

# Completion Report

**Quality assurance and product verification of the 2005/2006 forest cover assessment in Cambodia and capacity assessment and development of the GIS and Remote Sensing Unit within the RGC Forestry Administration**

**GRAS**

**Capacity building report**

**Draft Final  
March 2007**

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**Quality assurance and product verification of the 2005/2006 forest cover assessment in Cambodia and capacity assessment and development of the GIS and Remote Sensing Unit within the RGC Forestry Administration**

**Danida Natural Resource Management and Livelihoods Program,  
Cambodia 2006 – 2010**

GRAS A/S  
c/o Institute of Geography,  
University of Copenhagen  
Øster Voldgade 10  
DK-1350 København K

Tel: +45 35 32 25 78  
Fax: +45 35 32 25 01  
Dept. fax:  
e-mail: gras@gras.ku.dk  
Web: www.gras.ku.dk

**March 2007**

Client  Forestry Administration, Cambodia	Client's representative  H.E. Ty Sokhun
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Project  <b>Quality assurance and product verification of the 2005/2006 forest cover assessment in Cambodia and capacity assessment and development of the GIS and Remote Sensing Unit within the RGC Forestry Administration</b>	Project No
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Authors  Michael Schultz Rasmussen Mikael Kamp Sørensen  Missions:  December 11 – 15, 2006; January 29 – February 2, 2007 March 12 – 23, 2007	Date March 31 2007
	Approved by MSR

Revision	Description	By	Checked	Approved	Date
	Draft Final	Mks, msr	Msr	msr	31-3-07

Key words  Remote sensing, GIS, mapping, forestry, accuracy assessment, capacity building,	Classification  <input type="checkbox"/> Open <input checked="" type="checkbox"/> Internal <input type="checkbox"/> Proprietary
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Distribution FA, DANIDA	No of copies

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## ***ABBREVIATIONS***

DANIDA	Danish International Development Assistance
DGPS	Differential GPS
DIFID	Department for International Development (UK)
FA	Forest Administration
FRA	Global Forest Resource Assessment
GPS	Global Position System
IRS	Indian Remote Sensing Satellite
JICA	Japan International Cooperation Agency
LCCS	Land Cover Classification System
LISS	Instrument onboard the IRS to create images
MAFF	Ministry of Agriculture, Fisheries and Forestry
NRMLP	Natural Resource Management & Livelihoods Programme
RGC	Royal Government of Cambodia
RS	Remote Sensing
UNDP	United Nations Development Program
VHR	Very High Resolution satellite images

## **EXECUTIVE SUMMARY**

The GIS and RS unit at the FA is a well functioning unit capable of producing forest maps using simple visual interpretation of satellite images. They are well organized and committed to their tasks and produce different types of maps relative to their statutory mandate. The unit has been established and developed with external support and today, prior to the present contract, there were an obvious need to be upgraded in terms of soft- and hardware. The independent verification of the national forest cover maps from 2006 done within the present contract, equally revealed that the current methodology of doing simple visual interpretations had its limitations mapping both the main forest classes as well as the intermediate forest classes with a high accuracy. The order of accuracy is 74 % (when merging minor classes) which is fairly acceptable for the used methodology, however, far from sufficient if the FA should be able to describe the current development of the forest resources in Cambodia.

The GIS and RS unit should according to their mandate be able to produce three different types of maps: the national forest cover maps, local maps with detailed information about the forest types for management purposes and simple GIS maps showing the boundaries of the forest areas. The later may be simple maps just containing the boundaries collected using GPS coordinates. In order to produce these forest maps and of a high quality, the GIS and RS unit need the following methodologies:

1. improve the present methodology of visual interpretation by doing digital automated classification and improve the visual interpretation by integrating more spectral information in the process (use all relevant satellite bands)
2. have a procedure for independent verification of forest maps
3. be able to apply georeferences to all types of geodata (e.g. ortho rectification, polynomial rectification and working with projections and datum in the GIS environment)
4. be up-to-date in terms of soft- and hardware

The team at the GIS and RS unit all have forest backgrounds which is most appropriate, however, no one have in-depth GIS or remote sensing training. While this is often less critical when doing simple visual interpretations of images (satellite images or aerial photos), it becomes a major disadvantage when start working with digital image processing, both the more advanced classifications, but equally handling digital data in general. Consequently, the entire team needs to be upgraded within basic remote sensing and GIS theory and relevant methods. The following steps have been proposed to build adequate capacity at the GIS and RS unit to produce high quality accurate maps:

1. During the present assignment the following issues have been dealt with (the period December 2006 – March 2007):
  - a. Establish a procedure for independent verification of forest maps

- b. Introduction to ortho rectification of images (apply a truly planar projection)
    - c. A first introduction to remote sensing and digital classification methods
  2. Provide a tailored three-week remote sensing and GIS course to six people from the GIS and RS unit (May – June 2007) at AIT in Bangkok
    - a. The objective of this course is to provide the fundamentals of remote sensing and digital image processing as well as handling correctly and efficient georeferenced data in a GIS.
  3. Implementing a new improved classification methodology and accompanying procedures. This will be done in two steps:
    - a. A pilot project will be done by two people from the FA in Copenhagen supervised by GRAS (ca September 2007, two weeks)
    - b. Implementation of the new method through a on-the-job training course in Phnom Penh for all staff (ca October 2007, seven days)
  4. For long term consolidation of the mapping capability, the GIS and RS unit should aim at having people send off to obtain Masters in remote sensing and GIS on a regular basis.
    - a. Danida has presently made available a first grant for a person from FA to undertake a MSc in remote sensing and GIS at AIT in Bangkok.
    - b. Agreements with the MSc candidates should be made, so they will stay working at the GIS and RS unit for 3-4 years upon completion of the MSc.
  5. The English language level at the GIS and RS unit needs to be improved in order to facilitate training and consultations of technical documents such as manuals, reports and papers.
    - a. Eight people will be trained in English over the next 12 months under the present contract.
  6. Under the present contract the following upgrades have been made:
    - a. four PC's have been purchased and a file server
    - b. upgrading of two ArcView 9 GIS licenses
    - c. upgrade of Erdas Professional image processing software
    - d. a differential GPS has been purchased and training made

All the mentioned activities are being executed within the framework of the present contract except: the grant for the MSc at AIT (bullet number 4) and covering the costs for the differential GPS (bullet 6d).

## 1 INTRODUCTION

The GIS and remote sensing unit at the Forest Administration GIS and Remote Sensing Office is producing national forest cover maps from Landsat satellite images and local maps supporting forest demarcation, evaluation of the function of the forest and forests management plans. The present GIS and remote sensing (RS) settings and capabilities were established in 1993 up to 1998 with the support from GTZ. Other donors have supported the unit for short periods or for specific purposes. Consequently, the unit has received substantial support in the past both in terms of equipment and training. Today the unit is well functioning, well organized and is capable of producing forest maps using visual interpretation.

The present assignment has as the objective to propose and implement a method for the assessment of the accuracy of the recent 2006 national forest cover maps completed in January 2007 in order to give credibility to the maps. Furthermore, the computer equipment is old and need to be replaced and/or upgraded and the staff should receive remote sensing and GIS training to allow them to fulfil all their statutory commitments, produce maps of a high standard and to undertake new assignments.

