The National Land Representation System of Bangladesh

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In response to reduce the prevailing problems of inconsistency between land cover maps, developed by different organizations in different time at different scales, Bangladesh Forest Department (BFD) has led the process of developing an object-based National Land Representation System (NLRS) for Bangladesh. With technical support from Food and Agriculture Organization of the United Nations (FAO) and financial support from United States Agency for International Development (USAID), the initiatives have been taken under the project "Strengthening National Forest Inventory and Satellite Land Monitoring System in support of REDD+ in Bangladesh". The process has brought together several national organisations involving an extensive process of consultation, data collection, translation and analysis of existing classification systems beginning in 2013 and completed in 2016. The legends of the existing national land cover/use maps and gaps identified within these processes have been considered in order to develop a complete, dynamic and representative overview of land cover and land use in Bangladesh.

1   Introduction

The increased use of earth observation data combined with GIS techniques has resulted in an expansion in the production of geographic databases. These databases can be used in the context of natural and land resourcemanagement to monitor forest land area, forest carbon stock and stock changes. However, compatibility and comparability are often lacking between products, with most of the contradictions existing in the classifications and legends used. In this context, harmonization can reduce these inconsistencies by highlighting and explaining similarities and dissimilarities between existing definitions of land characterization.

Management of natural resources is closely dependent on the classification system used to monitor the evolution of the state of environmental resources. Therefore, definitions and classifications are crucial for the assessment of natural resources to evaluate whether policies and measures have positive or negative effects and meet their target(s). A standardized and harmonised classification system for a country is, hence, very important, for mapping the land cover. The system can, therefore, serve as a dynamic source of information for several different applications and objectives. Such a key-legend applicable to maps, prepared under different modalities, will facilitate the process of comparison, the production of statistics and consistent time-series data. This paper provides the formation of the National Land Representation System (NLRS) and also explains the potential it has for various national initiatives that require national land cover/use information.

2   Land Cover Meta Language

Land Cover Meta Language (LCML), developed by FAO, is an ISO (International Organization for Standardization) standard (ISO 19144-2) innovative object oriented meta-language that allows great flexibility in the description of land features (Di Gregorio, 2016). LCML emphasizes on the spatial distribution pattern and the overall appearance of a real life vegetation/non-vegetation element which is perfectly applicable to the concept of land cover mapping in Bangladesh because -

- It standardizes the process of creating classes
- It provides a general framework of rules that can be used to create specific legends
- If implemented it will bring the land cover community together to create a mutual understanding of land cover nomenclatures with the aim to produce global, regional and national data sets able to be reconciled at different scales, level of detail and geographic location
- It may further then be used to specify any land cover feature anywhere in Bangladesh, using a set of independent diagnostic criteria that allow correlation with existing classifications and legends as expected.

LCCS v3 (Land Cover Classification System) is a software that is developed to function in a way where there is an overall implication of the concepts of LCML. It will not only perform the harmonization of data but also improve the data quality and improve the efficiency in using the information. LCCS v3 has the access to make it function in an easy, fast and intuitive way. In addition, it has the capability to export through a specific application using a tool called "LCCS tool" that results in XSD format and can be converted into a proper UML schema or ingested into a system for advanced queries of the derived database.

The implication of the adaption of this methodology into a national system is much smoother and easier. It gives freedom to the potential users to innovate their data production and management. Users have the flexibility to create legends from the National Land Representation System based on their own requirement. The experience shows that the transition between two traditional legends is more complicated and difficult than the introduction to the LCML/LCCS method into a national system. But the methodology needs different levels of expertise to function in a proper way.

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3.1 Context

In Bangladesh, the information about land cover and forest inventory serves multiple purposes, such as commercial uses, natural resources management and conservation, climate change mitigation, tracking of greenhouse gas emissions, etc. Various agencies develop land cover maps for a range of purposes, by making use of remote sensing and ancillary data (Shaheduzzaman & Akhter, 2013). Apart from the inherent differences in organizational objectives, dissimilarities in methodologies, boundaries, definitions, classification systems, varying means and capacities altogether limit the utility and comparability of land cover maps across time, space and organizations. In brief, organizational differences are highly manifested not only in the end products but also in the processes involved. In consequence, the use of different land cover maps and their integration into one system is very limited.

