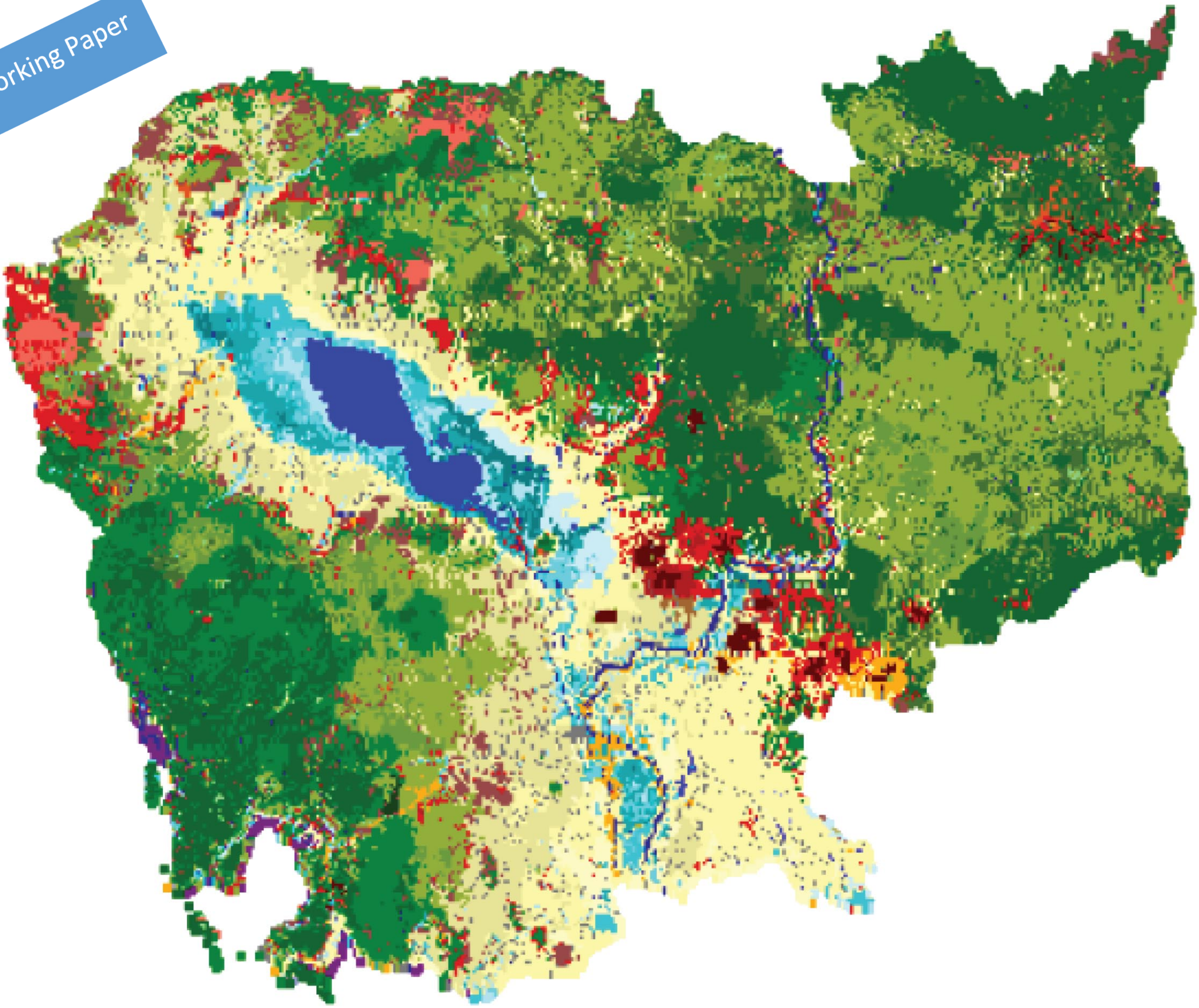
Working Paper



Recommendations on the land and forest classification system of Cambodia

Training working workshop on land cover classification in the context of REDD+ in Cambodia

Cambodia, 2013

REDD+ CAMBODIA

Disclaimer

This report prepared by Antonio di Gregorio, and does not necessarily represent the views of the Cambodia REDD+ Taskforce, the Forestry Administration, the General Department of Administration of Nature Conservation and Protection, the Fisheries Administration, and FCPF Project.

