hutan adat'. The resulting community maps were send back to the CIFOR office in Bogor.

While community maps were being prepared Made Sudana, CIFOR consultant on the facilitation team, travelled the length of the Malinau river to collect GPS coordinates of georeference points, to be used for rectification of the Landsat-TM image that CIFOR already had. These were mostly junctions of major tributaries of the Malinau. At the same time he took GPS points of all the villages. All field data, both digital and hard copy, were sent to Bogor.

Challenge

The data from the field reference point collection were lists of GPS coordinates with the names of tributaries. But back in Bogor the river junctions were very difficult to locate on the satellite image. Therefore only a few of them (major tributaries only) could be identified and used to rectify the image. Some GPS data from another CIFOR activity in the area were included to add to the number and improve the spreading of reference points.

The 1991 TM-image was rectified using these reference points[5] by Machfudh, the remote sensing expert for CIFOR's ITTO projects. He also prepared a layer of major rivers by classification from the satellite image followed by on-screen digitisation and matched names from the community maps with these tributaries.

Challenge

This creation of a river layer was more difficult than expected and the result was sub-optimal (very blocky lines, uncertain location, especially in the flatter downstream areas). It was even more difficult to match the names of tributaries from the community maps with this 'satellite image map', because not all tributaries were visible, they were drawn in their relative position only, and size was unknown.

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[3] These maps were drawn by the then coordinator of the participatory mapping activities, John Corbett. Since he left Indonesia by the end of 1999, I took over this role.

[4] This was probably instigated by the fact that just before the workshop, another CIFOR pilot study (Multi-disciplinary Landscape Assessment, MLA-1) had taken place in Paya Seturan, and had asked people to draw such a map as a guidance for fieldwork (see Sheil, 1999).

[5] Using ER-Mapper image transformation tools

Base maps were prepared per village area, according to our initial understanding of territories. The maps had a true colour satellite image in the background, which was very harsh green, overlain by the river layer and a 1 by 1km UTM grid, and contained river and mountain names as well. Maps of neighbouring territories often showed a large overlap and several territories needed 2-3 sheets, partly due to the fact that printing of large files was a problem at the time, and we therefore had to reduce the size of sub-sheets. The result was a large number of map sheets.

End products of this stage

- A set of georeferenced satellite image maps for the whole Malinau watershed, with major rivers, villages and their names drawn in and a 1x1km UTM grid as an overlaying layer.

Training the facilitation team — Jan/Feb 2000

Training in participatory approaches in Bogor

From January 17th till 20th the CIFOR members of the facilitation team met in Bogor in preparation of the mapping activities in Malinau. During two days we discussed the participatory character of the mapping, facilitated by Iwan Tjitradjaya from Universitas Indonesia, which resulted in drafting guiding principles. The next two days were dedicated to practical preparations.

Training workshop in Loreh

A training session was held in Long Loreh from Jan 25th till Feb 5th 2000 for members of the facilitation team. Lini Wollenberg and myself facilitated this training. Machfudh attended a day, while delivering a last set of printed maps. The training consisted mostly of thorough discussions of the whole approach to the participatory mapping process;

- Discussing the communities' interest in mapping
- Discussing the role of the facilitation team (stressing that the team is assisting the communities and not the other way around) and practising this in role plays
- Discussing how to handle conflicts within and between village communities
- Discussing how to ensure participation of communities and representation of all groups
- Building of a team spirit

Technical instructions and practice were covered as well:

- The use of GPS and compass

- Using the satellite image maps ; scale, coordinates, directions
- Finding GPS coordinates on the map, plus compass bearings
- Familiarisation with all steps of the mapping process

A manual was prepared as a reminder of what was learned.[6] Most importantly, the training included a one-week 'field trial'.

Trial in Long Loreh

Long Loreh was used as a test case for village border mapping after the training session. A community meeting was held in which a village committee was formed. The next day, training for the committee members took place to familiarise them with maps, GPS and compass, followed by four days of fieldwork with three teams.

