FOREWORD

Since the beginning of the Programme it has been evident that the information related to forest resources such as land classification, forest categorisation, growing stocks, boundary demarcation of use and tenure, etc. is not sufficient. Normally the total area of forest land is known but it is not very clear what kind of forests nor what is the growing stock. The boundaries of allocated forest land between different households is marked on the spot but proper maps indicating the boundaries are lacking. Some times even the exact village boundaries are not very clear. Also the land use maps at village and community level are lacking.

There is a need for simple appropriate systems that would easily and with low cost indicate this kind of information at village and commune level. The main focus of the Programme has been individual fan-n plans, comprising a simple sketch map. However, also village and commune level "land use plans" with resource information are needed.

The Programme has recently carried out a soil survey and prepared simple soil maps of the pilot villages. The Programme has also studied what kind of existing and potential agroforestry systems are most suitable for different soil types.

The Bac Kan province has recently contracted Forest Inventory and Planning Institute to carry out forest inventory at provincial level. The inventory will produce information which has primarily strategic importance. There is still need for information which could serve operational purposes.

The Programme contracted three consultants: Dr. Hoang Sy Dong, specialist from Forest Inventory and Planning Institute of Vietnam, Mr. Janne Sarkeala, specialist from Enso Forest Development Finland, and Mr. Pham Ngoc Thuong, specialist from Bac Kan province. The consultants carried out an exercise in forest survey and mapping in order to have (i) improved knowledge of forest resource information in the Programme area to serve operative purposes at village and commune level, and (ii) improved forest resource mapping & survey techniques in Bac Kan province. The exercise was carried out from 15 September to 5 November 1997. Two staff members from the Department of Agriculture and Rural Development, Mr. Pham Ngoc Kien and Mr. Ha Van Huan, assisted in the field work during the forest survey.

We wish to thank the consultants and all the participants who have contributed to finalise this report.
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EXECUTIVE SUMMARY

The existing forest survey and mapping methods and systems in Vietnam were reviewed to develop a low cost and easy to use method for land use and forest type mapping at commune level. There is a wide selection of maps and survey reports available, but their dissemination has not always been organised. Regardless of the variety of forest surveys conducted, there still is a lack of detailed forest stand level information showing the location, quality and quantity of the forest resource.

A simple visual survey method was applied in the field in the two pilot communes of the Programme. The survey consists of observing the forest area from a point of good visibility, and manually drawing the land use and forest type boundaries on a paper map. Instead of measuring field sample plots, the existing information of the growing stock by the Forest Inventory and Planning Institution (FIPI) was used. The land use and forest type classification of the Regulations for Forest Inventory, Management and Projection by FIPI was slightly modified and applied in the survey.

The main advantages of visual survey method are that it is economic, quick and easy to learn. On the other hand, there is high risk of errors because there are no objective means for controlling the output. The quality of the work is highly dependent on the skills and motivation of the field work team.

A computerised mapping unit was established at the Department of Agriculture and Rural Development in Bac Kan. The unit consists of a digitiser tablet for paper map input, a computer with MapInfo software for map data processing, and a colour printer for map output. The computerised mapping is preferred to the manual one because computer enables easy map updating, automatic area calculation, data combination and scale transformation, and output of a variety of coloured thematic maps. The staff of the Department was trained to be able to operate the system both in the field and in the office.

It is emphasised that any, map prepared must be also used, i.e. in order to justify forest survey and computerised mapping there must be demand for the maps and other results of the survey. Communal land use and forest type maps in scale 1:10000 are a tool for land use and forestry planning and for monitoring the consequences of the activities of the people in the forest. The computerised mapping unit can also be used to prepare various other types of maps, such as index maps, road maps, agricultural and livestock maps or town plans. Care must be taken to disseminate the maps and other survey results to all interested parties.

I INTRODUCTION

The main focus of the Vietnam-Finland Forestry Sector Co-operation Programme has been in developing living conditions and knowledge level of the village farmer not forgetting the environment where they live. Since the beginning of the Programme it has been evident that the information related to forest resources such as land classification, forest categorisation growing stock, boundary demarcation of use and tenure is not sufficient. Normally the total forest area is known, but it is not very clear what kind of forests there are nor what is the growing stock. Also detailed land use and forest type maps at village and commune level are lacking.
There is a need for simple appropriate systems that would easily, and with low cost indicate forest information at village and commune level. The main focus of the Programme has been individual farm plans comprising a simple sketch map for sustainable resource development. However, also village and commune level land use plans with resource information are needed.