UN-REDD PROGRAMME

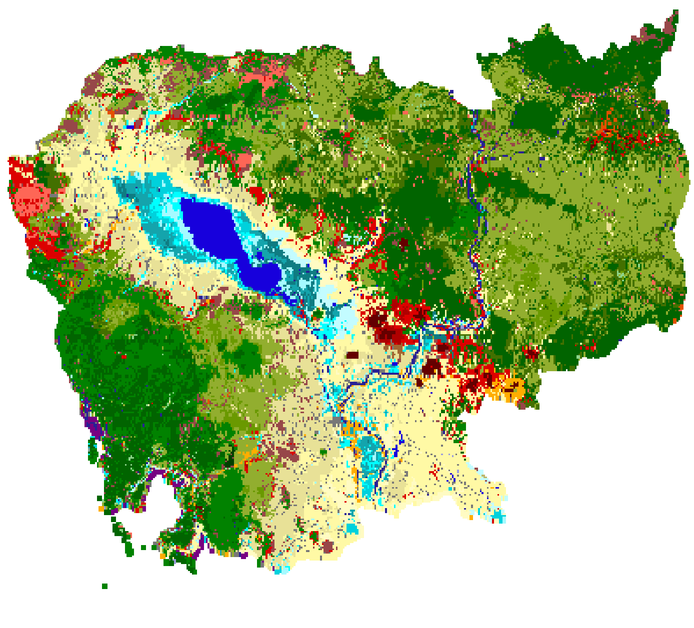
REDD+ CAMBODIA

Recommendations on the land and forest classification system of Cambodia, Training workshop on Land cover classification in the context of REDD+ in Cambodia

Antonio di Gregorio

March 2013

Phnom Penh, Cambodia



The UN-REDD Programme, implemented by FAO, UNDP and UNEP, has two components: (i) assisting developing countries prepare and implement national REDD strategies and mechanisms; (ii) supporting the development of normative solutions and standardized approaches based on sound science for a REDD instrument linked with the UNFCCC. The programme helps empower countries to manage their REDD processes and will facilitate access to financial and technical assistance tailored to the specific needs of the countries.
The application of UNDP, UNEP and FAO rights-based and participatory approaches will also help ensure the rights of indigenous and forest-dwelling people are protected and the active involvement of local communities and relevant stakeholders and institutions in the design and implementation of REDD plans.
The programme is implemented through the UN Joint Programmes modalities, enabling rapid initiation of programme implementation and channeling of funds for REDD efforts, building on the in-country presence of UN agencies as a crucial support structure for countries. The UN-REDD Programme encourage coordinated and collaborative UN support to countries, thus maximizing efficiencies and effectiveness of the organizations' collective input, consistent with the "One UN" approach advocated by UN members.

Contacts:

Khun Vathana
National REDD+ taskforce
Cambodia
Email: vathana.khun@gmail.com

Matieu Henry
UN-REDD Programme
Food & Agriculture Organization of the United Nations (FAO)
Email: matieu.henry@fao.org

Mathieu Van Rijn
UN-REDD Programme
Cambodia
Email: mathieu.vanrijn@fao.org

Recommended citation: Di Greogorio (2013) Recommendations on the land and forest classification system of Cambodia, Training workshop on Land cover classification in the context of REDD+ in Cambodia, UN-REDD Programme, Food and Agriculture Organization of the United Nations, Phnom Penn, Cambodia.

Contents

1. Introduction

Land cover (LC) is one of the most easily detectable indicators of human intervention on the land. Information on LC and/or Natural Resources and Forestry is, therefore critical in any geographical database. In modern maps, LC has become a sort of 'boundary object' between different disciplines. At a certain level, land cover provides the common ground for many actors and a discipline interested in land mapping and, thus, provides the platform to link different information between them. This, on one hand, enhances the intrinsic value of this information, but on the other hand, by enlarging the base of potential users, poses new challenges for its harmonization and correct use.
Despite the great need of data interoperability there is a huge problem of compatibility and comparability between land cover (LC)/Natural Resources and Forest products. Harmonization should be the process whereby differences among existing definitions of land characterization are identified, clarified and inconsistencies reduced. However, generally, current maps both at sub-national, national as well at regional level exist mostly as independent and incompatible data sets. This is mainly due to the poor compatibility of their classifications or legends, which are often an arcane 'black box' to anyone outside the immediate group involved in their preparation.

In order to integrate data from multiple sources there is a strong requirement for semantic interoperability. Semantic interoperability is one of the major unsolved problems in the modern use of LC data. Uncertainty is an inescapable element in all types of geographical information because truth as a distinct and indubitable fact cannot exist in a derived representation. Information is always relative to context. However in some disciplines (like LC) the level of semantic vagueness and relative misuse of the data is far too high and there is risk entailed in its practical use in many applications. Diffuse use of Geographical Information Systems (GIS) and spatial analysis has further exacerbated this problem, creating a vicious circle of vagueness and ambiguity in the LC semantic that constantly propagates and is strengthened through the interoperability issues encountered in using different data sets.