Lessons learned

***The satellite image maps were still poor**: the green background colour of the satellite image maps was too stark and obscured subtle differences. It would help a lot if ridges/valleys were clear, since most borders run along such natural features.*

*Around Loreh, **geometric displacement** appeared to be in the order of 500mtr, further upstream and downstream this could be up to 2-3km. This indicated that the field reference points were not well distributed over the whole area and/or had not been matched well with the satellite image.*

*Many of the tributary **names were placed with the wrong tributary** on the base maps (see explanation above) and this combined with the inaccurate positions confused people. E.g. if they took a GPS coordinate at the mouth of tributary X and found on the map that those coordinates were closer to tributary Y, they did not know what to believe more: their own knowledge of the river locations or the map.*

*Given the restricted time for the trial, it was **difficult to ensure true participation**: most committee members needed a lot of time to become familiar with GPS and compass and to understand how to enter new data onto the base maps*

For people who are only just learning how to use maps, 'insecurities' about the maps were confusing and discouraging.

*It was difficult to **collate maps** from many sheets, because the area was not systematically divided.*

*The members of the facilitation team need a **manual of procedures**, both for the introduction and training in each village and for the data collection in the field.*

[6] Pedoman Pemetaan Desa Partisipatif di sungai Malinau (*Manual for Participatory Village Mapping in the Malinau area*), March 2000, CIFOR, Bogor.

*The GPSes (Garmin 12XL and CX) often had **difficulty receiving enough satellite signals** to calculate position, due to canopy closure and terrain obstruction. An external antenna improved reception a lot.*

We therefore decided not to start for real immediately after the workshop, but to do another georeference data collection trip, to first improve the (geographic accuracy of the) base maps. This also gave us time to order the external antennae. Fortunately, the communities were happy to postpone the actual field mapping activities to the end of March, despite their request in November 1999 to begin mapping as soon as possible, because they were busy with harvesting activities.

End products of this stage

- A trained facilitation team
- A manual to guide the facilitation team in the mapping process
- A better idea of the reality of the mapping process
- Recognising the problems with the base maps
- GPS field data of the boundaries of Long Loreh, Sengayan, Bila Bekayuk and Pelancau
- Preliminary boundary map for Loreh on transparent paper

Improving the georeference of the base maps Feb-Mar 2000

Rivertrip for collection of georeference points

The objective of this trip was to collect GPS data from clearly identifiable positions (mostly river junctions) along a few of the bigger streams in the area. At the same time the trip was meant to spread the points further east and west (so far, data were concentrated along the Malinau river, which runs roughly from south west to north east). It also provided an occasion to discuss the mapping plans again with all villages and to solicit their suggestions for the timing of activities. The facilitation team was split into two small teams and divided the area and villages to visit.

A4 sized overlays containing a precise delineation of the river were prepared from the satellite image maps, and were taken on the trip. While travelling up or down the river, the GPS would be set for continuous registration ('tracking') and every position of a georeference point was drawn in on the overlay by comparison with the small **map display** one gets on the GPS (GARMIN 12CX). Its code and name was noted alongside and registered on a form too. Both teams performed this well and a total of 79 reference points were collected.

Apart from writing down the coordinates of the reference points ('waypoints') on a data sheet, and drafting their positions on the overlays, the digital data of the waypoints as well as the continuous data or 'tracks' were downloaded onto the computer once the teams were back in Long Loreh.

All digital and hand-written trip data, including the overlays, were send back to Bogor and arrived by Feb 28th at CIFOR.

On coordinate system and datum used during the mapping

- *At the start, we decided to collect field data in **the Universal Transverse Mercator** (UTM) coordinate system,[7] because this metric system is so much easier to use. Thus GPSes were standardised accordingly and base maps were given a 1x1km UTM grid overlay.*
- *In May 2000, in discussions with the Information Services at CIFOR, we were urged to adapt to their standard use of the world wide applicable **latitude and longitude** coordinates for all geographic data. This would be no problem, since we intended to use Arcview for the preparation of our maps, and this software can convert directly from geographic coordinates to UTM (but not vice versa).*
- *Thus, the digital field data (collected in UTM) and all other spatial layers available for the Malinau area were **converted** to latitude and longitude coordinates.*
- *The final maps (both hard copy and digital) use both geographic coordinates (15' each) and a UTM grid.*

Processing the field data and preparing new base maps

The field data from the river trip were first used to **improve the georeference** of the satellite images. Some 15 well spread reference points were found to be of good quality (exact position of the point visible on the satellite image), and resulted in a image transformation with RMS error[8] below 2 (= 2 map units, in this case a pixel of 30m). As a control we displayed all track and waypoint data from the river trips over the rectified image and found that they matched well with corresponding features on the image.