The objectives as written in the terms of reference for the present assignment are:

1. To ensure quality assurance and product verification, and thus, credibility of the forest cover assessment in Cambodia, the Forestry Administration requires an independent verification by an institution/consultant with more than ten years of experience in forest cover assessment, preferably with previous experience working in S.E. Asia.
2. To complement the above-mentioned core task, it was discussed and agreed to provide additional assistance to support capacity development of the GIS and Remote Sensing Unit within the Forestry Administration. This will enable the Forest Administration, other RGC partners and the Danida/DFID Multi-Donor Livelihoods Facility to solicit their services during implementation of the recently launched Natural Resource Management & Livelihoods Programme (NRMLP).

## 2 ***THE MANDATE OF THE GIS AND REMOTE SENSING OFFICE***

The mandate of the GIS & RS office was set out in the “Declaration on to prepare and implement the Forest Administration” Prakas nr. 509, September 17. 2003. The following is a non official translation of the text relative to the Watersheds and Forest Land Management Office (today: the GIS & RS unit) (the original Khmer text can be seen in appendix 1):

Tasks of the Watersheds and Forest Land Management Office

- Prepare legal documents concerning forest land.
- Prepare, classify and evaluate the watershed area and define the forest land boundary.
- Prepare and classify permanent forest reserves according to their function such as environment, economy, social and culture.
- Manage all geo-referenced data and information, produce forest cover, watershed and other maps used in the forestry sector.
- Scientific research on GIS and remote sensing techniques and produce and disseminate forest maps.
- Manage and control all forest map production services.
- Other tasks designated by the head of the FA.

Comments and understanding of the text:

Add 2: Regarding evaluation, it will be evaluated if the watershed area is critical or not in terms of erosion, water supply etc. and whether they need to be protected or not etc. The forest land boundary regards the forest land delineation.

Add 3: Identify the primary role of the forest and classify it accordingly as having an environmental, economic or tourist function, etc. The next step is to create the appropriate management plans.

Add 6: If other institutions produce forest maps, this should be controlled by the FA GIS office.

The FA GIS and RS office should be able to produce three kinds of maps in order to fulfil their commitments:

1. **National forest cover maps**, e.g. as presently are being produced from Landsat satellite images
2. **Detailed local forest maps** for identification of forest areas and make assessment of forest characteristics for evaluating forest types and use as well as monitoring, e.g. economic land concessions
3. **Local detailed maps** showing forest boundaries and demarcations, these are simple GIS maps and can be made without image support. These maps are often created as sketches on old maps or with the support of GPS coordinates.

### 3 **FOREST COVER MAPPING**

The present verification of the *forest cover maps* based on field surveys and very high resolution data shows that the forest cover maps have an overall accuracy of 70-75 %. The details of the accuracy assessment are described in the accuracy assessment report. The results of the field validation campaign show a high accuracy for the classes Evergreen Forest, Semi-evergreen Forest and Non-N-forest (accurate in the order 80, 95 and 70 % respectively).

All other intermediate classes such as different scrub classes and Other Forest, Deciduous Forest and Bamboo are not mapped with a satisfactory accuracy (50 % and lower). Based on an independent check against very high resolution data in more remote areas the results are similar but with lower accuracies for the three main forest classes (from 63-75 % for Evergreen, Semi-Evergreen and Deciduous) This is not surprising, since the 30 x 30 m pixels in the Landsat images do not allow detailed photo-interpretation including the identification of the woody scrub vegetation, which by the definition of FAO has less than 10 per cent woody forest cover.

Though the main classes are mapped correctly, the present methodology will not allow to accurately evaluate the gradual change and degradation (and possible improvement) of the forest cover, if the intermediate classes can not be mapped with a higher accuracy. Though the present choice of classes can be changed, there will be a requirement to be capable of mapping the intermediary classes correctly, since they are the primary indicators of the transition of the forest environment (Leisz and Rasmussen, submitted).

The present situation with a moderate accuracy of the forest national cover maps may expose the FA GIS & RS unit to criticism both from within FA and other RGC stakeholders as well as from donor agencies supporting a sustainable development of the forest and natural resources. In an international and regional context, the requirements for accurate and detailed forest mapping are expressed clearly. Cambodia is involved in the regional initiative by the FAO to create a regional forest cover map. Mr Sokhom from the GIS & RS office is assigned by FA and MAFF as the National Correspondent to FAO for FRA 2010 (Global Forest Resource Assessment). One of the main objectives of the coordination effort by FAO is to promote the use of mapping standards proposed by the FAO and UNEP to allow synthesizing national efforts into regional and eventually global land cover information. The GIS and RS unit will in the near future implement and be compliant to the classification scheme proposed by FAO and UNEP, through the Land Cover Classification System (LCCS). The system is flexible and allows national footprints on the land cover legends, and places these at the right level in the overall LCCS land cover class hierarchy.

Accurate mapping of intermediate and transitional forest classes can not be done accurately using simple visual interpretation alone, but calls for more advanced methods. Most important is the full exploration of the spectral information (using all bands) as well as the combined use of satellite images from more than one date in order to capture phenological information. This has been demonstrated among other places in Vietnam (Tottrup, 2004). Furthermore, in the near future the FA will have to work with other data than Landsat, since no replacement of the present Landsat 7 has been planned. New improved digital image processing and classification methods (e.g. supervised, unsupervised, hierarchical or tree digital classifications) are needed as well as the capabil-

ity to work with a broader range of different types of satellite data. It is planned to map the national forest cover again in 2009 and consequently new methods and procedures should be in place by this time at the latest.

There are several advantages to using automated mapping methods for forest cover mapping. First of all the methodology makes it possible to use the full multispectral capabilities of the satellite data. In a visual interpretation of Landsat images, only three bands can be displayed. Using an automated classification, all six 30 m resolution bands can be included, adding much more discriminative information. It is also possible to use multi-date images in one classification to pick up important information about vegetation phenology.

Secondly, the method is systematic. Even though the identification and digitisation of the training areas (identification of reference sites for each class) is subjective the method will ensure a systematic assignment of classes throughout an image. By using overlapping areas between individual Landsat scenes, consistency will be added to the mapping process even when working with images taken on different acquisition dates with potential differences in the phenology of the vegetation. Classification can be made where both visual interpretation and automated classification are used at the same time. The visual interpretation can be guided by maps created using automated digital classifications and visa versa.

Furthermore, for change detection purposes the training areas can be and should be re-used in all cases where no changes have occurred on the ground. This will ensure consistency over time and result in a more reliable change detection.

Finally, the minimum mapping unit is not required when doing automated classification compared to when doing manual digitisation (a question about reducing the workload). The classification will operate at the pixel level (for Landsat this is app. 0.9 ha and this information can be aggregated and presented at any map scale from 1:50.000 and downwards.

### **3.1 Detailed mapping of forest**

Previously the GIS and RS unit produced forest maps for minor areas to support production forest management plans. These maps were basically extracts from the national forest cover maps created from Landsat and today this approach will hardly be sufficient or acceptable, and certainly not with the knowledge of the problems with the intermediate classes as described above.

The FA has been and is producing detailed maps for:

- The minor forest concessionaires before 2002. But not for the larger companies obtaining concessions since they normally have their own GIS and mapping units
- Production forest outside the concession forest. This includes the local use where local companies bid for logging

- Preparing management plan for local staff of FA that uses maps to assess the growing stock.
- Community forest
- Rehabilitation or restoration forest, providing base maps
- Forest land reserved for reforestation, providing base maps
- Ad hoc production of maps for NGO's, international organisations and private companies

These maps all falls into the two categories of local maps either based on aerial photos or satellite images in order to assess forest characteristics or simple GIS based maps to demarcate land and this can be done using existing maps and/or collect coordinates with a GPS. In the later case, even if it is not required, image or photo support is desired, because it becomes much more accurate and faster to map additional features such as roads, buildings etc. that makes it easier to read and use the map. At the present images are not used for this purpose at FA.