Any land surface is heterogeneous and the mapping standards to acquire, represent and generalize land characteristics are as diverse as the land surface itself. In addition, there has been an explosion of LC/Forest data sets in the world, coupled with the growing use of new technologies and the fast moving changes in how information can converge across previously disparate families of disciplines. Hence fostering discussions and reviews toward development of national and internationally agreed standards to characterize and classify LC/Forest classes is a crucial task to minimize current inadequacies and to respond to the requests and needs of the international community.

In the context of the fight against deforestation and forest degradation, and reducing emissions of greenhouse gases emissions from the forestry sector, the assessment of land use systems is particularly important. All emission reductions under the REDD+ mechanism under the auspices of the UNFCCC must be measured, reported and verified (MRV) (UNFCCC, 2007). Assessment of emission reductions from the forestry sector must be made from a combination of field measurements and the use of remote sensing techniques (decision 4/CP.15 (UNFCCC,2009)). The MRV system for REDD+ proposed by UN-REDD is proposed to be based on the following three pillars: Satellite Land Monitoring System, National Forest Inventory, and the Greenhouse Gas Inventory (GHG-I) (UN-REDD programme,2012). The calculation of emission reductions must be made in accordance with the guidelines of the IPCC. At current status, non-Annex I country Parties are requested to use the revised 1996 IPCC guidelines (IPCC,1996) and encouraged to use the 2003 GPG (IPCC,2003). According to decision 5/CP.17 Annex I country Parties will be requested to use the IPCC 2006 guidelines (IPCC,2006). We may expect that non-Annex I country Parties will have to use 2006 IPCC guidelines. Chapter 4 of the IPCC guidelines 2006 provides guidance to countries on how to develop their land representation system for AFOLU sector. In the context of assessing the annual GHG balance the land representation is based on four elements: (1) quantifying the extent of lands: the total area containing your sinks and pools including its geographical position, boundaries and geographical co-ordinates; and the area of each subdivision, (2) identifying land categories: different vegetation types have a different capacity to uptake and store CO_2 from the atmosphere. (3) Stratifying lands in subsets (i.e. classes/categories/subdivisions): grouping altogether areas with similar characteristics in terms of expected GHG balance. (4) Tracking of lands: since changes in land use and/or management practices determine emissions and removals, and those emissions and removals are generated for long periods, tracking of lands may increase accuracy of estimates. Furthermore, the land cover classification system and land representation system decided by a country will have an impact on all steps related to the preparation of the GHG inventory for the AFOLU sector and the way natural resources are monitored and their status evaluated.

Stephane Brun (2013) made an inventory of national and sub-national land cover products in Cambodia. The document reveals problems in term of suitability, consistency, completeness and comparability of land cover assessment. In term of suitability, the classes are not always appropriately described or are prone to different interpretation. Land cover assessment is not consistent in time because of modification of the definitions and classification system. The land cover maps are not complete in the sense that some significant land cover types or separation in undisturbed and disturbed forest for the GHG inventory are not considered. Expert judgment is necessary during the preparation of the GHG inventory because the current classification system does not obviously match with the proposed land representation system as stipulated in IPCC guidelines.

2. General considerations

Is quite easy to produce land cover/vegetation maps with a rather low amount of efforts. However, it is challenging to derive ‘efficient’ maps that are interoperable and satisfy the requirements of the end user community. Technology driven mapping often reflects technological capabilities rather than the needs of users. Many national and regional land mapping products are tailored to serve a variety of potential applications. Their development is driven by different national or international initiatives; the subsequent mapping standards adopted reflect the varied interests, requirements and methodologies of the originating programs. Often they lack flexibility and interoperability. Continuity and consistency in observation for both fine and coarse resolution satellite data and in situ information is one essential issue that is to be addressed by the satellite and ground data providers. Land cover and more general Natural Resources information, as key land feature, has to be ‘compatible and comparable’ for multi-temporal analysis and map updates, within and between countries, within and between applications, disciplines and agencies and among local to global scales (vertical and horizontal harmonization). This requires a common ground, a ‘common language’ to communicate land information among the different domains. Each land mapping product should be accompanied by a ‘solid estimation of accuracy ’that can be achieved only when the thematic content of a map is comprehensible and unambiguous. The adequacy of mapping products for applications implies 'open access and exchange' of data sets and information and that the user community is informed about their availability and ways of dissemination. Basically, a modern operational land observation system requires an integrated use of observations, their transformation into useful and flexible products, their assimilation into models, effective model design and their use in assessments, policy and decision-support systems.