The Bac Kan province has recently contracted, Forest Inventory and Planning Institute: (FIPI) to carry out forest inventory at provincial level. The inventory will produce information which has primarily strategic importance. There is still need for information that could serve operational purposes.

In order to clarify the status of mapping and survey in the Programme area and to develop the technology, techniques and capabilities for simple forest information system including forest data collecting and management, the Programme has set the following objectives for forest survey and mapping in commune level:

- Improved knowledge of forest resource information in the Programme area to serve operative purposes at village and commune level.
- Improved forest resource mapping & survey techniques in Bac Kan province.

Existing forest survey and mapping methodologies in Vietnam were reviewed and found applicable and could be adopted in the Programme area to some extent. The objectives set by the Programme were met by analysing and modifying the existing methods and designing a low-cost forest survey and mapping system for communal land use and, forest data collecting and management. The method was tested and implemented in the two pilot communes of the Programme, Ngoc Phai and Dom Lac in Cho Don district.

The survey and mapping method consists of two parts a visual classification of the commune area into land use and forest type classes in the field, and establishment of computerised mapping unit in the office of the Department of Agriculture and Rural Development (later the Department) in Bac Kan. Training of the Department staff both in the field and in the office to operate the mapping system were considered essential part of the work. As computerised systems are sometimes vulnerable, also the traditional hand made mapping was implemented parallel to the computerised one.

The Department is in process of establishing a consultancy company for forest, agriculture and water resources services including forest survey and mapping. The activities during the Forest Survey and Mapping consultancy, and the investments by the Programme in the hardware and software support the initial stages of the company aiming to carry out independent work. Even though forest inventory services can be contracted from outside, it is justified to have a unit capable of survey and mapping under direct control of the Department. Such unit can be in short notice flexibly allocated to tasks prioritised by the Department. Presently the focus is in commune level forest survey, but the system can be expanded step by step to cover district and province levels with their specific needs.

Forest mapping is not justified if no evident uses can be indicated for the maps. Land use and forest type maps in scale 1:10000 can very well serve for various kinds of planning and monitoring activities, e.g. land use planning, forest plantation planning, forest protection, forest cover monitoring and detecting changes in land use and forest types. Up-to-date land use and forest type map is an indispensable tool in the land allocation process that is going on in the Province. The Department should define its specific needs for forest mapping, and identify any other possible governmental bodies or other organisations which would use updated maps.

Detailed land use and forest type maps can be used to monitor the effects of the land allocation process on forest cover and structure. A forest type map produced before the land allocation for private farmer, and another one e.g. five years after the allocation can be compared in the mapping system and changes in forest cover calculated. The information produced should be of interest for people and organisations involved in the land allocation.

The direct outputs of the mapping and survey system are thematic maps with corresponding tabular data on forest area and its distribution. The basic thematic map is the one of land use and forest types, but a wide range of other maps can be prepared, including maps of other themes than forest. However, the most important output is the establishment of the methodology and mapping system including training of the staff capable to independently conduct field surveys and process the forest related data by modem means.

2. FOREST SURVEY AND MAPPING IN VIETNAM

2.1. General

Several types of forest inventories and mapping operations have been conducted over the years in Vietnam. Various organisational levels have inventories for their specific needs, but the information produced seems often to be kept within the parties of the inventory. This yields to a situation where even organisations working in the same geographical area do not always know about the data existing of the area, which leads to incomplete operations due
to lack of information or to wasting of resources by doing double work.

In order to carry out forest survey, the consultants identified a vast number of maps of different types and scales are found in Vietnam, some of which are presented in Table 1. The list is not comprehensive but it aims to give examples of the maps handled in or produced by forest survey.