One problem at the FA is the access to existing updated aerial photos. The present national coverage of aerial photography from the ministry of Lands and the Cambodian Mekong River Committee dates back to 1992 and is outdated. The FA has access to these data in paper format and need to ortho rectify the photos when and if they want to use them. They do have a procedure for doing this. The JICA acquired a national coverage of aerial photos during the period 2000 – 2002. These data are georeferenced, however, it has proven very difficult for the FA to get access to these data because of the data are under the authority of the Ministry of Lands. Access can be granted subject to payment (fairly high), but the dispute equally reflect severe problems of data sharing between the public institutions. It may be anticipated that these data or parts of these becomes available to the FA in the near future, however it is important that the FA can get access to alternative data as well as new up-to-date data. These could be new aerial acquisitions, but the new Very High Resolution (VHR) satellite images from QuickBird (60 cm resolution), Ikonos (1 m), Formosat (2 m), IRS-LISS (~ 2 m) and SPOT (2.5 m) should equally be considered because of their potential general availability for any location at any time. Data can be purchased by the km<sup>2</sup> and new acquisitions can be programmed to match the need in terms of time (the dates) and the area of interest.

Another minor shortcoming has been the access to precision GPS recordings. However, this problem is being dealt with at the present. Under the present assignment a DGPS is being purchased and made operational at FA by demonstrating the equipment and conduct training.

### **3.2 Working with aerial photos and satellite images for detailed mapping**

When working with aerial photos or VHR satellite images, the most important first step is to apply a georeference to the data. This is in both cases done in the same way, where x, y and z coordinates are used to get a true planar projection, which is needed particu-

larly for legal land tender issues and in areas with topography. Once the data have been ortho-rectified, they can be visually interpreted or more advanced methods can be used. GPS coordinates can be added and identifications of landmarks can be done. When it is needed to classify forest types or land use and land cover, or assesses certain forest parameters, such as forest density, it can still be done manually using photo interpretation; however, digital classification or parameterisation can help creating more accurate and consistent maps.

### **3.3 *The decentralization and deconcentration process***

FA has the task of defining forest boundaries and demarcating these throughout the national territory. This imposes a major challenge to the GIS and RS office simply because of the potential amount of work, once the process picks up speed. The technical challenge can be handled by the present team, however, they will need to increase their production capacity and there will be a political wish to see decentralization to the existing 14 FA provincial offices. Here the role of the GIS and RS office will be to train provincial staff and provide methods, guidelines and basic data input (e.g. orthorectify images or aerial photos) and do quality assurance on the output according to their mandate from the prakas 509. See appendix 2 for a short overview of what would be needed at the province level to create simple mapping capacity.

### **3.4 *More advanced use of remote sensing***

Remote sensing data and methods can be used for a number of other purposes relevant for the FA:

- Carbon stock estimation
  - FAO request information about above and below ground estimation of carbon stock
- Wild fire monitoring and mapping
- Assessment of the growing stock and growth rate of commercial spices for the assessment of annual logging volume

In all three cases the remote sensing methodology will be most different from the mapping methodologies. For estimation of the growth of the vegetation, long time-series of remote sensing data are needed and data with a reduced spatial resolution (e.g. 1 x 1 km<sup>2</sup>) and improved temporal resolution (e.g. daily) are needed. Relevant data are MODIS, Meris and AATSR. Processing of these data require remote sensing expertise at a high level. Furthermore, the use of these remote sensing products often requires complementary expertise within modelling and other advanced sciences. It is therefore suggested that addressing these new topics may happen later in the capacity building process at FA.

## **4 STAFF AND HUMAN RESOURCES**

The staffs at the GIS & RS unit all have a degree in forestry (five BSc and two MSc). All but two have accomplished their education in Cambodia. They have received short training courses in relation to past projects and activities and various TA input has assisted in building the present capacity.

Using a fairly simple mapping approach and mastering GIS (ArcView 3.2) has proven to produce good results. There are clear and well elaborated procedures for all major tasks, which have been made in the past mostly with external assistance. The staff has no or very limited skills within digital image processing, automated digital classification and photogrammetry for creating ortho rectification. These are the basic skills needed to produce accurate and high quality maps, both for the national forest cover maps as well as for local detailed maps. The staffs are aware of their lack of more in-depth remote sensing and GIS expertise that make them dependent of input and TA from the outside and limit and slow down the further development of the office. The team acknowledge that they need to consolidate their capacity in remote sensing by having at least one person with a MSc in remote sensing, someone that can propose new methods, implement these and do quality assessments.

English skills are limited and are a problem for the long term capacity building. Today only one staff member will be able to attend an international MSc study, because of the requirement of documented proficiency in English (minimum 5.5 in the Tofle test or equivalent). Most staff members have a potential to develop their English skills, however, a considerable effort has to be made by each individual.

No one at the GIS & RS unit has programming background or skills. A minimum of programming skills (low level programming) are needed to permit the unit to work with macro language to streamline production and to implement new methods. The next level will be to solve more substantial problems through programming (high level programming); however, this will not be needed for digital mapping, but for more advanced remote sensing applications such as monitoring biomass and wild fires.

It is a major advantage that all staff members have a solid forest background, and this explains also why the relatively simple mapping approach has been very successful this far. There appears to be a very good understanding of mapping and spatial issues, which is an important point of departure for the capacity building.

## **5 COST RECOVERY**

When the GIS and RS office in the near future, and as a result of the present capacity building exercise, master the methods to map accurately forest types and characteristics the unit can be a partner in various RGC development projects and provide land cover and land use maps for multiple purposes. Mapping and using land cover and land use maps is essential for the NRMLP program on providing access to land and resources to the poor people.

The rampant situation of forest resource grabbing as described in the NRMLP will most likely necessitate further studies of the development of the economic land concessions. Here specific studies can be requested from the GIS and RS unit. Appendix 3 presents a proposal and example on how to study the forest development and changes within the areas subject to economic land concessions.

## **6 CAPACITY BUILDING AT FA**

We see the priorities for the GIS and RS unit to be able to:

- Accurately map the national forest cover, including mastering the quality assessment procedure.
- Create more detailed local maps using aerial photos and or Very High Resolution satellite images

Consequently the most urgent needs at the GIS and RS office are:

Remote sensing:

- geo-referencing images including ortho rectification
- consolidate the fundamentals of digital image processing
- update existing mapping procedures to new software
- improve visual classification by including the use of all spectral bands
- implementation of automated digital classification
- mastering quality assessment methods

GIS:

- Applying georeference to data and work with these (e.g. change datum and projection)

Other:

- English training to allow further upgrading to MSc levels within GIS and RS and to consult software manuals, reports and scientific papers
- Upgrade of hard- and software
  - purchase new computers and a server
  - upgrade GIS software

- upgrade RS software
- Differential GPS:
  - o Acquire the equipment
  - o Operate the DGPS
- Internet access

Other long term needs:

- Further consolidating in remote sensing and GIS at MSc level
- Programming capacity
- Advanced remote sensing topics, e.g. biomass assessments, wild fire monitoring

The present contract allows addressing the most of the urgent needs for capacity building. Hard- and software has been acquired. A differential GPS has equally been purchased (under another budget line). With respect to the training we suggest that staff should be sent to AIT to acquire basic skills primarily within remote sensing and to a lesser extend within GIS. Once the basic skills are in place, new mapping methods can be implemented at the GIS and RS unit as on-the-job training and where procedures are documented. Finally, a MSc grant from Danida will allow one staff member to obtain a MSc in remote sensing and GIS at AIT.