Harmonization of databases essentially deals with the organization and representation of the thematic content of a map. Ideally, harmonization should be guided by existing or evolving standards, in the present case a national mapping project should refer to a recognized classification system to build up its national or sub-national legend. Basically, this is same approach adopted by soil science since the 1960s, where the FAO classification system was used as the standard classification system and common language to harmonize existing national and regional soil maps and their legends (FAO/ISRIC/ISSS,1998). In an abstract, ideal sense a classification system should exhibit the following properties:

- Use of consistent, unique and systematically applied classificatory principles;
- Comprehensive, scientifically sound and practically oriented;
- Capable of meeting the needs of a variety of users (neither single-project oriented nor taking a sectoral approach); users can use just sub-sets of the classification and develop them to their own specific needs;
- A *flexible* system that can be used at different scales and at different levels of detail, allowing cross-reference of local and regional maps with continental and global maps without loss of information;
- Adapted to fully describe the whole gamut of features types.

The classes derived from it are all unique, mutually exclusive and unambiguous. Able to describe the complete range of land cover features (e.g. forest and cultivated areas as well as ice and bare land, etc.), with clear class boundary definitions that are unambiguous and unique. In addition they should include some key characteristics to support evolving standards and science:

- Be potentially applicable as a common reference system or be able to converse with other systems.

3. Use of LCCS in national LC/Forest mapping

Land mapping activities can be understood as process of information extraction governed by a process of generalization. This implicitly points to the loss of detail in the interpretation process to map specific land features. The degree of generalization and thus the efficiency of representing realty in 2-dimensional form are directly linked to three major factors:

- The 'thematic' component refers to the land classification system and the adopted land cover legend.

- ‘Cartographic’ standards include the spatial reference system, and the minimum mapping unit (MMU) and the mapping scale.
- The ‘interpretation’ process is reflected in the characteristics of the source data, the timing, interpretation procedures, skills of the interpreter etc. These factors affect the mapping products, its content, quality, flexibility and efficiency for applications.

3.1 Thematic map content

The way how the thematic content of a map is build up, its meaning is formalized and saved in a data base is most probably one of the main important aspects the remote sensing community has to solve. Mapping is by its nature a local activity, so at one level it can be understood why there is a tendency to establish unique legends to fit local conditions; however, these incompatibilities make it difficult to aggregate broader sub-national, national and regional data sets. In order to be able to integrate data from multiple sources there is a strong requirement for semantic interoperability.

Categorization has always been a useful method to minimize the complexity of the real world. However, use of a single ontology system (a class name with class description) with a predefined list of categories implies important constraints that increase the fuzziness of the data and create huge interoperability problems:

- Class definitions are often imprecise, ambiguous or absent;
- The buildup of the definition in the form of a narrative text is unsystematic (many diagnostic criteria forming the system are not always applied in a consistent way) and in any case do not always reflect the full extent of the information;
- Generalization into categories where meaning is very often limited to the class name, or has only an unclear class description, implies rigidity in the transfer of information from the data producer to the end user community. End users have limited if any possibility to interact with the data, and must therefore accept them ‘as is’;
- The representation of the granularity of the aspects summarizing a specific feature of the real world is drastically reduced or lost;
- Often (in the worst cases) some vagueness in the class definition is artificially included by the map producer to hide some ‘technical anomalies’ when reproducing a certain feature on the map;
- Moreover, vagueness or extreme complexity in the class definition makes it difficult to correctly assess the accuracy of the data set;
- Structure of a data with just a name and a corresponding separate text description make it very difficult to manage the data set with modern GIS techniques.

3.2 Evolution of LCCS

To contribute to solve this situation since 1996 FAO started to develop a new way to approach the problem. A new set of classification concepts were elaborated and were discussed and endorsed at the international Africover Working Group on Classification and legend (Senegal July 1996; Di Gregorio and Jansen 1996; FAO 1997). The system was developed in collaboration with other international ongoing initiatives on classification of land cover such as the U.S. Federal Geographic Data Committee (FGCD) – Vegetation Subcommittee and Earth Cover Working Group (ECWG); the South African National Land

Cover Database Project (Thompson 1996); and the international Geosphere-Biosphere Programme (IGBP) - Data and information System (DIS) Land Cover Working Group and Land Use Land Cover Change (LUCC) Core Project. After a test period in the FAO Africover project in 1997-1999; the first official release of LCCS (v.1) was published in the year 2000. A second version was developed through an international feedback approach involving a large global community in 2005 (LCCS v.2 (Di Gregorio and Jansen,2005)). A new version will be released in the year 2013.

LCCS follows the idea that it is deemed more important to standardize the attribute terminology rather that the final categories. LCCS works creating a set of standard diagnostic attributes (called classifiers) to create/describe different land cover classes. The classifiers act as standardized building blocks and can be combined to describe the more complex semantics of each land cover class in any separate application ontology (classification system) (Ahlqvist,2008). The creation or the increase of detail in the conceptualization/description of a land cover feature is not any more linked to an unsystematic text description but to the choice of well-defined diagnostic attributes. Hence the emphasis is no longer on the class name but on the set of well quantifiable attributes. This follows the idea of a hybrid ontology approach with standardized descriptors allowing for heterogeneous user conceptualization (Ahlqvist,2008). The LCCS approach in this way is different from most of the other examples of standardized land cover systems (e.g. Anderson CORINE etc.) that follow a single ontology approach where all semantic descriptions available have been created with a very similar view on a domain and have to be shared by all users (Lutz and Klien,2006).