Table 1. Topography, land use and forest maps in Vietnam

<table>
<thead>
<tr>
<th>Theme</th>
<th>Coverage</th>
<th>Made by</th>
<th>Year</th>
<th>Scale</th>
<th>Located at</th>
<th>Digital Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topo</td>
<td>Vietnam</td>
<td>FIPI + GLMD</td>
<td>1975-1996</td>
<td>1:10,000</td>
<td>FIPI + GLMD</td>
<td>p (+ d)</td>
</tr>
<tr>
<td>Topo</td>
<td>Vietnam</td>
<td>GLMD</td>
<td>1965-1985</td>
<td>1:25,000</td>
<td>GLMD</td>
<td>p</td>
</tr>
<tr>
<td>Topo</td>
<td>Vietnam</td>
<td>GLMD + FIPI</td>
<td>1965-1985</td>
<td>1:50,000</td>
<td>GLMD + MD + FIPI</td>
<td>p + d</td>
</tr>
<tr>
<td>Topo</td>
<td>Vietnam</td>
<td>GLMD</td>
<td>1965-1985</td>
<td>1:100,000</td>
<td>GLMD + MD</td>
<td>p (+ d)</td>
</tr>
<tr>
<td>Topo</td>
<td>Vietnam</td>
<td>GLMD</td>
<td>1965-1985</td>
<td>1:250,000</td>
<td>GLMD + MD</td>
<td>p</td>
</tr>
<tr>
<td>Topo</td>
<td>Vietnam</td>
<td>GLMD</td>
<td>1965-1985</td>
<td>1:500,000</td>
<td>GLMD + MD</td>
<td>p</td>
</tr>
<tr>
<td>Land use + for</td>
<td>Vietnam</td>
<td>FIPI</td>
<td>1980</td>
<td>1:500,000</td>
<td>FIPI</td>
<td>p</td>
</tr>
<tr>
<td>Land use + for</td>
<td>Regional</td>
<td>FIPI</td>
<td>1995-1996</td>
<td>1:250,000</td>
<td>FIPI</td>
<td>p + d</td>
</tr>
<tr>
<td>Forest type</td>
<td>Vietnam</td>
<td>FIPI</td>
<td>1995</td>
<td>1:1,000,000</td>
<td>FIPI</td>
<td>d + p</td>
</tr>
<tr>
<td>Land use + for</td>
<td>Vietnam</td>
<td>FIPI</td>
<td>1996</td>
<td>1:1,000,000</td>
<td>FIPI</td>
<td>p</td>
</tr>
<tr>
<td>Land use + for</td>
<td>Province</td>
<td>PCC</td>
<td>1990-1995</td>
<td>1:100,000</td>
<td>PCC of DARD</td>
<td>p</td>
</tr>
<tr>
<td>Land use + for</td>
<td>District</td>
<td>PCC</td>
<td>1980-1995</td>
<td>1:50,000</td>
<td>PCC of DARD</td>
<td>p</td>
</tr>
<tr>
<td>Land use + forest</td>
<td>Forest</td>
<td>FE</td>
<td>1980-1995</td>
<td>1:25,000 or1:50,000</td>
<td>FE</td>
<td>p</td>
</tr>
<tr>
<td>For master plan</td>
<td>Province</td>
<td>PCC DARD</td>
<td>1990-1997</td>
<td>1:1,000,000</td>
<td>PCC, DARD</td>
<td>p + d</td>
</tr>
<tr>
<td>For master plan</td>
<td>District</td>
<td>PCC</td>
<td>1990-1997</td>
<td>1:50,000</td>
<td>PCC, FIPI and DARD</td>
<td>p</td>
</tr>
<tr>
<td>For land alloc.</td>
<td>Commune</td>
<td>FPS</td>
<td>1990-1997</td>
<td>1:10,000</td>
<td>FPS</td>
<td>p (+ d)</td>
</tr>
<tr>
<td>Updated topo</td>
<td>Commune</td>
<td>FPS</td>
<td>1990-1997</td>
<td>1:10,000</td>
<td>FPS</td>
<td>p</td>
</tr>
</tbody>
</table>

National

The first national forest inventory over the whole country was conducted 1979-1983 by FAO and UNDP. Forest Inventory and Planning Institute (FIPI) organised the second one 1991-1995, and the third one is presently in process also by FIPI. The present inventory is based on visual classification of satellite data combined with systematic field sample. The inventory includes establishment of permanent sample plots for growth and yield studies. The national forest survey program is focusing also in forest monitoring activity covering part of the country annually.

The satellite image classification is stored in digital format in computer, which enables output of a variety of thematic maps in different scales. The thematic maps include land use, forest type and soil maps, and they have corresponding tabular database. The satellite data in possession of FIPI is given in Table 1.