In practical terms, we suggest the following solution:

- build basic remote sensing capacity through a tailored short term course at AIT (3 week course for 6 staff members)
- implement new remote sensing classification methods at the GIS and RS office with an on-the-job training period (through two steps, on-the-job training in Copenhagen at GRAS and secondly implementation of new procedures at FA in Phnom Penh done with assistance from GRAS).

The advantage of a short term course at AIT is that it allows six staff members to be upgraded within a short period of time, e.g. 3 months. The combination of first acquiring the basic skills and then implementing these skills rapidly after an on-the-job training is very attractive. In this way the unit can respond to needs of the FA for accurately map forest characteristics. Furthermore, the unit can equally assist the implementation of the NRMLP program in terms of conducting studies (e.g. on economic land concessions) and assist the demarcation process.

The desire for the GIS and RS office to upgrade its staff to the MSc level in remote sensing is absolutely valid and we share their view on this necessity. However, our recommendation is to seek alternative funding for this and as of February 2007 there is DANIDA funding for an MSc. There may be opportunities for additional MSc grants in the future. Since all staff members need to improve their English skills (except one per-

son), actions can already be taken now to prepare for obtaining funding for an additional MSc at AIT. Funding opportunities may include Danish grants under the present NRMLP program and FA may equally apply for AIT scholarships.

One problem exists relative to the upgrading of government staff to the MSc level, is that newly educated MSc candidates tend to move to other better paid jobs. However, the consequence of not upgrading the staff to the MSc level is that they will remain dependent of external assistance. The unit is very interested in reducing the dependence on external expertise. It may be envisaged that for a well functioning government office such as the GIS and RS unit, that they more or less on a permanent basis seek opportunities to upgrade staff to the MSc level. Furthermore, the office should try to negotiate with the candidate for a MSc grant a minimum period of work at the GIS and RS unit once the MSc has been completed. FA and DANIDA are prepared to make it a requirement that the candidate for the upcoming DANIDA funded MSc works for the FA for four years after the MSc is completed.

Another topic is the absence of programming capabilities. Two solutions could be envisaged: 1) more staff is needed in the GIS & RS unit and programming capabilities could be a part of the job description. 2) Support a MSc study in programming in Phnom Penh.

The lack of Internet access within the unit is a problem both in terms of communication and access to resources such as:

- Documents, standards, best practise, networks, discussion forum
- Free (or cheap) GIS scripts and tools
- Google Earth
- Free data e.g. Landsat images, Aster (cheap), DEM (SRTM), MODIS
- Communication, email

As of March 2007 an internet connection is available in the GIS and RS office.

## 6.1 Capacity building - actions taken

<b>Topic</b>	<b>Solution</b>	<b>Actions taken</b>
Upgrades of old computers and the computer network	Buy and install new equipment	4 high-end computers and one network server has been purchased and is now functioning at the GIS & RS office
Remote sensing software	Upgrade of ERDAS professional	ERDAS Imagine Professional has been upgraded (one license)
GIS software	Upgrade existing ESRI GIS software	Two ArcGIS licenses purchased
Differential GPS	Acquire a differential GPS	A Leica DGPS has been acquired and training been provided (expenses covered by a separate budget)
English courses	Staff should attend English lessons in PP	8 staff members will attend English lessons for four semesters (one year)
Remote sensing training	Dedicated short term training at AIT	Six staff members will go to AIT in Bangkok for training, see appendix 4
Implementation of new mapping methods	Plan Training course for FA staff in Copenhagen Plan an on-the-job implementation course at the GIS and RS office	Two FA staff will travel to Copenhagen for pilot study GRAS will assist with implementation of methodology See appendix 5
Consolidate remote sensing and GIS capacity	Provide GIS and RS office staff members with MSc	MSc grant already in place from DANIDA. FA needs to appoint candidates as soon as possible.
Internet access	Share existing Internet connection at the FA	Internet access established in the GIS unit
Programming capacity	New staff member at the GIS and RS office has this capacity	No action has been taken
Acquiring advanced remote sensing topics	Through MSc and possible PhD at AIT or equivalent	No action has been taken

Appendix 6 shows a summary of the total budget

## 7 RECOMMENDATIONS

- Build mapping capacity by sending six people to AIT for short term training in remote sensing. Follow up on this with an on-the-job mapping implementation course in Copenhagen and at the GIS and RS office.
- The GIS and remote sensing office should more or less permanently have someone doing a MSc at AIT or at an alternative training and education institution.
- The FA should negotiate access to existing JICA aerial photos
- Donors should request mapping studies and tasks from the FA GIS and RS unit.
- The GIS and RS unit should maintain close ties with the FAO forest mapping initiative LCCS and seek compliance with standards proposed.

## 8 REFERENCES

Danida/DIFD, 2006, Natural Resource Management and Livelihoods Programme, Cambodia (2006 – 2010) Programme Document, Danida: Ref. No. 104.Cambodia.1.MFS.20 April, 2006.

FAO, 200?, Using Geovis and LCCS Manual, GCP/RAF/287/ITA, Africover. Compiled by Craig von Hagen, Supervised by Antonio De Gregorio.

Forestry Administration, 2002, “Forestry Law” Forestry Administration, Ministry of Agriculture, Forestry and Fisheries

Leisz, S.J., Rasmussen, M.S. (submitted): Mapping fallow lands in Vietnam’s north central mountains: Combining multispectral classifications with a simple land cover model to create consistent, accurate and detailed land cover maps of previously unclassified areas. Submitted to the International Journal of Remote Sensing.

Tottrup, C., 2004. Improving tropical forest mapping using multi-date Landsat TM data and pre-classification image smoothing. Int. J of Remote Sensing. Vol. 25, No. 4, 717–730

## **9 NOTES**

### **Georeference**

Used map references: 1:50.000, Defence Mapping Agency Topographic Centre, USA, 1971, UTM zone 48, Horizontal datum: Indian 1960 (Indian-Thailand in Garmin GPS), Vertical datum: mean sea level at Hà Tiên, Vietnam, Spheroid Everest. 5 m contours.

10 APPENDIX 1: "DECLARATION ON TO PREPARE AND IMPLEMENT THE FOREST ADMINISTRATION" PRAKAS NR. 509, SEPTEMBER 17. 2003 – THE ORIGINAL KHMER TEXT