3.3 Practical use of the system

During the practical use of the system through the years the authors have noticed an unexpected trend in the utilization of the system by the international user community; in addition to the creation of specific legends for specific applications, the system was also used as reference bridging system to compare classes belonging to other existing classifications. This possible use of LCCS as “boundary object” that supports representation negotiation and analysis of dynamic and heterogeneous classification system (Ahlqvist,2008) was for certain aspects under-estimated. The use of LCCS in LC/Forest mapping has several positive impacts on the preparation of modern data bases. The major effects can be summarized as following:

- Clear and systematic description of the LC/Forest classes. In LCCS the class description avoids unclear text description that can generate confusion and ambiguities especially for users that are not necessarily familiar with the remote sensing derived geographic information. In LCCS each class is clearly defined by a sequence of well distinct class elements (in the old LCCS version called “classifiers”) therefore is very easy and straightforward to understand it’s semantic. This will greatly contribute to avoid misuse of data by users that are not familiar with remote sensing products. The transparent meaning of the LCCS classes contributes to a clear understanding of the potential and limits of each class and the data base in general in respect to several different applications;

- LCCS supports a concrete standardization of different LC/Forest data bases. The possibility to certainly and undoubtedly inter-compare the thematic content of different data bases from different geographic areas and/or different scales is an evident progression and expansion of the potential of remote sensing products;

- It rationalizes and links field and remote sensing derived data. The LCCS classes are defined by a combination of unambiguous simple elements easily identifiable in the field. Field surveyors must detect just the single elements (and their characteristics) forming the class and can avoid to deal with the class name (often ambiguous or confusing). This will help to link field observations (typical of national traditional statistics) and data derived from remote sensing;

- The use of LCCS sustains a high flexibility of the thematic content of a data base. In LCCS a thematic class is not a black box but an open unit composed by different elements. The user will have new possibilities to interact with the data base, not only at the level of the class on its whole but also at level of aggregation of single class elements. This advanced flexibility is a great opportunity for advance GIS applications;

- It allows the building up of new procedures of data accuracy assessment. A correct assessment of map inaccuracy is an essential aspect in the operational use of LC/Forest data bases. The use of LCCS methodology to express the thematic content of a map has a substantial impact on how we are able to assess the map accuracy;

- The systematic and unambiguous description of each LC class (above mentioned) rationalizes the error analysis avoiding erroneous interpretation of the semantic class meaning and avoiding the use of vagueness and ambiguity that map producer can introduce to the legend to mask poor results. If for instance the map producer is not able to correctly identify and map two different features (trees and shrub savannah from grassland) it was a common practice to introduce a class (for instance rangeland) so vague and/or with a very general meaning that can include the features difficult to identify. The resulting effect is that the class (rangeland in our example) shows a very high accuracy just because it’s extreme vagueness. LCCS avoid these situations because oblige the map producer to clearly specify the semantic content of each class;

- The easy verification of the LCCS derived class in the field avoids misjudgment and subjectivity in the field work. This aspect contributes to a more correct collection of ground truth data, thus to a more efficient assessment of the accuracy of the map;

- In LCCS the semantic meaning of a class is the resultant of the sequence of the elements used to form the class itself. This modular approach to create a thematic class supports an easier understanding of the types of errors and their relation in the confusion matrix and a more efficient and flexible use of it. This will results in a more effective management of the omissions/commissions table (confusion matrix) and eventually in a more rational simplification/aggregation of the original LC classes to achieve a desired final acceptable accuracy of a map;

Figure 1 gives an example of the improved flexibility on the manipulation and utilization of the accuracy results for a given LCCS class.

Name	code	GIS code	LCCS elements	% accuracy by element
Enset (false banana)	1En	1 1217-12626-S13Zs1	A2 Shrub Crops B2 Small Sized Field(s) C2 Intercropped (Second Crop) D1 Rainfed Cultivation D9 Permanently Cropped Area C3 One Additional Crop C7 Herbaceous Terrestrial Crop (Additional Crop) C17 With Simultaneous Period (Second Crop) ZS1 User defined code:Enset	90 90 90 90 90 90 90 90 60

Figure 1: LCCS class structure

The figure presents how an LCCS class is structured, in the first four columns there is the class name, the map code, the LCCS GIS code and the list of all the elements used to build up the class itself. If the accuracy is calculated in the traditional way by the entire class the resulting accuracy in the example will be very low (60%), however if the accuracy is calculated separately for each of the elements forming the class, a new flexibility on the use of data materializes. The user can, for instance, utilize the class information (organized in LCCS elements) with a high accuracy and remove the ones with a lower one. This option gives a more flexibility on the use of final data.