Table 2. Satellite data in FIPI

<table>
<thead>
<tr>
<th>Type</th>
<th>Coverage</th>
<th>Year</th>
<th>Located at</th>
<th>Digital Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landsat - MSS</td>
<td>Whole country</td>
<td>1975-1980</td>
<td>FIPI-RSS</td>
<td>paper</td>
</tr>
<tr>
<td>Landsat - TM</td>
<td>Whole country</td>
<td>1990</td>
<td>FIPI-RSS</td>
<td>paper</td>
</tr>
<tr>
<td>Landsat - TM</td>
<td>Whole country</td>
<td>1993</td>
<td>FIPI-RSS</td>
<td>paper</td>
</tr>
<tr>
<td>Spot</td>
<td>Whole country</td>
<td>1995-1996</td>
<td>FIPI-RSS</td>
<td>paper</td>
</tr>
</tbody>
</table>
2.2. Province

Many of the provinces, including the former Bac Thai and the present Bac Kan provinces, have contracted FIPI (or actually sub-FIPI, that is a regional office of the main institution) to make a provincial forestry master plan. The master plan is a comprehensive study on the forestry sector containing also forest survey and map production. The master plan maps are usually hand-made in scales 1:50,000 - 1:100,000 (Annex 1). Normally no aerial photos have been available for forest delineation, thus the maps are somewhat inaccurate and do not show much detail. During the preparation of the master plans field sample plots are measured by forest stand to calculate mean growing stock by forest type.

The national forest inventory maps can be enlarged into province level to obtain an overview of the land use and forest classes with a possible update of the information.

2.3. District

There is no particular district forest inventory applied in the country, except in the districts that have rich forest resources, nationally important watersheds, natural parks or nature conservation areas. These forest surveys have been carried out by sub-FIPI or by a provincial consultancy company. Those districts that have no specific inventory can be covered by extracting data from the provincial master plans.

2.4. Commune

The base for communal forest survey is the topographic map in scale 1:10 000 which covers the whole country. Several national and local organisations, such as sub-FIPI, provincial consultancy companies, Department of Agriculture and Rural Development, Forest Protection Department and forest enterprises, have prepared land use and forest type maps for their specific needs covering their area of interest. There does not exist any table or catalogue of the surveys made, the survey information and maps are hold by the contractor and the provider of the information.

The communes, where the forest land has been or is being allocated to farmers, have detailed land allocation maps showing the location and boundaries of individual forest lots. The land allocation has been manually drawn on topographic maps in scale 1:10 000, and it includes estimation of the growing stock. In some cases also the topographic information has been updated when preparing the land allocation maps.

The provincial master plan maps have sometimes been manually enlarged into commune level in scale 1:10 000, which provides rough information on land use and forest types. The accuracy is sufficient for the main land uses, but the forest types tend to be large in area and not showing the existing mosaic of land uses and forest types.

The commune level forest survey is discussed more in the next chapter.

3. FOREST SURVEY AND MAPPING SYSTEM

3.1. Field survey

3.1.1. Survey method

The forest information at commune level must be organised by stand, which enables localised management and planning, i.e. planning with a map where the coordinates of every stand are known. The most accurate method for standwise forest inventory is to use fresh aerial photographs or, video images. If the imagery is good quality, very little or no field checking is required for high quality forest maps. The stand boundaries can be drawn directly on the images and digitised into computer format. If using traditional aerial photos it is necessary to correct the distortion caused by the central projection of camera to obtain correct scale, but video images and digital aerial photos are usually rectified automatically thus yielding correct area with no extra work.
One of the requirements for forest survey in communal level defined by the Programme is a simple appropriate system that would easily and with low cost indicate land use and forest type information. If the main requirement is to produce information quickly and economically, it is not possible to produce also information of high accuracy. Usually low cost means also low accuracy, and higher cost higher accuracy. The requirement of low cost rules out aerial photography and videography thus leaving only the option of visual mapping and stand delineation for communal forest survey.

Estimation of growing stock by measuring field sample plots is very time-consuming in the terrain and forest conditions of Bac Kan province. Thus the easy and low cost method of volume estimation is to utilise the results of the most recent inventory, if it was not carried out more than three to five years ago, instead of measuring the field sample. Such is e.g. the master plan inventory of the Bac Kan province that was conducted 1997 by sub-FIPI. The existing data of previous inventories provides mean wood volume and number of bamboo shoots per hectare by forest type, which can be used as such in the first phase of inventory. Later, if resources allow, sample plots can be measured by forest type or even by forest stand to update the estimates of the owing stock into more detailed data by, commune.