**ព្រះរាជាណាចក្រកម្ពុជា**  
**ជាតិ សាសនា ព្រះមហាក្សត្រ**

**ក្រសួងកសិកម្ម រុក្ខាប្រមាញ់ និង នេសាទ**

លេខ : ៥០៩ ប្រក.កសក.បុ

**ប្រកាស**  
**ស្តីពី**  
**ការរៀបចំ និងការប្រព្រឹត្តទៅរបស់រដ្ឋបាលព្រៃឈើ**

**រដ្ឋមន្ត្រីក្រសួងកសិកម្ម រុក្ខាប្រមាញ់ និង នេសាទ**

- បានឃើញរដ្ឋធម្មនុញ្ញនៃព្រះរាជាណាចក្រកម្ពុជា
- បានឃើញព្រះរាជក្រឹត្យលេខ នស/រកត ១១៩៨/៧២ ចុះថ្ងៃទី ៣០ ខែវិច្ឆិកា ឆ្នាំ ១៩៩៨ ស្តីពីការតែងតាំងរាជរដ្ឋាភិបាលនៃព្រះរាជាណាចក្រកម្ពុជា
- បានឃើញព្រះរាជក្រមលេខ ០២/នស/៩៤ ចុះថ្ងៃទី ២០ ខែកក្កដា ឆ្នាំ ១៩៩៤ ដែលប្រកាសឱ្យប្រើច្បាប់ស្តីពីការរៀបចំ និង ការប្រព្រឹត្តទៅនៃគណៈរដ្ឋមន្ត្រី
- បានឃើញព្រះរាជក្រមលេខ នស/រកម/០១៩៦/១៣ ចុះថ្ងៃទី ២៤ ខែមករា ឆ្នាំ ១៩៩៦ ដែលប្រកាសឱ្យប្រើច្បាប់ស្តីពីការបង្កើតក្រសួងកសិកម្ម រុក្ខាប្រមាញ់ និង នេសាទ
- បានឃើញព្រះរាជក្រមលេខ នស/រកម/០៨០២/០១៦ ចុះថ្ងៃទី៣១ ខែសីហា ឆ្នាំ ២០០២ ដែលប្រកាសឱ្យប្រើច្បាប់ស្តីពីព្រៃឈើ
- បានឃើញអនុក្រឹត្យលេខ ២០ អនក្រ.បក ចុះថ្ងៃទី ៣០ ខែមេសា ឆ្នាំ ១៩៩៦ ស្តីពីការរៀបចំ និង ការប្រព្រឹត្តទៅរបស់ក្រសួង និង រដ្ឋលេខាធិការដ្ឋាន
- បានឃើញអនុក្រឹត្យលេខ ១៧ អនក្រ.បក ចុះថ្ងៃទី ០៧ ខែ មេសា ឆ្នាំ ២០០០ ស្តីពីការរៀបចំ និង ការប្រព្រឹត្តទៅរបស់ក្រសួងកសិកម្ម រុក្ខាប្រមាញ់ និង នេសាទ
- បានឃើញអនុក្រឹត្យលេខ ៦៤ អនក្រ.បក ចុះថ្ងៃទី ១១ ខែ កញ្ញា ឆ្នាំ ២០០៣ ស្តីពីការប្តូរឈ្មោះនាយកដ្ឋានរុក្ខា-ប្រមាញ់ ទៅជា រដ្ឋបាលព្រៃឈើ
- យោងតាមការចាំបាច់របស់ក្រសួងកសិកម្ម រុក្ខាប្រមាញ់ និង នេសាទ

**ស ៩ ២ ៥**

**ប្រការ ១ :** រដ្ឋបាលព្រៃឈើគឺជាអាជ្ញាធររដ្ឋាភិបាល ដែលចំណុះក្រោមក្រសួងកសិកម្ម រុក្ខាប្រមាញ់ និង នេសាទ ក្នុងការគ្រប់គ្រងព្រៃឈើ និង ធនធានព្រៃឈើស្របតាមគោលនយោបាយវិស័យព្រៃឈើជាតិ និង ប្រកបស្តីពីព្រៃឈើ ។

អាសយដ្ឋានលេខ ២០០ មហាវិថីព្រះនរោត្តម សង្កាត់ទន្លេបាសាក់ ខណ្ឌការពារ រាជធានីភ្នំពេញ កម្ពុជា  
N° 200 Preah Norodom Sanyukt Tere Basak Khan Chankasmon B / D Phnom Penh, Cambodia

ទូរស័ព្ទលេខ : (០២៣) ២១១ ៣២១ / ២១១ ៣២២ ទូរសារលេខ : (៨៥៥) ២៣-២១៧ ៣២០  
Phone : (023) 211 351/211 352, Fax : (855) 23 - 217 320



G15 office

៥. ការិយាល័យគ្រប់គ្រងទីជម្រាល និង ដីព្រៃឈើ មានតួនាទី ភារកិច្ច :

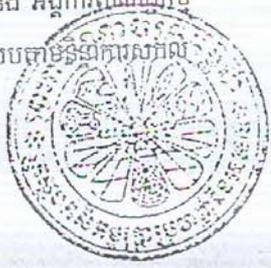
- សិក្សាស្រាវជ្រាវ កសាងគម្រោងលិខិតបទដ្ឋានដែលពាក់ព័ន្ធដីព្រៃឈើ
- រៀបចំ ចាត់ថ្នាក់ និង វាយតម្លៃតំបន់ទីជម្រាល កំណត់ព្រំប្រទល់ដែនដីព្រៃឈើ
- រៀបចំ និង ចាត់ថ្នាក់សម្បត្តិព្រៃឈើអចិន្ត្រៃយ៍ទៅតាមមុខងារ បរិស្ថាន សេដ្ឋកិច្ច សង្គម វប្បធម៌
- គ្រប់គ្រងព័ត៌មានភូមិសាស្ត្រ រៀបចំកសាងផែនទីប្រើប្រាស់ដីព្រៃឈើ និង ទីជម្រាល និង ផលិតផែនទី បម្រើឱ្យវិស័យព្រៃឈើ
- ស្រាវជ្រាវវិទ្យាសាស្ត្របច្ចេកទេសថតរូប គូស និង បោះពុម្ពផ្សាយផែនទីព្រៃឈើ
- គ្រប់គ្រង ត្រួតពិនិត្យការបោះពុម្ព និង ធ្វើសេវាកម្មផលិតផែនទីព្រៃឈើ
- ទទួលភារកិច្ចផ្សេងទៀត ដែលផ្ទុកដឹកនាំរដ្ឋបាលព្រៃឈើប្រគល់ឱ្យ។

៦. ការិយាល័យអភិវឌ្ឍន៍ឧស្សាហកម្ម និង ពាណិជ្ជកម្មព្រៃឈើ មានតួនាទី ភារកិច្ច :

- កសាងផែនការយុទ្ធសាស្ត្រ និង សកម្មភាពការងារសម្រាប់ការអភិវឌ្ឍន៍ឧស្សាហកម្ម សេដ្ឋកិច្ច និង ទីផ្សារព្រៃឈើ តាមរយៈការបង្កើនគុណភាពផលិតផលព្រៃឈើ និង ប្រើប្រាស់ផលព្រៃឈើ ឱ្យអស់លទ្ធភាពសម្រាប់បម្រើសេចក្តីត្រូវការក្នុងស្រុក និង នាំចេញទៅបរទេស
- សិក្សាស្រាវជ្រាវតម្លៃទីផ្សារ កសាងលិខិតបទដ្ឋានច្បាប់ បច្ចេកទេស លើកកម្ពស់សេដ្ឋកិច្ចធនធានមនុស្ស លើមុខជំនាញបច្ចេកវិទ្យាឈើ ការកែច្នៃផលព្រៃឈើ និង ទីផ្សារ
- សម្របសម្រួលបែបបទត្រួតពិនិត្យការនាំចេញ នាំចូលផល អនុផលព្រៃឈើ និង ផលិតផលព្រៃឈើកែច្នៃ និង កិច្ចសំណើបិទភ្លិតលើខុនផែនដីផ្ទុកផល អនុផលព្រៃឈើនាំចេញ
- សិក្សាស្រាវជ្រាវបច្ចេកវិទ្យាកែច្នៃផល អនុផលព្រៃឈើ និងប្រភេទឈើ ដែលមានសក្តានុពលសម្រាប់ការប្រើប្រាស់
- រៀបចំបែបបទបង្កើតមូលដ្ឋានឧស្សាហកម្មឈើ រោងចក្រអារឈើ និង សិប្បកម្មកែច្នៃផល អនុផលព្រៃឈើប្រភេទធំ និង មធ្យម
- សិក្សា និង លើកកម្ពស់លើកំណត់តួនាទីនាំចេញ នាំចូលផល អនុផលព្រៃឈើប្រចាំឆ្នាំ ចេញលិខិតអនុញ្ញាតដឹកជញ្ជូនផល អនុផលព្រៃឈើនាំចេញ នាំចូល
- ពង្រឹងពង្រីកកិច្ចសហប្រតិបត្តិការអន្តរជាតិ ជាពិសេស ការងារអាស៊ាន និង អង្គការពាណិជ្ជកម្មពិភពលោក ដើម្បីអភិវឌ្ឍន៍ឧស្សាហកម្ម និង ផលិតផលព្រៃឈើកម្ពុជា ស្របតាមទិសដៅការងារ
- ទទួលភារកិច្ចផ្សេងទៀត ដែលផ្ទុកដឹកនាំរដ្ឋបាលព្រៃឈើប្រគល់ឱ្យ។