Therefore, there is a long-standing data integration problem in Bangladesh in the domain of land cover mapping: how to reconcile semantic differences between classification systems. This hinders for example comparative analysis of multi-temporal mappings (i.e., change detection). The need to improve the interoperability between datasets can be achieved by overcoming differences in data semantics. It is thus expected that the harmonization of the existing classification systems and development of normative one based on a standard land representation system will help to reduce the reporting burden, thus reducing costs and in some cases also improving the quality, robustness, completeness and transparency of the information.

3.2 Development Process

The NLRS is the result of several processes of data collection, translation, analysis and the identification of the gaps of existing land cover/use mapping processes. This process started in 2013 and was finalised in 2016. The legends of existing national land cover/use maps were collected, documented and translated using LCML. This first step allowed the identification of the gaps of existing legends and identification of the meaning of the land feature classes considering the objective of the institution involved in the land cover map development.

The first training and national workshop on land classification system was held in Dhaka in 2013. Several documents were developed to support the documentation of the existing land cover mapping activities in Bangladesh (Shaheduzzaman & Akhter, 2013). In 2015, the second training on LCCS was organized to present and train representatives from various national institutions the new LCCS v3 (FAO, 2015).

In collaboration with the Bangladesh Forest Department, from over 1000 locations, field data have been collected by Bangladesh Society of Geoinformatics (BSGI) and Centre for Environmental and Geographic Information Services (CEGIS) all over the country. The objective of this field data collection was to collect field ground data using a specific manual (BSGI, 2016) in order to develop the NLRS. During the process of the NLRS development, the field ground data are used to characterize the national classes. In March 2016, the national workshop for the development of the NLRS was organized. With the contribution of experts from Bangladesh Agricultural Research Institute (BARI), Bangladesh Forest Department (BFD), Bangladesh Institute of Planners (BIP), Bangladesh Society of Geoinformatics (BSGI), Bangladesh Space Research and Remote

Sensing Organization (SPARRSO), Bangladesh University of Engineering and Technology (BUET), Centre for Environmental and Geographic Information Services (CEGIS), Food and Agriculture Organization of the United Nations (FAO), National Land Zoning Project, Ministry of Land (MoL), Survey of Bangladesh (SoB) and Soil Resource Development Institute (SRDI) a draft national land representation system for land cover/use mapping was developed. The flexibility and comprehensiveness of the system to accommodate and integrate all possible national classes were recognized during a national consultation (held right after the workshop) with the stakeholders in March 2016 (Hadi et al., 2016). Figure 1 shows some pictures from different development phases of NLRS development.

(a) Training workshop on land cover classification (March 2013)

(b) Training on LCCS and field data collection for development of NLRS (December 2015)
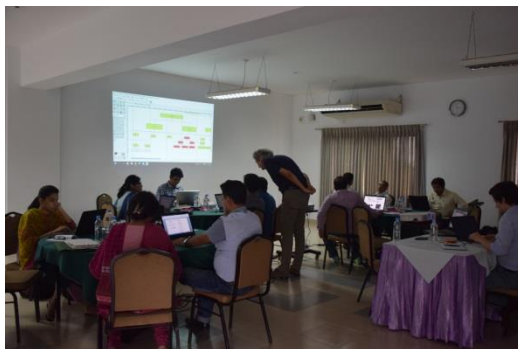
(c) Working session on land cover classification system development (March 2016)

(d) National consultation workshop on land cover classification system (March 2016)

Figure 1 Different development phases of National Land Representation System

3.3 Overview

The NLRS is not just a simple legend rather it is a more comprehensive structured list of categories that provides a solid reference to many mapping activities. In the past a "Representation System", when presented, had a static list of classes in the best case ordered according to simple hierarchical levels. A standard system should represent and affirm the minimum amount of information (classes list) that any national mapping activity is expected to provide at national level. Different mapping agencies dealing with different mapping activities can refer to the "Representation System" to apply the minimum set of classes necessary at national or local level or to further expand the system to create specific application derived extra information.