4. Building up of a national reference legend for LC/Forest mapping

The importance and the complexity of the creation of a national reference LC/Forest legend is very often underestimated. Very often different national systems in use are derived from the work of single national institutions that have not considered the development of a common reference system as a real national priority. Direct consequences of this situation are:

- very difficult exchange of Land Cover/Forest information between national Institutions and users;
- reduced efficiency of the national data bases;
- very difficult to update the land cover information;
- loss or inefficient use of financial and human resources.

The adoption of an international standard (as LCCS) is an important step toward the rationalization and harmonization of national reference systems; however the generation of a national legend remain a local activity. LCCS is a very useful tool to guide in the uniform and standardized generation of the classes, nevertheless the number and details of each single class is a decision that must reflect local needs and local technical capabilities. LCCS on the contrary of other static and rigid systems offers the possibility of an extremely flexible system that allow any single country or institutions to modulate the number and details of the classes according to their needs and technical capabilities. However this unlimited flexibility in the generation of thematic classes, demands to consider the inherent characteristics of a specific country and other essential operational factors (scale, MMU, source images etc). It is important to ***recognize the balancing act inherent in classifying.*** A consistent national reference system should be the functional synthesis between the information needed by the different national agencies and the effective capabilities to derive this information from remote sensing data and represent them in a data base. Fig. 2 tries to provide a schematic overview of the process.

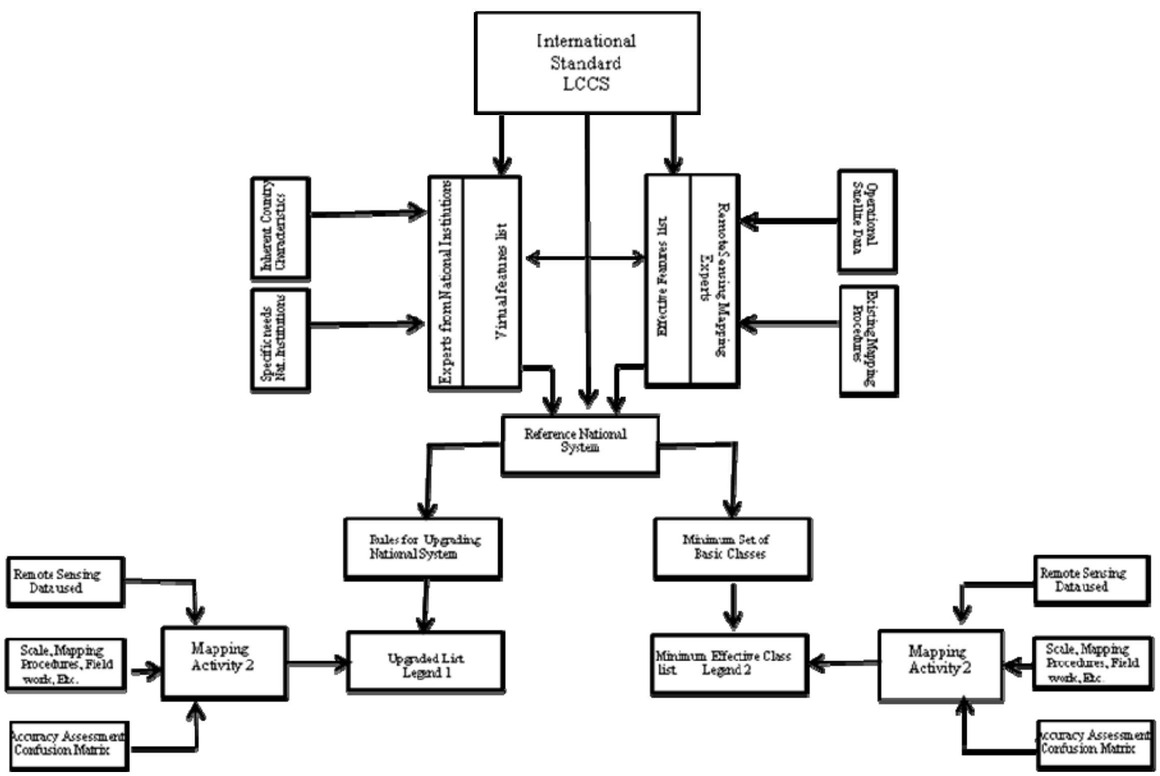


Figure 2: schematic representation of the generation and operational use of a "Reference National L.C./Forest System"

It provides a schematic representation of the whole process. A National reference system should be the functional combination of a “Virtual List” elaborated by the different experts of the national institutions involved in the exercise with an “Effective List” generated by a group of national remote sensing/GIS experts. The two lists reflect different approaches/perspectives:

1. The first one reflects the information needs of the various national institutions, not necessarily linked to the use of remote sensing and GIS data. Many national institutions, for instance, produce periodically a set of information based on traditional statistics with a large amount of field data. The National institutions need a set of information to answer to internal and international demand;
2. The second one considers only the feasibility of the use of remote sensing data on providing a set of realistic information.