៧. ការិយាល័យដាំឈើ មានតួនាទី ភារកិច្ច :

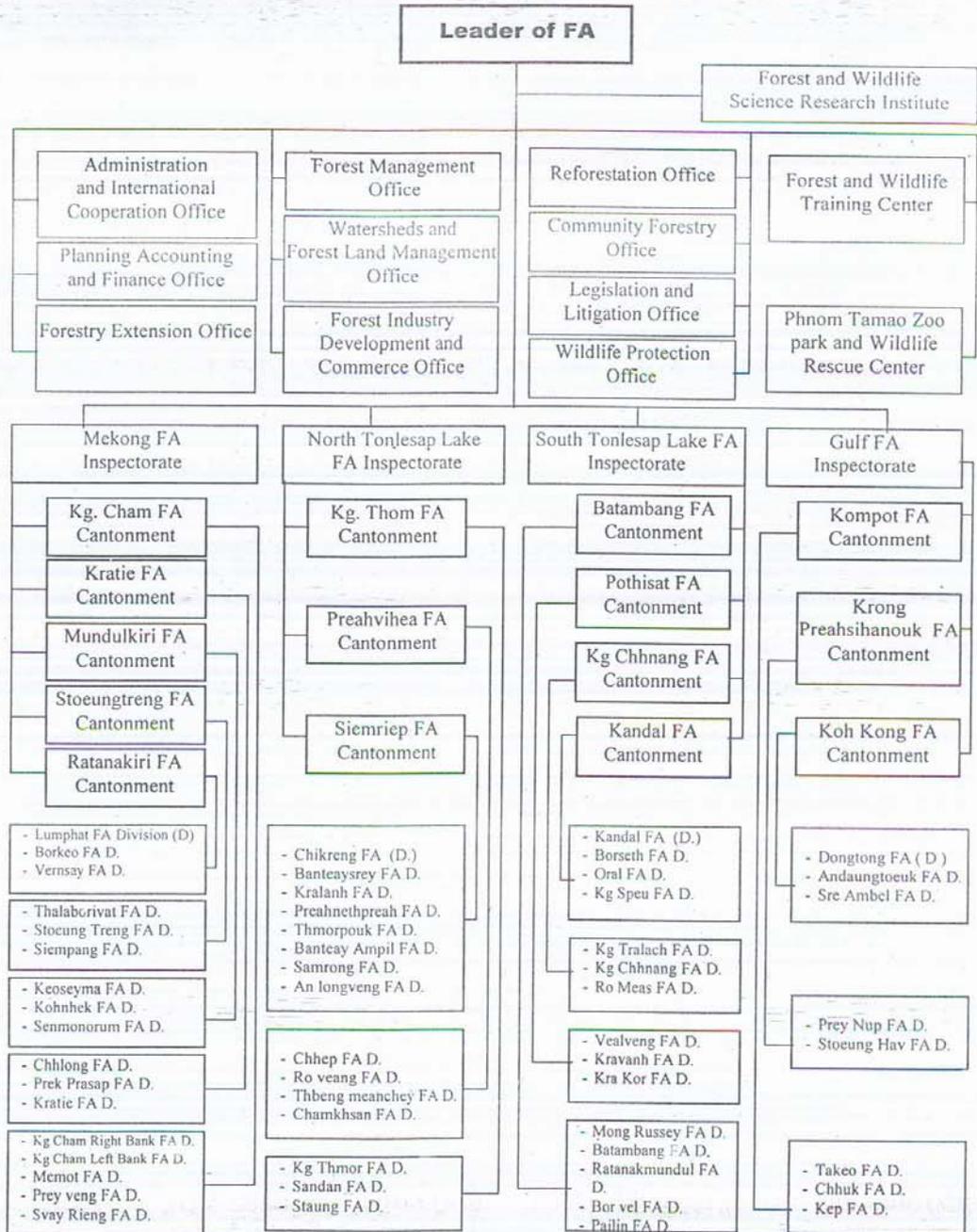
- រៀបចំផែនការពង្រីកផ្ទៃដីដាំដុះព្រៃឈើ
- ស្តារ និង បង្កើនធនធានព្រៃឈើតាមរយៈការដាំដុះព្រៃឈើ



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### 8.1 The Organization Chart of Forestry Administration



## **11 APPENDIX 2: BUILDING GIS CAPACITY AT THE PROVINCIAL LEVEL**

It is envisaged under the NRMLP that nine provincial centres under the FA should be capable of producing simple maps using GIS. Documenting the demarcation of forest boundaries is the main issue and maps with an accurate georeference are needed. The maps can be created using GPS coordinates collected in the field and/or drawing lines on existing maps or photos.

**It is suggested that the role of the GIS and RS office will be to:**

- conduct GIS training for the provincial staff
- establish mapping procedures (manuals)
- provide georeferenced aerial photos or Very High Resolution satellite images
- conduct quality control of maps produced by the provincial offices

**In order to compile maps in GIS with the boundary information, the following skills are needed at the provincial level:**

- Basic GIS skills, can operate a simple GIS
- Basic understanding of projection and datum, so the person can set the correct settings in the GIS and on the GPS
- Can create simple composite maps and analysis, e.g. overlay different GIS layers to create new maps
- Can use a georeferenced aerial photo or satellite image to map demarcations (possible assisted with GPS recordings)
- Create lay-out of maps, knows about mapping standards (north arrow, scale, annotations, projection/datum etc.)
- Can perform quality assessment of maps by checking accuracy and the level of completeness of paper maps (respecting mapping standards).
- Can work with a simple GPS

**The profile of the provincial staff candidate for GIS training will be:**

- Basic knowledge on how to operate a computer
- Work experience from working with digital data on a computer. Knows how to work with Excel or equivalent
- Natural science background

**Needs in terms of equipment:**

- Fairly new PC, not older than 3 years, running Windows XP. Must have a read and write CD/DVD (max USD 1,000 for one PC)
- GIS licence, e.g. ArcView (ca USD 1,850 for one licence)
- In-jet printer (A4 and A3) (max USD 250 for one printer)
- GPS (low cost with 10 m accuracy ca USD 400)
- Consumables paper, ink

## 12 **APPENDIX 3: OUTLINE OF A STUDY TO CONDUCT FOREST COVER ASSESSMENTS OF SELECTED ECONOMIC LAND CONCESSIONS IN CAMBODIA**

### **Summary**

*The Royal Government of Cambodia (RGC) is committed to the sustainable conservation and management of the country's forest resources. The Technical Working Group on Forestry and Environment (TWG F & E) has adopted a four-year Forestry and Environment Action Plan 2007-2010 that is aligned with the RGC's National Strategic Development Plan.*