The whole logic of the system is based on an "object oriented" approach. Each of the categories populating it is constructed according to the ISO standard FAO LCML (Land Cover Meta Language). The LCML/LCCS v.3 syntax works by making available a set of basic standard LCML "object" (called LCML "elements", for instance trees, shrubs, buildings etc.) that can be organized in strata and can be enriched with different types of "attributes". These LCML elements act as standardized building blocks and can be combined to describe the more complex semantics of each LC class in any separate application ontology (classification system). Each LCML derived category is represented in a modelling language (UML) that in one side make easier and more accurate the description of the "real world" features and on the other side easier the understanding of their ontology and more efficient their utilization in an advanced GIS modelling environment.

For each one of the classes instantiated in the system an LCML/LCCS v.3 instantiation model exist (in graphical and XSD format) (Figure 2) and it is stored in the National Land Representation System Digital Registry. Therefore when any national (or international) institution wants to use those classes they just need to refer through the map code to the registry both for the class description and for any other advanced modelling and GIS operations that require the use of XSD Mark-up language.
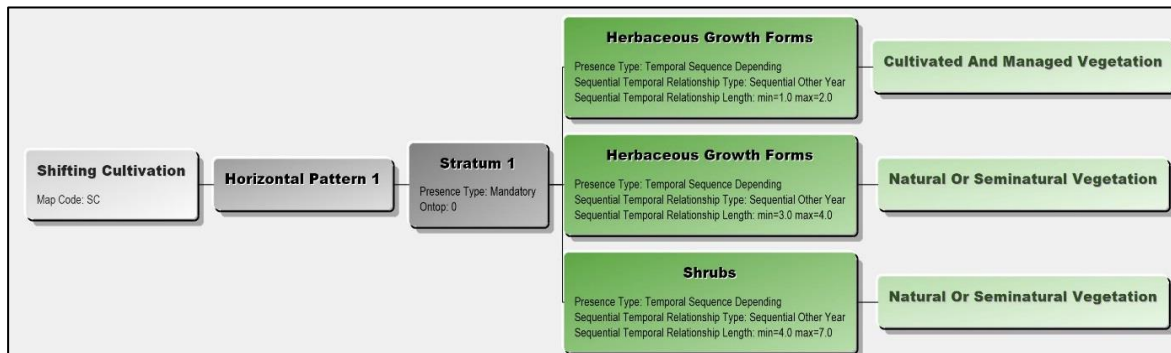

Figure 2: Model representation of the graphical format of the class "shifting cultivation"

The classes instantiated in the system are the "essential" one when considering a basic Land Cover data base at national level. However, they must be considered as a kind of "Meta Classes" that can be further expanded according to the needs of specific applications that would require an increased amount of information. The present model fully supports and guides this expansion. The grey boxes show the extra attributes that can be added to the model basic "Meta Classes" (Figure 3). Figure 3 presents examples of the attributes (grey boxes) that can be used to further expand the thematic content of the system "Meta Classes" (in this specific example general class "Natural Vegetation" or a more detailed class "Forest"). Such list of attributes is a guide to harmonize the further class enrichment and is open ended.
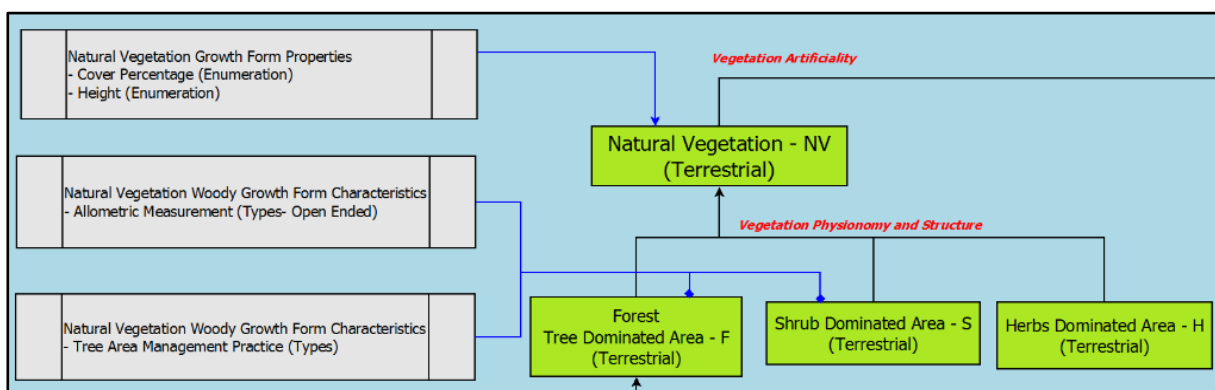