The river trip data were also used to prepare a new **river and village name layer**. We choose to only name those rivers on the maps that we were 90% sure of (where both the name and GPS coordinates of river junctions were known and a tributary was visible on the satellite image).[9]

[7] Kalimantan falls in UTM zone 50-N. For the datum, we selected the widely used **WGS-84** datum.
[8] RMS error = root mean square error, an indication of the achieved accuracy of a geometric transformation (one RMS unit is one pixel in the rectified image).
[9] See section 'Preparing map layout' and appendix 'Possible future improvements to the data' for a discussion of language and spelling of local names

For the satellite image displayed in the background we used a more differentiating algorithm with a less green appearance.[10]

Another change from the first set of base maps was the systematic subdivision of the whole image area into areas of roughly 15 by 15km (at first forced by the fact that we could not print beyond A2 format), with roughly a kilometre overlap between adjacent maps.

In the meantime, Feb 2000

Finally the long awaited **creation of a digital elevation model (DEM) from radar imagery** started. A consulting company in Jakarta (BLOM Pty.) was contracted by CIFOR to order radar imagery and prepare a DEM of 30 meters vertical resolution. For geometric rectification of the model, they used the 15 selected reference GPS points from the river trip collected by our facilitation team. However, the geometric accuracy of the DEM never matched that of the satellite images, probably due to the difficulty of locating field reference points on the DEM image, and so we could not use the data jointly at this stage.

A separate contour map was prepared from the DEM and printed, to serve as a reference of relief.

Challenges

*We wanted to await the **river layer** that BLOM was expected to prepare from the DEM before printing a new set of maps, but this information was not delivered. A river layer would have provided an objective guide for a selection of tributaries with names to be shown on our final maps (only those that could be distinguished at this scale/resolution would have been included and named).*

The DEM (and the contour layer derived from it) have poorer geographic accuracy than the satellite images. Shifts between the two are clearly visible in sharp valleys and on sharp ridges. Due to the earlier delays in preparing the base maps, we did not manage to print a set of contour maps as well.

End products of this stage

- A set of well georeferenced, annotated base maps, but without river overlay
- GPS Field data of many natural features (mostly river junctions)

[10] Combining a shaded terrain model created from the DEM with this image did not improve the terrain impression any further. This was probably due to the fact that the satellite image itself was quite shaded already (the image was taken in the early morning, when the sun is still at a low angle and casts clear shadows).

The implementation of participatory mapping Apr- July 2000

After a brief refresher workshop (Long Loreh, March 26th– 28th), the whole facilitation team, including myself, went downstream to Long Adiu for a trial with the new base maps. We evaluated this trial thoroughly before continuing the mapping work elsewhere.

Findings from the trial in Adiu

*The **new base maps were much more useful** for the mapping process because they had proper georeference and valleys were more visible than before. The smaller size (and lamination) made them easy to take along in the field too.*

*Ridges (watershed boundaries) very often form the outer boundary of villages and they were **not always clearly visible** on the base map. We therefore asked Machfudh by radio to print contour maps as well, and send them up to us with the first possible traveller.*

*On April 18th the requested **contour maps** arrive, with contours at 15 meter interval. They are, however, displayed with an elevation colour look up table that is not consistent between map sheets, which is confusing. The location of major ridges is clear enough, and so are the mountainous areas. But the relief of flatter areas around the Malinau river (below 100 m.a.s.l.) is very distorted and may in fact be showing clumps of taller vegetation as contours of 'bumps' in the terrain. We therefore conclude that the contour maps should only be used as a rough topographical guidance.*

After the evaluation of this second 'mapping trial', the facilitation team spend four months travelling from village to village to assist in the participatory mapping of territories of each village.

Village territory mapping in five steps

The following is an overview of the five steps involved in the boundary mapping of each village:[11]

1. Community Meeting

As soon as a village had made boundary agreements with its neighbours, the facilitation team would be invited to help map the boundaries. In a community meeting the background and purpose of the project, the role of the facilitation team as well as the principles of and steps involved in the mapping process were explained. Questions were answered and a village committee was formed to represent the community in the field activities.

2. Training of the village mapping committee

The village committee received a short training before going to the field. The background and purpose of the mapping was explained again, the base map was studied and it was discussed where the boundaries were. Committee members

[11] See the *Pedoman Pemetaan Desa Partisipatif di sungai Malinau* for full description of each step.

were then trained in the use of compass and GPS, and how to use the results for the preparation of a map.