*Economic Land Concessions have been granted by the RGC during the period 1992-2006. A Sub-Decree 146 was promulgated on 27 December 2005. More than one third of all approved ELCs have been cancelled. There is some evidence to suggest that ELCs are being used to continue illicit logging after forest concessions were banned following the promulgation of a new forestry law at the end of 2001. Remote sensing is an excellent method to monitor and study land use and land cover changes. The capacity currently being developed at the Forestry Administration GIS/RS Unit will enable the staff to undertake a forest cover assessment of selected Economic Land Concessions in 2007. The Royal Danish Embassy-Development Co-operation Section/Multi-Donor Livelihoods Facility, as part of its support to the TWG F & E Secretariat, will fund the study of forest cover changes in selected ELCs. Detailed Terms of Reference and a work plan will be prepared before 30 June 2007.*

### **12.1 Background**

Chapter 5, Article 25 of the Sub-Decree 146 on Economic Land Concessions (ELCs) mentions the administrative mechanism of documenting, providing comments, and decision making to grant ELCs whereby the competent authority who signs the contract has legitimate power in contract signing with concessionaires after receiving the delegated right from the Prime Minister (specified in Article 2). Competent Authorities who sign contracts are:

1. Minister, MAFF has the right and responsibility to grant economic land concession from at least 1,000 ha and less than 10,000 ha;
2. Provincial/municipal Governors have the right and responsibility to grant up to 1,000 ha. The process of document preparation, examination and giving comments on economic land concession would involve Technical Secretariat, Committee for State Land Management at the provincial/municipal level, State Land Working Group at district/ khan and commune/sangkat council.

During the period 1992 to 2006, the Royal Government of Cambodia (RGC) granted 97 locations of land concessions to 96 companies in 16 provinces/municipalities (Table 1).

*Table 1: Economic Land Concessions granted 1995-2006*

Period	1995-1998	1999-2004	2005	2006
No. of ELCs approved	4	18	9	26

Several ELCs were inactive and did not appropriately comply with their contractual obligations and hence, MAFF proposed to RGC to cancel a number of companies as follows:

- In 2000, a total area of 123,680 hectares was removed from 16 land concession companies.
- During the period 2004-2006, a total area of 141,559 hectares was removed from 14 land concession companies.

Amongst the above 30 companies, 5 were located in Kampong Speu, 1 in Pursat, 1 in Battambang, 3 in Kampong Thom, 4 in Kampong Cham, 5 in Kampot, 1 in Ratanakiri, 2 in Mondolkiri, 6 in Koh Kong, and 02 in Takeo. Amongst the 96 companies permitted by RGC, 9 received agreements in principle, but had not signed their contracts with MAFF by 31 December 2006. Therefore, the valid remaining 57 companies are in 58 locations of 15 provinces/municipalities, i.e. 10 in Stoeng Treng, 9 in Kampong Speu, 2 in Pursat/Kampong Chhnang, 5 in Kampong Thom, 5 in Kampong Cham, 3 in Kampot, 5 in Ratanakiri, 2 in Mondolkiri, 7 in Kratie, 3 in Siem Reap, 2 in Oddar Meanchey, 2 in Koh Kong, and 2 in Sihanoukville.<sup>1</sup> In particular, if considering only the period from 2000-2006, the Royal Government of Cambodia granted concession land to 50 companies. However, as one company in Kampong Thom was inactive (CAM CHI International, Agriculture Development, contract signed in March, 2000) MAFF requested the Royal Government to cancel it in April 2006.

## **12.2 Forest Cover Assessments of selected Economic Land Concessions in Cambodia**

Remote sensing is an excellent method to monitor and study the changes of forest and land. Ideally the JICA aerial photos from 2000 / 2002 can be used as the reference and new satellite data will be acquired to assess the present day situation. If the JICA photos cannot be made available, archive satellite data can also be used. The following remote sensing data can be used for the study:

- QuickBird, 0.6 m

<sup>1</sup> The objectives and concrete activities of the above companies are specified in details in the Report on Land Concession disseminated on MAFF's website available at <http://www.maff.gov.kh/elc/index.html>

- Ikonos, 1 m
- Formosat, 2 m
- SPOT 5 m or better
- IRS 5 m or better
- SPOT 10 m (may not be suitable, depending on the scale)
- Aster 15 m (may not be suitable, depending on the scale)
- Existing Landsat 15 m panchromatic / 30 m multispectral may be used for initial screening to locate areas of particular interest to study in more detail using higher resolution data

The simplest approach is to do visual interpretation of geo-referenced images. However, in the case that more detailed studies are needed on progressive changes of forest classes and specifically the degraded and marginal classes such as scrub and degraded forest, digital classification of multi-spectral satellite images are needed. Furthermore, advanced change detection methods can be employed.

The GIS and RS office will be able to study the changes within the economic land concession areas. Depending on the type of changes that will be encountered, some external assistance may be anticipated for a pilot study.

### **12.3 *An example of a study of changes within an area with economic land concessions***

- Programming of new QuickBird or Ikonos VHR data (100 km<sup>2</sup> of QuickBird data ca USD 2,200; ca USD 22 per km<sup>2</sup> for new programmed data)
- Larger areas can be covered by using SPOT 5 m data (60 x 60 km costs 6,200 Euro), or SPOT 10 m data (60 x 60 km costs 3,500 Euro) or Aster 15 m data (80 x 80 km ca USD 80).
- Archive data from either:
  - JICA aerial photos 2000 – 2002 from the Ministry of Lands
  - QuickBird or Ikonos VHR data from ca 2000 -2002 (100 km<sup>2</sup> of QuickBird data ca USD 1,800; ca USD 18 per km<sup>2</sup> of archive data)
  - Larger areas can be covered by using SPOT 5 m data (60 x 60 km costs 5,400 Euro), or SPOT 10 m data (60 x 60 km costs 2,700 Euro) or Aster 15 m data (80 x 80 km ca USD 80)

- Use VHR data as geo-reference (exact geo-location is not needed, nominal horizontal accuracy of QuickBird data are +/- 25 m). If accurate location is needed, accurate differential GPC reference points have to be collected in the field (including height).
- Conduct visual interpretation and change detection
- Alternatively classify detailed forest classes using digital classification and change detection. Technical back-up from external remote sensing experts can be made through Internet if needed.

## 12.4 An overview of Economic Land Concessions in Kratie Province

In Kratie Province seven (7) companies have been granted Economic Land Concessions with a total area of an estimated 64.373 hectares, viz.,

- Global Agricultural Development (Cambodia) Co. Ltd (9.800 hectares in Sambor District; contract signed on 15 March 2006 to develop teak (*Tectona grandis*) plantations. MAFF permitted the company to level the land for boundary identification on 11 May 2006 (letter No. 2393/201). MAFF approved the company Master Plan on 28 November 2006 (Letter No. 6258).
- Asia World Agricultural Development (Cambodia) Co. Ltd (10.000 hectares in Sambor District; contract signed on 15 March 2006 to develop teak (*Tectona grandis*) plantations. MAFF permitted the company to level the land for boundary identification on 11 May 2006 (letter No. 2394/202). MAFF approved the company Master Plan on 28 November 2006 (Letter No. 6257).
- Green Island Agricultural (Cambodia) Co. Ltd (9.583 hectares in Sambor District; contract signed on 15 March 2006 to develop teak (*Tectona grandis*) plantations. MAFF permitted the company to level the land for boundary identification on 11 May 2006 (letter No. 2394/202). MAFF approved the company Master Plan on 28 November 2006 (Letter No. 6257).
- Plantation Agricultural Development (Cambodia) Limited (9.214 hectares in Sambor District; contract signed on 11 August 2006 to develop Fang Lean Tree (?) plantations. MAFF permitted the company to level the boundary surrounding the concession, build roads and construct a company site on 02 October 2006 (letter No. 5281/412).
- Great Asset Agricultural Development (Cambodia) Limited (8.985 hectares in Sambor District; contract signed on 11 August 2006 to develop Fang Lean Tree (?) plantations. MAFF permitted the company to level the boundary surrounding the concession, build roads and construct a company site on 02 October 2006 (letter No. 5279/412).