Visual classification is simple and low cost method for land use and forest type mapping. The idea of visual classification is to draw the land use and forest type boundaries in the field directly on paper map using no other devices but compass and binoculars. The main working steps of visual forest type mapping are:

1. Acquire paper base map of the area in scale 1:10 000
2. Update the commune boundary and new settlement area on the map
3. Classify the area into land use and forest type classes by
   a) visual observation from a point of good visibility of a large area
   b) drawing the stand delineation on the map:
   c) moving to other observation points to cover the whole area
4. Collect mean forest volume estimates from existing sources
5. Collect the information of biodiversity, fauna and flora and medicinal species
6. Calculate area by stand either by hand or by computer
7. Combine the volume and area estimates for totals of the commune
8. Produce the forest map either manually or by computer
9. Prepare tables and report of growing stock and area estimates

The method is justified in the terrain of Bac Kan province characterised by good accessibility, small forested mountains, and settlement areas and rice fields in small valleys between the mountains. Another must is a good, quality base map indicating topography in scale 1: 10 000. In this type of terrain a number of mountain slopes are visible and identifiable from an opposite mountain or across a paddy field. Due to existing road network and small and accessible mountains or hills, it is fairly quick to move from one observation point to another, either on foot or by car or motorcycle.

The advantages of visual classification are that it is economic, quick and easy to learn. The only costs involved are the labour and transportation costs; the system requires hardly no direct investments. The only major investment is the establishment of computerised mapping system, which can be considered as one-time investment usable in several communal inventories over many years. The speed of inventory is relatively high as one team of one or two men equipped with a motorcycle can cover several hundreds of hectares in a day, thus covering an average commune in a couple of weeks, including pre-processing the map material and the field work. The knowledge and experience of visual forest classification already exists in Vietnam. A person with knowledge of maps and mapping can team the process in matter of days if accompanied with an experienced mapping officer.

The main shortcoming of the visual mapping system is that, there are no real means of quality control, except also visual checking by an independent controller, and that the reliability estimates can not be calculated. The quality of the classification is highly dependent on the skills of the field work team. A skilful logically working team can produce fairly good maps that show more detail than the existing forest type maps produced for strategic purposes in the province level. However, no matter how good the team is, the result is not comparable in stand level with other classifications made previously or in future. The results are biased if comparing results of inventories that have different methods of classification. Also, there is no objective independent reference for visual classification, even though the successive
classifications were made by the same team. An overall comparison on commune level can be made, even by forest type, if the restrictions and shortcomings of this type of inventory are kept in mind and presented in the corresponding report.

3.1.2 Land use and forest type classification

Several land use and forest type classifications exist in Vietnam. The one that suits the requirements of communal forest survey is from the Regulations for Forest Inventory, Management and Projection by FIPI 1984. It has been slightly modified for the local conditions by omitting some classes that do not exist in the area or that are very rare, and by joining some classes together. The class codes of the forest and bare land classes (I - III) are adopted from the above mentioned classification. The codes of the other classes are simply abbreviations of the class names to create a short names which are needed in computerised mapping and area calculation system (Table 3). Actually, it makes no difference how the classes are shortened and called, as long as the interpretation of the class does not change and as long as there is no risk of confusing the classes with each other.

Table 3. Land use and forest type classification

<table>
<thead>
<tr>
<th>Class</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Forest land</td>
<td></td>
</tr>
<tr>
<td>IIIA3</td>
<td>Rich forest</td>
<td>Total volume &gt; 150m(^3)/ha</td>
</tr>
<tr>
<td>IIIA2</td>
<td>Medium forest</td>
<td>Total volume 80 - 150m(^3)/ha</td>
</tr>
<tr>
<td>IIIA1</td>
<td>Poor forest</td>
<td>Total volume &lt;80m(^3)/ha</td>
</tr>
<tr>
<td>II A</td>
<td>Young forest after shifting cultivation</td>
<td></td>
</tr>
<tr>
<td>II B</td>
<td>Young forest after logging</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natural bamboo</td>
<td></td>
</tr>
<tr>
<td>B2</td>
<td>Big size bamboo</td>
<td>mean diameter &gt;5 cm</td>
</tr>
<tr>
<td>B1</td>
<td>Small size bamboo</td>
<td>mean diameter &lt;5 cm</td>
</tr>
<tr>
<td></td>
<td>Mixed forest</td>
<td></td>
</tr>
<tr>
<td>T+B</td>
<td>Evergreen trees and bamboo</td>
<td>Evergreen forest and bamboo, evergreen dominating</td>
</tr>
<tr>
<td>B+T</td>
<td>Bamboo and evergreen trees</td>
<td>Bamboo and evergreen forest, bamboo dominating</td>
</tr>
<tr>
<td></td>
<td>Plantation</td>
<td></td>
</tr>
<tr>
<td>PT</td>
<td>Tree plantation</td>
<td></td>
</tr>
<tr>
<td>PB</td>
<td>Bamboo plantation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Bare land</td>
<td></td>
</tr>
<tr>
<td>IA</td>
<td>Grass</td>
<td></td>
</tr>
<tr>
<td>IB</td>
<td>Shrub</td>
<td></td>
</tr>
<tr>
<td>IC</td>
<td>Scattered trees and bamboo</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Agriculture land</td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td>Two crops per year</td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>One crop per year</td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>Shifting cultivation</td>
<td>Area presently in shifting cultivation</td>
</tr>
<tr>
<td>A4</td>
<td>Industrial tree plantation</td>
<td></td>
</tr>
<tr>
<td>A5</td>
<td>Fruit tree plantation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Other land</td>
<td></td>
</tr>
<tr>
<td>O1</td>
<td>Urban land</td>
<td>Urban land and permanent settlements</td>
</tr>
<tr>
<td>O2</td>
<td>Special land</td>
<td>Cemeteries, etc.</td>
</tr>
<tr>
<td>O3</td>
<td>Water</td>
<td>Lakes, ponds</td>
</tr>
</tbody>
</table>
The soil fertility is taken into account by classifying the forest land into fertile and rocky, and adding the letter ‘R’ after the forest type class in case of rocky land. Also the fertility classification is of national origin.