It was then discussed how the fieldwork would be organised and divided between the members and practical arrangements were made. As much as possible, representatives of (the) neighbouring village(s) would be involved in this planning phase, to ensure transparency and agreement from the start. A field team always consisted of members of the village committee plus 1 or 2 of the facilitation team.

3. Collection of field data

The task of the field team was to walk along the boundaries of the village territory and collect GPS coordinates. These were stored in the GPS with standardised coding and each point was described in a form as well.

Where boundaries followed a natural feature that was already clearly visible on the base map, e.g. a river or a sharp ridge, it was not necessary to walk the whole distance. The team had to convince itself of the location of this river or ridge by taking a compass or GPS reading at a sample spot, but the boundary drawing was based on the feature on the map.

Apart from collecting boundary information, also names of tributaries, ridges, peaks and other important features were noted while in the field.

4. Entering field data onto the base maps

All positions with their codes and names were drafted on to the base map, whether still in the field or back in the camp/village at night. The boundaries were then drawn by connecting these points or by following the natural feature on the base map that formed the boundary.

5. Finishing the maps

After completion of the fieldwork, the team copied base map information onto transparent paper overlays. This included rivers, roads, ridges, village locations, GPS points and boundaries. One copy remained in the village, one was taken to Loreh and later to Bogor for reference.

6. Presentation of the results

Before the facilitation team left the village, another community meeting was held to present the results of the mapping efforts, explain the (non legal) status of the map and discuss follow-up activities.

See the report '*Pemetaan Partisipatif sebagai Alat Menyelesaikan Konflik*' for a description of findings during this process.

Double-checking the geometric accuracy of our data.[12]

In July and August 2000 Arnaud Holtzscherer, a French surveyor, worked for CIFOR as an intern. His task was to establish ground control points by GPS at selected and well-distributed points in the research area, including altitude. He used a Trimble TDC1, a supposedly more accurate GPS than the Garmin 12 series GPS we were using in the participatory mapping.

Despite breakdown of the equipment within a week, he managed to take 7 good quality (< 1m accuracy) GPS points with the Trimble GPS and another 10 points with the Garmin 12CX that he borrowed from us to replace the Trimble TDC1. He also compared coordinates taken by the Trimble and by the Garmin GPS of one point in Long Jalan (N1.2030) and three points in Long Loreh and found they differed less than 5 meter. These results confirmed that the Garmin 12 GPS series was adequate for our data collection.

We checked the locations of the new control points, especially those in the north-western and south-eastern corner with reference to our base maps. We found that all points were within 80 meter of the right feature (river junctions) and three quarter of them even within 50 meters. Therefore, the georeference of the satellite image performed in March with the control points of our own team had been successful and no new transformation of the image was required.

End products of this stage

- Set of **GPS data** per village, on data sheets as well as in digital format (*.dbf files), with annotations. Proven accuracy of these data, based on independent cross-checking by Holtzscherer.
- '**Transparent maps**' per village; transparent overlays hand-drawn from the base maps, with GPS points, ridges, rivers and annotated border information. NOTE: due to its character (hand-drawn, folded and possibly expanded/shrunk by use) not accurate enough for direct digitisation.
- Set of **base maps**, sometimes with the GPS points, rivers, ridges and boundaries in, as well as names (rivers and mountain peaks), but often not. NOTE: this is the only set of map data with reliable georeference.
- Set of **contour maps**, sometimes with ridges and rivers drawn in, but not consistently. NOTE: the georeference of these maps was clearly different from that of the satellite images.

[12] See Holtzscherer, A., 2000. Establishment of ground control points in selected areas of the Bulungan Research Forest, CIFOR, Bogor.

Data processing & preparation of final maps July - Nov 2000

Compilation of information onto one set of maps

Though the base maps (with satellite image in the background) were good for the fieldwork phase, we wanted to produce more conventional line maps as final products. Such maps would be easier and cheaper to reproduce, people are more familiar with them than with a satellite map and they have a more official appearance. The presentation of lines (rivers, roads) and names on top of an already multi-coloured satellite image is also more difficult, whereas rivers especially are an essential feature for the area.