Figure 3: Example of attributes

NLRS of Bangladesh is divided into 7 distinct levels for the complete understanding of all the land features in Bangladesh. These levels are generated with the help of LCCS v3. Each of these levels come from one master category and are further granulated for identifying more distinct land cover which is how a hierarchy of legend has been developed (Figure 4). Level 1 consists of two classes 'Vegetated' and 'Non-vegetated'. Level 2 consists of four classes dividing the former classes based on presence of water. Level 3 consists of total 8 classes based on artificiality of the previous classes. Level 4 and level 5 includes 21 and 24 classes, respectively, where most of the classes are in vegetated category. Level 6 includes 10 classes and level 7 has 5 classes which are basically the extended class from upper ones.
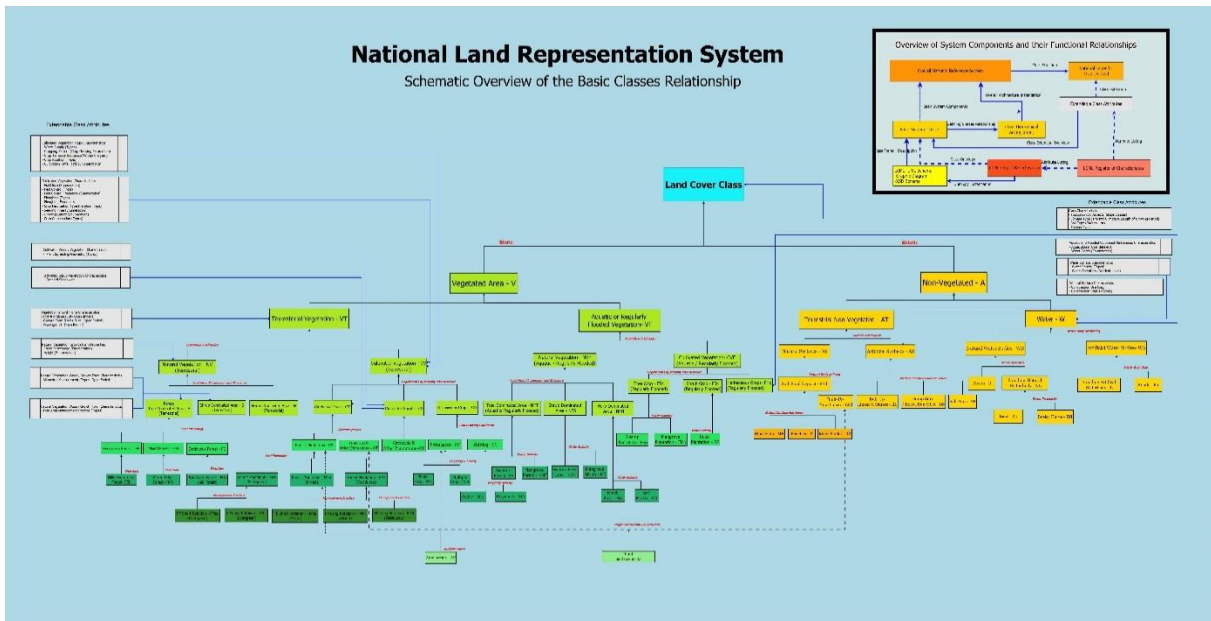
Figure 5: The major structure of the national land representation system of Bangladesh