The forest mapping and classification is presented in detail in "Guidelines for Forest Survey and Mapping.

3.2. Computerised forest mapping

3.2.1. Benefits

Computerised maps have during the past ten years replaced the hand-drawn maps in many parts of the world. There are several reasons to this change. Even though establishment of a computerised mapping unit is not always easy, on the long run the computer will speed up the map production process and improve the quality of the maps.

The main benefit of computerised mapping is that it is not necessary to repeat the heavy mapping process completely when information in the field changes. Updating only a part of the map is possible with no need to redo all the area of the map. For example, if a new forest plantation is established on bare land, the boundary line of the plantation is digitised, the land use of the area changed and the updated map or a part of it printed.

Computerised mapping makes area calculation fast and error-free. Traditional area calculation, by dot-counting is time consuming and sometimes inaccurate, whereas area calculation with computer is highly accurate and error-free. The accuracy of the result depends on the quality of field delineation of forest stands, and on the digitising process which must be completed carefully.

Scale transformation can be done on-line with computer. Computer mapping is independent of map scale; the map scale can be changed in a fraction of a second on the screen, and the maps can be printed in any scale, keeping in mind the fact that it is not wise to enlarge the map very much beyond the original scale of data collection. If forest typing field work has been done in scale 1:10000, it is not recommended to print the map in bigger scales than 1:5000.

There is a wide variety of thematic maps available in computerised mapping system. Any variable or combination of variables stored in the computer database can be used to produce informative thematic maps on-line once the basic information has been digitised. The most common thematic maps in forest mapping include land use, forest types, soil fertility, wood volume and stand density.

Computerised mapping allows data combination from various sources, i.e. multi-source in mapping. Existing topographical maps, administrative maps, land-use maps, land-allocation maps and aerial photos and satellite images can be simultaneously used as data sources regardless of their original scale. For example in communal forest type mapping topo maps can be used for contours and road network, administrative maps for communal boundaries and aerial photos for detailed forest types.

3.2.2. Components

The forest mapping work station established in the Department consists of a micro-computer with a large high-resolution screen, a digitising tablet and a colour printer (Figure 1). The computer is equipped with digital mapping software. The digitiser is used for map input, the computer for map processing and the printer for map output.

Figure 1. Forest mapping work station
The software selected for communal forest mapping is MapInfo, which provides simultaneous management of map and tabular databases. MapInfo is used in several organisations and companies in Vietnam, thus support and training is available also after the programme period. Using identical software and data formats in different organisations enables easy data exchange and sharing with no-need for format transformations from one software to another.

### 3.2.3. Functions

The forest mapping work station is used for input, processing and output of maps according to the needs of the Department. In the beginning the work station is used to produce communal forest maps and to build up databases for forest monitoring and planning purposes, to be used both in the provincial and communal levels. Gradually a forest and general map database can be built up expanding the data from commune to district and province levels.

The forest map preparation by computer is presented step by step in "Instructions for Forest Map Preparation by MapInfo".

### 3.3. Outputs

The field survey and digital mapping produce a computer database of both tabular and map data. The combined map and tabular database is used to prepare thematic maps and tables on forest area and growing stock. The basic output of the survey is a thematic map of land use and forest types with accompanying tables of area, volume and number of bamboo shoots by land use and forest type.