We decided that such a 'final draft' of the village territory map should contain the following information:

- Location of villages + names
- Rivers visible on the satellite image (+ names where certain)
- Ridges and mountain peaks (+ names where certain)
- Roads (both main road (unsurfaced) and major tractor tracks)
- All GPS points taken along the village boundaries
- Village boundaries, with differentiating symbols/annotations regarding their status

Challenges

CIFOR does not have a detailed river layer yet for any or the whole area. But digitising rivers from the satellite images seems possible when combined with the contour information and the GPS points for the river junctions.

Watershed boundaries need to be digitised too, since they often form the boundary between adjacent villages. Unfortunately, digitising directly from the contour maps is not possible, because the georeference of these maps is not correct.

Considering the above, it appeared that the satellite image maps were the best available base information to compile information on. While still in Loreh, Godwin Limberg and I therefore copied all field information onto this set of maps, and drew all visible rivers and ridges as well. The contour maps served for guidance.

End product of this phase

- A set of base maps with all information from the field, as well as interpreted rivers and ridges drawn onto it.

Digitisation of information[13]

The rivers, ridges and boundaries on the annotated base maps were digitised by Johny Simatupang from BAKOSURTANAL, using ARC/INFO. Digitising took place per base map sheet: since these were laminated immediately after printing stretching/ shrinking was supposedly limited. Also, all maps contained a 1x1km UTM grid and therefore good reference corner points for all map sheets were available as control for transformation.

Where territory boundaries followed natural features like rivers or ridges, the latter would be digitised first and boundary lines would be copied from these, in order to have exactly the same positions.

All the individual map sheets of one theme were compiled into one thematic Arc file, covering the whole Malinau area. This resulted in a river, ridge and boundary file respectively.

I then displayed these layers in ArcView, together with the GPS field data and the digital satellite image. I sometimes also used the contour map derived from the DEM, in order to control and correct, e.g. where the course of rivers and/or ridges was wrongly interpreted from the satellite image. Since the DEM covered a larger area than the satellite image, we were able to complete the upper watershed boundary of the Malinau river as well.

Observations/problems

Digitised rivers fitted well with the satellite image when displayed on the screen (N.B. they were digitised from prints of the same image), but more importantly also with the GPS field data. Where corrections or additions had to be made because of mistakes observed with the contour layer, I tried to visually correct for the inherent shift in the latter. E.g. if a 200 meter shift in north easterly direction was observed nearby (i.e. based on sharp valleys), I would digitise a line at similar distance and direction from the observed ridge top. This was only needed in some of the outer parts of the map.

As explained earlier, the DEM did not fit perfectly with the satellite image/field GPS data (shifts of up to 300m were observed) and therefore the digitised ridges have a lower geometric accuracy then the rivers. Since village territory boundaries were partly derived from the ridge information, the same holds true for them.

Preparing map layout

I used Arcview not only to display all the digitised information, and to make annotations, but also to prepare print files for individual sheets. The 'temporarily final' maps of village territories contained the following information:

- **Boundaries**: with different coding/colours for those sections that follow rivers, ridges or roads respectively, those that are just straight lines between

[13] I would herewith like to recognise the contribution and assistance of Ibu Atie Puntodewo during this phase of the work.

reference points (GPS) and those sections that are still disputed between neighbouring villages.

- **GPS field data** are presented as points on the map, with their code. The first 2 digits of a code reflect the village whose territory was being mapped, the third digit (a letter) indicates the character of the site (boundary, river mouth, crossing of roads/rivers, special etc.), followed by a 3 digit sequential number.
- **Villages** are marked with a red 'house' symbol and named. Where several villages are located in one location, only one symbol was used, but the names of all the constituting villages appear next to it.
- **Rivers and tributaries:** are drawn as blue lines, but smaller tributaries could not be included, since they were not visible on the satellite image and could therefore not be digitised. Names are presented in the language and with the spelling as given to us by the village committee members while in the field. Checking (the spelling and choice of language of) these names with a larger representation of each village community is still pending.
- **Ridges**: locations of peaks were added, based on observation from the contour layer and annotated with names where those were known.
- **Roads**: the main road from Malinau to Paya Seturan and camp Seturan, as well as the major logging tracks that were visible on the 1997 satellite image.

Map sheets follow the official BAKOSURTANAL system of coding and naming in which each sheet covers a quarter degree section.[14] Both latitude and longitude coordinates and a UTM grid (5km) are overlaid as reference.