4   Land Cover Map 2015

SPOT 6 satellite imagery of 2015 was used for the development of land cover map under Forest Department. Considering the resolution of the imagery and NLRS a classification system has been developed (Figure 6) to use the satellite imagery for the development of land cover map for 2015 (Figure 7). Followings are the legend and land cover map 2015 that was validated with over more than 14000 samples plots using google earth by engaging the organizations mentioned above through an extensive workshop.
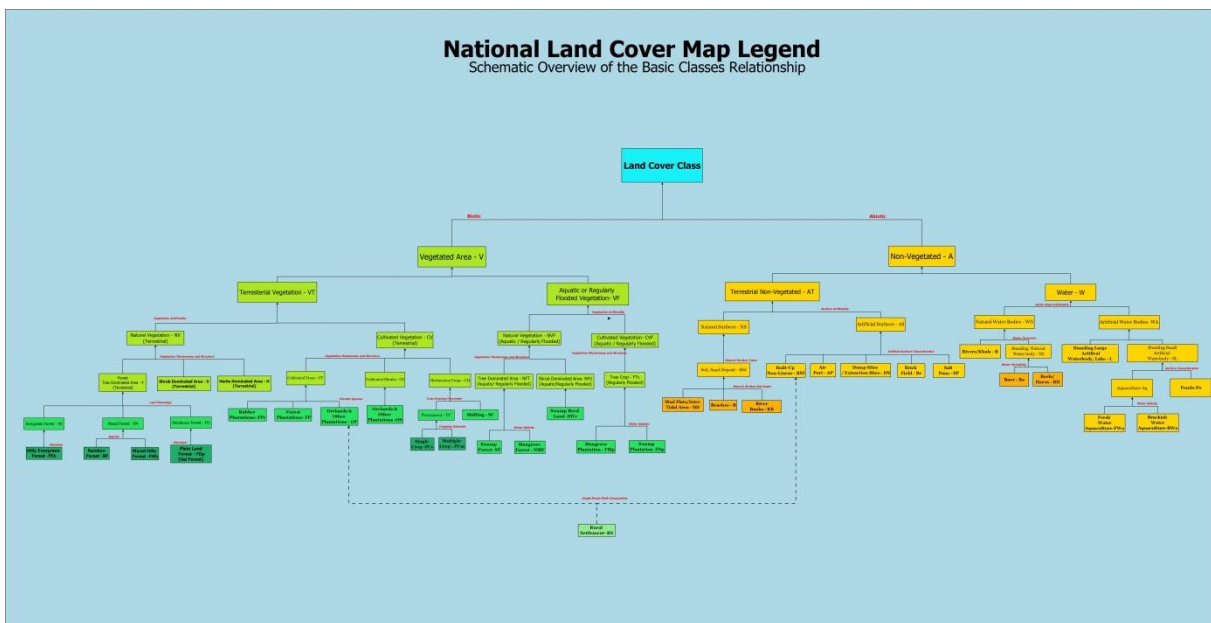