The computer database enables production of other thematic maps besides the combined land use and forest type map. With the information presently in the database at least the following maps can be prepared highlighting some specific aspects:

- Land use by the main land use classes
- Forest types without other land uses
- Soil fertility (rocky, not rocky)
- Forest plantations
- Shifting cultivation

If the system is expanded to include other map layers (forest compartments and units, land allocation and forest protection, wildlife, biodiversity), also other thematic maps can be produced:

- Land allocation status
- Forest types within forest protection and special use forest
- Conflict of land allocation and forest protection
- Enlarged forest maps by forest unit
- Distribution of medicinal plants
- Protection areas for endangered species

The main tabular outputs of the survey are tables presenting area by land use, forest type and soil fertility including subtotals by land use and forest type group, wood volume and number of bamboo shoots by forest type and soil fertility. The data for the area tables is automatically produced by the mapping software. The estimates of growing stock are derived from the area and mean growing stock figures by forest type. If the forest management units and land allocation are included in the system, also the tables can be calculated by these classes.
4. DISCUSSION AND RECOMMENDATIONS

4.1. Development of the mapping and survey system

There are possibilities for future improvements and investments in mapping and information management software and hardware if the present system proves to be operational; i.e. operated by the local staff and without direct support from the Programme.

A table scanner of size A3 should be included in the mapping work station for laying the contour lines into the background of forest type maps. The expanded forest mapping work station would consist of a digitiser, scanner, computer and printer (Figure 3). The working steps using a scanner for data input in the system are:

1. Scan topo maps of commune into raster format in pieces of size A3 so that the coordinate crosses are visible.
2. Take each map into scanning software for editing: remove unnecessary objects (e.g. rivers that have changed their course) and correct existing ones (e.g. contours).
3. Import each map piece into MapInfo and geocode it using control points (coordinate crosses).
4. Overlay the raster map pieces with vector information produced with digitiser.
5. Cut and remove the raster map outside the commune boundary.
6. Print the raster map with selected vector layers.

Figure 3. Expanded forest mapping work station

It is also possible to digitise directly from the raster map on the screen, e.g. rivers, roads, houses and contours, but the digitising is not as accurate as with the digitising tablet. It is even possible to manage without a digitiser, by scanning the forest type map and digitising the land use classes and forest types on the screen with mouse. Besides paper maps, also rectified aerial photographs and satellite images can be imported into mapping system by scanner. Other uses of a scanner are production of training and extension materials or bringing any other information in paper into computer.

At the moment backup copies of the maps are taken on 1.44 Mb diskette. The amount of map data, even though compressed will on the long run increase above the size of a diskette. Therefore it is recommended to acquire second hard disk of 1-3 GB and install it internally into an empty slot or externally by SCSI-interface, The external hard disk makes it also possible to transfer large amounts of data from one computer to another, e.g. for quality printing in FIPI. In a system of two separate hard disks map preparation would be done in the hard disk, and the data copied daily also to another disk.

If the Department decides to continue digital forest mapping, permanent staff should be trained and allocated for the digitising work. A person or persons with basic computer skills could do the digitising, and person or persons with computer mapping skills could do the final map preparation by MapInfo and be responsible of the whole process.

If there are plans in future to expand the mapping activities by installing another mapping work station in the Department, an option to use AutoCAD instead of MapInfo should be considered. Digitising can be done using AutoCAD software, without investing in another licence of MapInfo. AutoCAD produces basic polylines, that can be converted into MapInfo formal and processed into final maps by MapInfo. There are several companies in Hanoi giving training in AutoCAD.
The database connected with the land use and forest type maps contains presently only the very basic forest information. The existing and future databases can be expanded to include any information considered important by the Department. Such information may be land allocation, population, livestock, wildlife and non-wood forest products. Some of the data may be put into existing map layers, for some data new map layers must be created.

When the communal forest mapping expands to other communes, also the general map database will expand. On the long run district wise or provincial map layers will be generated covering administrative boundaries, river systems, road network and urban centres. Even though prepared by commune, the identically structured map layers can be joined together into a seamless map.

Improved estimates of the growing stock can be obtained by measuring sample plots by forest and later also by forest stand instead of using the existing data of the previous inventories. For example, a small number of plots allocated into different forest types in different parts of commune would be sufficient in the beginning. Then the number of plots could be increased, and for high accuracy the plots could be measured even in every stand.