End products of this stage

- An Arcview project with annotated views of all available data (each of them briefly described) and prepared print files ('layout') for all map sheets at a scale of 1:50,000 as well as a 3 sheet version at 1:75.000.
- A printed set of 'temporary final maps' to be presented in a community meeting in Setulang, Malinau (Dec 2000).

Presentation to community meeting

In a well attended community meeting in Setulang, Malinau, on December 4th till 6th, the preliminary results of the village mapping activities were presented.[15] It was discussed how and when the mapping could be finished and how communities can use the village maps in the future. The facilitation team will follow-up on this in 2001.

[14] We may review this subdivision, because the location of the Malinau watershed is such that many outer map sheets contain very little information.

[15] This was only part of the agenda. See ACM-BRF team (2001) for full description of issues discussed in the meeting.

Appendices

List of products created during the mapping process

Products	Where kept?	Name	Format
DIGITAL			
All GPS georeference points	Server CIFOR	Gcps.dbf	dBase
Georeferenced satellite images 1991	Server CIFOR	BRF91-542	ER-Mapper
Arcview project	Server CIFOR	Wilayah_desa_Malinau.apr	ARCView
GIS layers: boundaries	Server CIFOR	batasfin.shp	Shape (Arc)
rivers	Server CIFOR	sungedit.shp	Shape (Arc)
ridges	Server CIFOR	pungedit.shp	Shape (Arc)
roads	Server CIFOR	roaddig.shp	Shape (Arc)
logging roads	Server CIFOR	logroads.shp	Shape (Arc)
villages	Server CIFOR	desa.shp	Shape (Arc)
GPS field data	Server CIFOR	batgpsgeo.shp	Shape (Arc)
peaks	Server CIFOR	puncak.shp	Shape (Arc)
'Print files' for all map sheets	Server CIFOR	Wilayah_desa_Malinau.apr	ARCView
HARD-COPY			
Set of community maps Nov/Dec 1999	Respective villages Malinau	Returned to respective villages, but maybe useful again in follow-up activities (rencana tata ruang)	
Field Manual for participatory mapping of village boundaries	Facilitation team, villages	Pedoman Pemetaan Partisipatif. A small booklet to take to the field for guidance	
Set of transparent maps for most villages, with GPS pts, rivers, ridges and borders sketched in	Resp. villages, CIFOR Loreh, CIFOR Bogor	All the information drawn onto these transparent maps has been digitised and is therefore digitally saved in the above mentioned shape files.	
Data sheets with descriptions of all the GPS field data	CIFOR Loreh, CIFOR Bogor	All the information from these forms has been entered in a database: batgpsgeo.shp	
Set of base maps with all the information from the field	CIFOR Bogor	All the information drawn onto these transparent maps has been digitised and is therefore digitally saved in the above mentioned shape files.	
Set of contour maps	CIFOR Bogor	Georeference still needs improving	

Possible future improvements to the maps/data

- More detailed and accurate **river information** preferably based on airphoto interpretation. Rivers are such important orientation features in East Kalimantan, due to the lack of other infrastructure, that a quality base map should contain as many streams as possible. This would result in revision of (a few of) the boundaries that follow rivers.
- The **Malinau river** should be a clearer/bolder line on the maps to improve people's orientation.
- **Annotations:** spelling and language of names used on the maps should still be checked and corrected together with the respective communities. Also, on the 1:75.000 maps (tributary names) annotations should be slightly larger to improve legibility.
- A better georeferenced **Digital Elevation Model**. This would result in a revision of the ridge information, which in turn would require the revision of the boundaries, since many boundaries follow ridges and the outer boundary of all Malinau villages combines is the Malinau watershed boundary.
- Once all border disputes between villages have been resolved and the territory mapping can be completed, the territories can be **polygonised** and given unique colours, to improve presentation of the information. Also automatic assessment of area size will then be possible.
- As it was noted that people are not very familiar with 'scale' or '**size of area'**, a square of 100 and 1000 hectares could be shown in the legend, for reference.
- Recently CIFOR acquired a good quality, more updated (1999) Landsat TM image (and may be getting a 'land cover change analysis (1991-2000) carried out by BLOM Pty. as well). It would be very interesting to properly georeference this image and to be able to use it for further activities in the area, like natural resource assessment and land use planning.

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