- Great Wonder Agricultural Development (Cambodia) Limited (9.231 hectares in Sambor District; contract signed on 11 August 2006 to develop Fang Lean Tree (?) plantations. MAFF permitted the company to level the boundary surrounding the concession, build roads and construct a company site on 02 October 2006 (letter No. 5280/413).
- Tai Nam (K) Ltd (7.560 hectares in Snuol District; contract signed on 18 September 2006 to develop cassava, rubber and cashew plantations. The Technical Secretariat of Economic Land Concessions within MAFF completed the demarcation and collection of statistical data of areas of dispute in November 2006.

The status of an additional eight (8) ELCs of up to 10,000 ha and twenty-two (22) ELCs of less than 1.000 ha in Kratie remains unclear.<sup>2</sup>

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<sup>2</sup> Overview of Economic Land Concessions, Provincial Governor's Office, Municipality of Kratie (No date).



## 13 **APPENDIX 4: AIT TRAINING IN BASIC REMOTE SENSING**

### **Remote sensing training at AIT for FA staff**

The following topics will be included in the training, subject to final acceptance by the AIT staff.

#### ***Fundamentals (1 day)***

Electromagnetic radiation, the basic fundamentals of remote sensing. Focus on the spectral resolution and the spectral characteristics. The student should be aware of the richness of information in spectral data and the importance of the near infrared for discriminating classes.

#### ***Data (1 day)***

Using different remote sensing data. Understanding differences and advantages and disadvantages of different RS data: SPOT, Landsat, IRS, Ikonos, QuickBird and Formosat.

#### ***The Georeference (1 day)***

Understanding the georeference, the significance of projection and datum

Polynomial rectification – the students should learn the difference relative to ortho rectification and be able to do polynomial rectification. Accuracy assessment of rectified data.

#### ***Mapping (7 days)***

Supervised and non supervised classifications

Visual interpretation, working with more than 3 bands

How to deal with shadows (in mountains)

How to develop consistent classifications across different satellite images (e.g. between two Landsat images)

Create and use NDVI maps

Accuracy assessment

#### ***Change detection (2 days)***

Different methods and principles. What to watch out for (e.g. anniversary dates, vegetation phenology etc.)

#### ***GIS (3 days)***

Working with georeferences in ArcGIS. How to reproject and how to apply information about projection and datum to a GIS file that does not have these attributes, but is pro-

jected (e.g. to imported data). The problem working with the Indian 1960 datum should be addressed, how to transfer this to WGS 84.

Editing vector files in ArcGIS – learn good procedures and tools and maintain topology and high data integrity. This should help the FA people when doing visual interpretation and updating of maps.

Organizing data. Using metadata.

### **Budget for the training course at AIT:**

<b>Short 3 weeks GIS</b>	<b>Unit</b>	<b>Price</b>	<b>Number</b>	<b>Total</b>	
Coursework	credit	17000	1	17000	USD
Health insurance	months	100	6	600	USD
Accommodation	days	10	126	1260	USD
Per diem	days	30	126	3780	USD
Visa	year	25	6	150	USD
Airfares		250	6	1500	USD
<b>Total</b>				<b>24290</b>	<b>USD</b>

## 14 **APPENDIX 5: IMPLEMENTING NEW METHODS FOR FOREST LAND COVER MAPPING – ON-THE-JOB TRAINING BY GRAS**

### **Step 1: on-the-job training for two FA staff members at GRAS in Copenhagen**

Two FA staff members will travel to Copenhagen and spend 10 working days on a pilot study implementing supervised classification methods for forest classification. The FA staff will have access to the library (electronic version as well) and be encouraged to read selected papers and discuss these. Remote sensing classifications examples will be demonstrated and the staff members will be exposed to university staff as well as GRAS staff. GRAS will be available for 5 man days for methodology discussions, support and technical assistance.

The pilot study will be implemented using Landsat data from Cambodia. This will enable the FA staff to test the suitability of the methodology and compare with the manual digitisation currently performed by the FA.

The training will take place in August or September 2007.

#### **Budget:**

Item		Days	Rate	Total	
Per diem		30	40	1200	€
Airfare		2	1600	3200	€
Local transport		30	5	150	€
Hotel		14	100	1400	€
GRAS input		5	750	3750	
<b>Total</b>				<b>9700</b>	€
				12,904	USD

### **Step 2: implementation course conducted by GRAS at FA in Phnom Penh**

In order to follow up in the on-the-job training in Copenhagen, GRAS will travel to Phnom Penh to assist with the implementation of the supervised methodologies in the context of mapping the entire territory of Cambodia. The output will be manual describing the necessary steps for making countrywide updates of the forest cover maps.

#### **Budget:**

Item		Days	Rate	Total	
Staff input and travel time (MKS)		7	750	5250	€
Airfare and local travel				1600	€
Per diem		7	40	280	€
Hotel		7	50	350	€
<b>Total</b>				<b>7480</b>	€
				9,951	USD

## 15 APPENDIX 6: TOTAL BUDGET

<b>Software</b>		<b>Item</b>	<b>Price</b>	<b>No</b>	<b>Total</b>	
ArcView 9	Aruna	licence	2,158	2	4,315	USD
Erdas Professional upgrade	Informi GIS	licence	4,050	1	4,050	USD
<i>Total Software</i>					<i>8,365</i>	<i>USD</i>
<b>Hardware</b>						
High-end brand PC, IT Star, Dell Precision w 21 screen	IT Star	units	1,493	4	5,970	USD
Server, 2 TB, IT Star	IT Star	units	2,770	1	2,770	USD
Back-up facilities for server (external 200 GB HD plus DVD)					300	USD
Internet connection (cables and installation)					0	USD
Scanner A3					1,000	USD
<b>Data - field work</b>						
QuickBird		25km2	500	4	2,800	
<i>Total Hardware</i>					<i>12,840</i>	<i>USD</i>
<b><u>TOTAL</u></b>					<b><u>21,205</u></b>	<b><u>USD</u></b>
Budget, equipment					33,569	USD
Balance, equipment					12,364	USD
<b>Training</b>			<b>Item</b>	<b>Price</b>	<b>No.</b>	<b>Total</b>
AIT 3 week customized RS & GIS short course				24290	1	24,290 USD
Training at GRAS				12,904	1	12,904 USD
GRAS RS implementation course				9,951	1	9,951 USD
English (12 months)				720	8.25	5,940 USD
<b><u>TOTAL</u></b>					<b><u>53,086</u></b>	<b><u>USD</u></b>
Budget, training					41,962	USD
Balance, training					-11,124	USD
<b>Overall balance</b>					<b>1,240</b>	<b>USD</b>

GRAS will be administrating all funds and once the final expenses have been paid, a final account will be send to FA and Danida. GRAS will try to respect the different budget lines, however, if amounts changes, cuts in remaining budget lines must be an-

ticipated. There will be no spending beyond the overall budget. Some minor expenses must be expected to cover bank transfer etc. Possible unspent funds will be returned.

Note: it was agreed with DANIDA to transfer funds from the equipment budget to the training budget.