4.2. Co-operation with FIPI and other organisations

Digital map preparation is time consuming work, and any chance for overlapping work should be discovered and double work avoided. Therefore it is important to share and exchange the map data as much as possible. At least FIPI, PAM-project and some provincial bodies execute digital mapping, and an agreement on data interchange between the ones operating in the same area should be reached. For example, digital contours of FIPI could be used in the province, and updated provincial maps could be given to FIPI.

Before splitting of the Bac Thai province forest map and database development was started in the consultancy company of the Department of Agriculture and Rural Development of Bac Thai. The database is established especially in the Programme pilot communes, and it is recommended to acquire the data from Thai Nguyen to Bac Kan. Also FIPI has some large scale digital data covering the Bac Kan province.

During the Forest Survey and Mapping consultancy period only very limited number of the staff of the Department has been given training in digital mapping. Since FIPI is capable of giving specific training in MapInfo, the mapping staff of the Department should be sent to training in FIPI. The training is most efficient if the persons for training are already somewhat familiar with digital mapping, thus they could present their specific problems and seek answers to those. The training should be tailored to the skills of the participants.

If serious problems in using the system arise, it is also possible to ask a specialist from FIPI or Harmony Ltd. (the representative of MapInfo in Vietnam) to travel to Bac Kan to solve the problems in location.

It is recommended to study the possibility to produce large size high quality maps in FIPI, since FIPI has long experience in map printing and is equipped with big size colour plotters and a printing shop. It is not feasible to invest in large size plotter in Bac Kan because of its high price and relatively infrequent use.

4.3. Forest classification

The definition of bare land and its classification is confusing, especially if it has scrubs, some trees or bamboo. From the distance it is not easy to differentiate between scrubland and young forest, instead you would have to enter into the forest to study the species composition. Bare land can develop into forest if left intact for some time, which cause's uncertainty in classification. Actually, bare land should be one class within forest land, e.g. forest in very disturbed stage or in its initial stage. Also the name "bare land" is misleading, because it refers to land without vegetation and in reality most of the bare land is heavily vegetated. However, the classification in this study was not modified in bare land; the national classification was followed.

Similarly, shifting cultivation is one class of agriculture land, even though most of shifting cultivation is practised in forest or bare land. And if left intact, it develops either directly into forest land or first into bare land and later into forest land. There is a rapid change in land use in the zones of shifting cultivation, successive forest surveys will show changes in magnitude and location of land use in these areas.

One possibility to clarify the classification of bare land and shifting cultivation would be to classify these areas into transitional zones, where final land use has not yet been defined, or into potential forest land. The areas will hardly be changed into permanent agriculture since they are usually situated in steep slopes. Nevertheless, the forest inventory identifies the land use and forest type by the classification valid at the time of inventory, so there is no confusion between the results of the inventories carried out applying the identical classifications.
There is a conflict between reality and the classification of forest in the provincial master plans into protection and production forest. Much of the protection forest is actually not protected, but it is in normal use by the local people. Forest land allocation for private farmer by one government body has taken place in forests allocated for protection by another government body, even though forest land allocation for private farmer in protection forest is prohibited by law. This calls for action by the bodies involved in land allocation and in allocation of forest land into use classes.

4.4 Other

Aerial photographs and video images, digital or in paper, are the best data for commune level mapping. If aerial data becomes available it is highly recommended to acquire and use it in the inventory.

It is possible to use the Spot satellite data for rough commune, district and province level land use mapping. The ground resolution (minimum area detected) of Spot images is about twenty meters that is sufficient to visually classify vegetation cover for areas bigger than half hectare or even less. It is not possible to differentiate the traditional forest types using Spot images, instead the images are classified first into land use classes and then into forest classes according to vegetation cover. The fresh images are available in FIPI, and they can be used directly in digitiser or as scanned backdrop images.

One of the advantages of digital mapping is the possibility to update the maps without remapping the whole area and all the map layers. It is recommended to update the maps continuously by the department and commune staff, at least when major changes take place in the field.

Care must be taken to keep the computer facilities clean and dry. Using vacuum cleaner and wet rug daily or at least weekly, and air-conditioner or dehumidifier during humid seasons are suggested to increase the operating span of the computer hardware.

Many times the dissemination of survey results and maps has been incomplete. Therefore care should be taken to distribute copies of the results to concerned parties and find real uses and users for them. The objective of survey and mapping is not only to produce nice maps to be hanged on the wall, but especially to use them for land use and forest planning and monitoring the activities and changes taking place in the area.

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