The two groups can work separately or in conjunction, however the most efficient method to build up a useful list would be that the “Remote Sensing/GIS” group revises the list provided by the “National Institutions experts”. The revision criteria would be the effective feasibility to map the proposed classes through the core use of remote sensing. The use of LCCS (based on the use of simple objects and characteristics) will simplify the communications between the two groups and will make easier the evaluation if the proposed classes can be mapped or not. The resulting effect of this iteration should be the “National Reference System. A “National Reference System” is somehow different from a simple legend. A legend is always the final result of a specific mapping activity that depends from many specific concrete factors as remote sensing data used, scale, mapping procedures adopted, field work etc. A “National Reference System” on the contrary is a more comprehensive structured list that should provides a solid reference to many different national mapping activities. However a “National Reference System” should not be a static register of classes, it should provide the rules and the conditions for future expansion of the system both to allow for the increase in details of specific classes or for the creation of new features themself. It should also determine and assert the minimum asset of information (classes list) that any national mapping activity is expected to provide. Different mapping activities (as shown in fig.2) can refer to the “Reference System” to expand the system or to apply the minimum set of information depending from the limitations of the activity itself. LCCS provides a structured and scientifically sounded tool to support both these functions.

5. Country specific recommendations

In Cambodia the two main ministries involved in management and development planning of land, water, forest and other natural resources in the country, are:

- Ministry of Environment (MoE)
- Ministry of Agriculture, Forestry and Fisheries (MAFF).

The management of the protected area system (about 25-30% of the total forest land) falls under the General Department of Administration for Nature, Conservation and Protection (GDANCP) of the MoE.

Two main departments of the MAFF have a significant stake in the management of the forested areas: the Forestry Administration (FA, former Department of Forestry and Wildlife, DFW) and the Fisheries Administration (FiA).

The FA is responsible also for regulating forest and forest product use on state public lands, including production forest and protection forests as well as other public or private forests associated with indigenous minorities, private individuals, and others. MAFF is also responsible for forest areas allocated for conversion as economic land concessions.

Even if not consistent for scale and legend many different mapping initiatives exist in the country. Figure 3 provides an overview of the main products, their final scale and MMU, the main and additional source of images and presence of ground truthing.

Year	Institution	# Classes	Forest definition	Interpretation	MMU	Scale	Source imagery	Imagery provider	Additional imagery	Ground truthing
1965	U.S. Army Map Service	15 classes (9 F)		Visual on hardcopies		1/50.000	Aerial photographs			No
1973/1976*	FAO/UNDP/MRC **Land Cover Atlas** LUMO	27 classes (9 F)	Crown cover >10%	Landsat Interpreted and digitized data	0.25 km²	1/250.000	Landsat TM	**RSMU/LUMO**		
1985/1987*	FAO/UNDP/MRC **Land Cover Atlas** LUMO	27 classes (9 F)	Crown cover >10%	Landsat Interpreted and digitized data	0.25 km²	1/250.000	Landsat TM	**RSMU/LUMO**		
1988/1989	**Reconnaissance landuse map**/Mekong Secretariat	20 classes (9 F)	Crown cover >10%	Visual on hardcopies	1 km²	1/500.000	Landsat TM	**RSMU**	Aerial photographs	No
1992/1993*	FAO/UNDP/MRC **Land Cover Atlas** LUMO	27 classes (9 F)	Crown cover >10%	Landsat Interpreted and digitized data	0.25 km²	1/250.000	Landsat TM	**RSMU/LUMO**		
1992/1993**	Mekong River Commission/GTZ **FCMP**	29 classes (15 F)	Crown cover >20%	Visual on hardcopies	0.5 km²	1/250.000	Landsat TM	**FCMP/DFW**	SPOT and Aerial photographs	Field Verification
1993/1995	JAFTA **Wide Area Tropical Forest Resources Survey**	17 classes (8 F)	Crown cover >10%	Digital processing		1/250.000	Landsat TM	**JAFTA**	Aerial photographs	
1996/1997**	Mekong River Commission/GTZ **FCMP**	29 classes (15 F)	Crown cover >20%	Visual on hardcopies	0.5 km²	1/250.000	Landsat TM	**FCMP/DFW**	SPOT and Aerial photographs	Field Verification
2002	Department of Forestry and Wildlife, MAFF/FRM	8 classes (5 F)	Crown cover >20%	Visual on screen	0.5 km²	1/50.000	Landsat ETM+	**FCMP/DFW**	Landsat TM	88 samples
2005/2006	Forestry Administration	8 classes (5 F)	Crown cover >20%	Visual on screen	0.2 km²	1/50.000	Landsat ETM+ gap-filled	**FA's GIS/RS Unit**	Landsat TM, Quickbird	100 samples
2009/2010	Forestry Administration	10 classes (7 F)	Crown cover >10%	Visual on screen	0.2 km²	1/50.000	Landsat TM	**FA's GIS/RS Unit**		104 points