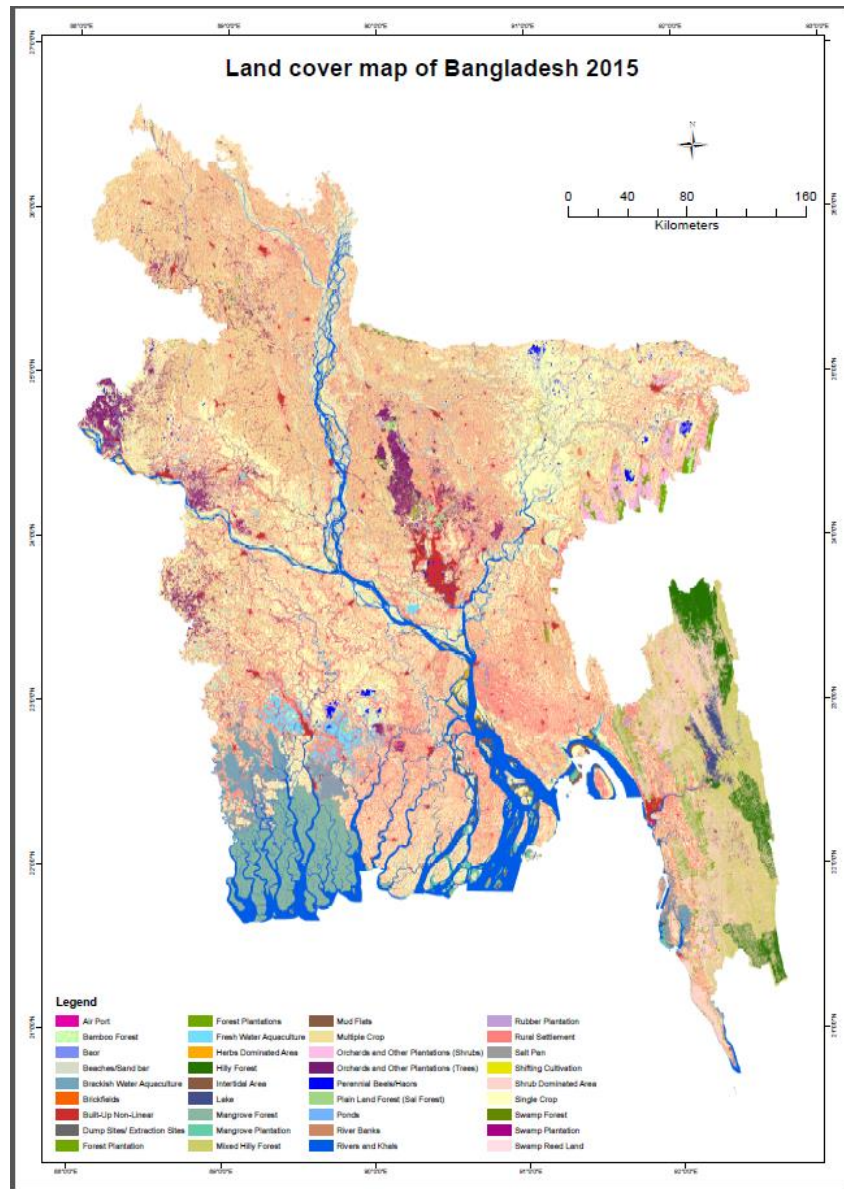Figure 6: National land cover map legend

Land cover map of Bangladesh 2015

Legend
Air Port · Forest Plantations · Mud Flats · Rubber Plantation
Bamboo Forest · Fresh Water Aquaculture · Multiple Crop · Rural Settlement
Baor · Herbs Dominated Area · Orchards and Other Plantations (Shrubs) · Salt Pan
Beaches/Sand bar · Hilly Forest · Orchards and Other Plantations (Trees) · Shifting Cultivation
Brackish Water Aquaculture · Intertidal Area · Perennial Beels/Haors · Shrub Dominated Area
Brickfields · Lake · Plain Land Forest (Sal Forest) · Single Crop
Built-Up Non-Linear · Mangrove Forest · Ponds · Swamp Forest
Dump Sites/ Extraction Sites · Mangrove Plantation · River Banks · Swamp Plantation
Forest Plantation · Mixed Hilly Forest · Rivers and Khals · Swamp Reed Land

Figure 7: National land cover map 2015

5 Conclusion

The NLRS of Bangladesh represents the structural form that has been developed as a complete classification system in order to describe the features that are most likely to be found in Bangladesh. The present system tries to instantiate all these basic requirements in a logical innovative framework that is tailored and fine-tuned for Bangladesh. To better understand the overall concept of the system it is important to analyze its overall structure and the functional relationship of the different elements that represent it.

The NLRS can represent all past, present and future legends in a harmonized way. It is expected to be the foundation for building sustainability in land cover assessment and monitoring in Bangladesh allowing comparability between maps developed by different agencies and for different purposes. The dynamic nature of the land cover system of Bangladesh makes it hard to keep tracks, but the NLRS has the potential to ease the process not only at present but also in the near future. The system has been designed to be flexible enough to be adapted to all specific in-country needs. In addition to the creation of specific legends for specific applications, the system has also been used as a reference bridging system to compare classes belonging to other existing classifications. The system was served in determining the legends for developing the Land Cover Map for 2015.

6 References

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