Existing national forest cover products available for Cambodia

Figure 3: Existing national forest cover products available for Cambodia (source: UN-REDD Forest Classification Systems in Cambodia)

Considering that forest areas account for approx. 57% of the country surface a national LC/Forest reference system should first put the bases for a proficient and standardized Forest and Natural Vegetation legend. An excellent overview of the different forest types present in the country is provided in the UN-REDD Cambodia programme paper 'Land Cover and Forest Classification Systems of Cambodia' (Brun S., 2013),as a good base to create a reference system. It is advisable to start from clear Physionomic/Structural parameters such as:

- crown cover,
- height,
- leaf type,
- leaf phenology
- layering, (single or multi strorey)

adding later measurable additional characteristics as:

- soil edaphic conditions,
- altitude,
- if necessary main Floristic aspects.

All this with the purpose to understand how many main forest types can be represented in a satellite based data base. LCCS 3 will guide the users in the building up of other non forest natural vegetation classes. Regarding the agricultural areas it must be noticed that in Cambodia different types of agricultural practices exist expecially regarding the water management for irrigation. FAO has however developed two major Land Cover data bases with app. 32 total classes. The data bases were produced using Landsat TM data as main image source; they include also a change assessment for different dates. The most recent one, even if realized only for internal use, has been coded with LCCS v.2 derived legend. It is, therefore, an optimal base from which derive a L.C. legend.

The national committee should include experts from Moe and MAFF but also representatives of the Ministry of Land Management, Urban Planning and Construction (MLMUPC) and main NGO's active in the country. The UN-REDD program could contribute to the overall process by funding some international and local Remote Sensing/GIS experts that will have the function to promote, revise and test the new national legend

References

Ahlqvist, O. 2008. In Search of Classification That Supports the Dynamics of Science – the Fao Land Cover Classification System and Proposed Modifications. . *Environment and Planning B: Planning and Design* (35): 169-1996.

Akhter, M. & Shaheduzzaman, M. 2013. *Forest Classification Systems in Bangladesh* (UN-REDD Programme, Food and Agriculture Organization of the United Nations, Dhaka, Bangladesh).

Di Gregorio, A. & Jansen, L. J. M. E. a. N. R. S. 8. 2005. *Land Cover Classification System Classification Concepts and User Manual Software Version (2).* Rome: (Food and Agriculture Organization of the United Nations).

FAO/ISRIC/ISSS. 1998. *World Reference Base for Soil Resources.* (World Soil Resources Reports, 84, ISBN 92-5-104141-5). http://www.fao.org/docrep/W8594E/W8594E00.htm

IPCC. 1996. *Revised 1996 Ipcc Guidelines for National Greenhouse Gas Inventories*. Paris, IPCC/OECD/IEA, UK Meteorological Office, Bracknell.

IPCC. 2003. *Good Practice Guidance for Land Use, Land-Use Change and Forestry*. Kanagawa, Japan, IPCC National Greenhouse Gas Inventories Programme. http://www.ipcc.ch/

IPCC. 2006. *2006 Ipcc Guidelines for National Greenhouse Gas Inventories*.

Lutz, M. & Klien, E. 2006. Ontology-Based Retrieval of Geographic Information. *International Journal of Geographical Information Science*,(20): 233-260.

UN-REDD programme. 2012. *The National Forest Monitoring Systems: Monitoring and Measurement, Reporting and Verification (M & Mrv) Functions in the Context of Redd+ Activities.* (UN-REDD programme, Food and Agriculture Organization of the United Nations, Rome, Italy).

UNFCCC. 2007. *Decision 1/Cp.13 Reducing Emissions from Deforestation in Developing Countries: Approaches to Stimulate Action.* Nusa Dua, Bali, Indonesia: (United Nations Framework on the Convention on Climate Change).

UNFCCC. 2009. *4/Cp.15 Methodological Guidance for Activities Relating to Reducing Emissions from Deforestation and Forest Degradation and the Role of Conservation, Sustainable Management of Forests and Enhancement of Forest Carbon Stocks in Developing Countries*. Report of the Conference of the Parties on its fifteenth session, held in Copenhagen from 7 to 19 December 2009.