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The Vietnamese Wetlands Classification System

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Abstract. The Vietnamese Wetlands Classification System is an important basis for governmental agencies, non-governmental organizations, and scientists to identify wetlands that are under-represented in the List of Wetlands of International and National Importance in order to encourage their designation and appropriate long term management. The classification also serves as a broad framework to aid the rapid identification of the main wetland habitats represented at each site, to provide units for mapping, and to encourage uniformity of concepts and terms in national wetland inventory.

The Vietnamese Wetlands Classification System is a hierarchy of systems, subsystems, classes, and types or sub-types of wetlands. The systems are defined based on salinity of water or distance of wetland from the sea - marine/coastal wetland (salty/brackish wetlands) and inland wetland (freshwater wetlands). The subsystems are based on the main origin of wetlands – natural or artificial wetlands. The classes are defined based on the hydrological regime, they would be permanent or non-permanent (covered by water) wetlands. The most important level in the classification system is the types. The types are defined based not only on geomorphologic, geologic features and origin of wetlands, but also the dominant life form of vegetation or physiography and composition of substrate features. Further, the modifiers of the classification systems (sub-types) can be added based on relevant criteria and using objectives; they must be developed by the users.

There are 38 wetland types defined in the classification system purpose to ensure uniformity throughout the whole country and to serve individuals or organizations with varied interests and objectives. Building the Vietnamese Wetland Classification System is necessary now, when sustainable use of natural resources is an important task of development course of Vietnam.

Keywords: Wetland; Classification system; Wetland types; Wetland inventory; Wetland management.

1. Introduction

In general, wetlands are lands where water saturation is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. The single feature that most wetlands share is soil or substrate that is at least periodically saturated with or covered by water. The water creates severe physiological

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problems for all plants and animal except those that are adapted for life in water or in saturated soil [1].

According to the RAMSAR Convention, wetlands are areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters [3].

Wetland development is a function of climate (precipitation, temperature, wind and insolation), hydrology (internal and external drainage), chemistry (water and soils), geomorphology (landform and soil parent material), and biology (fauna and flora). Wetland development is dynamic since various types of wetlands represent transitions from one type to another. As a result, wetlands often share characteristics of more than one wetland class or type.

Vietnam has a shoreline of 3,260 km in length, about 3,000 near-shore islands and more than 100 estuaries. The Vietnamese coastal zone is characterized by various wetlands which are diverse not only in types, functions, ecosystems and biodiversity, but also in resources (biota, water, mineral, tourism, transportation, etc.), which is favorable for many economic sectors, e.g. fishery, aquaculture, agriculture, forestry, tourism, transportation, etc.. The ecological systems of coastal wetlands are widely distributed throughout Vietnamese coastal zone, including the tidal flats, estuaries, lagoons, mangrove forests and swampy areas. Today, Vietnam has 68 wetland areas with national and international importance [4], including the Xuan Thuy and Bau Sau (recognized as Ramsar Sites), the Tien Hai Nature Reserve, Tam Giang - Cau Hai, Tra O Lagoons, Can Gio Biosphere Reserve, Ca Mau Cape, U Minh, Tram Chim National Parks. Thus, there is a need to have a classification system for organizing the great array of wetlands with a common set of names that everyone can recognize.

In Vietnam, there are some published wetland classification systems which were built by numerous authors, such as Le Dien Duc (1989), Nguyen Hoang Tri (1995), Phan Nguyen Hong (1996), Vo Tong Xuan (1996), Nguyen Chu Hoi (1999), Nguyen Huy Thang (1999), The Vietnam National Committee of Mekong River (1999), Nguyen Chi Thanh (1999, 2002), Hoang Van Thang (2002), Vu Trung Tang (1994 - 2004), The Forest Inventory and Planning Institute (1996 - 2003), VEPA (2000 - 2006) [2]. However, these classification systems are not adequate, unique enough to serve the national tasks of wetland conservation, management, wise use and study. Also, these systems are not consistent: (1) the criteria selected for establishing categories are different; (2) some classifications are not applied consistently in different parts of the country; (3) the elements classified are not consistent. That's why, in 2007, the Vietnam Environmental Protection Agency collaborated with this paper's authors to build a new version of the Vietnamese Wetlands Classification System that would enable effective management, utilization and research of the wetlands in Vietnam.

The Vietnamese Wetland Classification System (VWCS) is based on the best available science and accessible to specialists and non-specialists. The system is hierarchical in that classes are based upon actual features of the wetlands rather than on interpretations of the various uses of wetlands. However, interpretation involves a second step - mapping - that is essential if the information is to be used effectively for wetland management. As the classes are based on defined features of the wetlands, the

divisions between classes or their combinations allow them to be readily identified in the field and then delineated on maps.

The system is based upon an "expert-based approach" in which the user is expected to have a general knowledge of wetland processes and associated characteristics. It is relatively simple and straightforward once individuals are familiar with its basic principles. Furthermore, the system is intended to be used for any purpose at any geographical scale. The generalized key for the wetland types aim to help the user of the classification system, but cross-referencing to detailed definitions and descriptions may also be required.

1.1. Rationale and principles for building the classification system

The VWCS was built based on wetland classification systems of Ramsar, Mekong River Committee, IUCN, countries (such as Canada, the United States, and Japan), and other Vietnamese authors. VWCS was also based on the results of many studies related to wetlands (biodiversity, ecology, geology, geomorphology, hydrology,...) conducted in the last 20 years and the practical experience the authors have from studying, mapping, and surveying in the field of wetland research for over 10 years.

VWCS was built to contribute to implementation the Decision No 109/2003/QD-TTg of the Prime Minister on conservation and sustainable use of wetland areas (September 2003), and the Decision No. 79/2007/QD-TTg on the National action plan for biodiversity to the year 2010 and orientation to 2020 for implementing Biodiversity Convention and Cartagena Protocol of biological safety (May 2007).

VWCS was built based on the following principles:

- As wetlands are products of the interaction of various environmental factors, they usually develop different characteristics that can be used to group them into classes. In VWCS, the greatest importance is attached to the various conditions that have affected wetland development, i.e. wetland morphology (elevation above surrounding terrain, surface form and pattern), source of water, chemistry of that water (nutrient levels, base saturation, pH), basin depth and shape, phytosociology and physiognomy (plant communities and their structure), and substrate characteristics (physical and chemical properties).
- At the more detailed levels of classification, emphasis is placed on combinations of more specific factors associated with wetlands, such as specific soil environments, as well as distinct, ecological processes and associated vegetation.
- Because ecological relationships affect wetland development, the resulting wetland is characterized by specific properties that were, or are, sensitive to the environmental conditions under which that wetland developed or continues to develop. Each level of classification thus reflects the environment in which the wetland developed, whether these are climatic, hydrologic or chemical factors at a general level of classification, or specific forms of vegetative communities at a detailed level of classification
- The chemistry of the water can follow different geochemical gradients. The terms "salty" and "brackish" are used to differentiate waters along the ocean coast according to the amount of dissolved salts, mostly sodium. The concentration of dissolved salts is controlled by distance from the open sea.
- Considering that the hydrological

regime of a wetland is characterized by water level regime and fluctuations (permanent or non-permanent), which are possible to classify wetlands accordingly.

- The upland limit of wetland is defined as: the boundary between land with predominantly hydrophytic cover and land with predominantly mesophytic or xerophytic cover; the boundary between soil that is predominantly hydric and predominantly nonhydric; or in the case of wetlands without vegetation or soil, the boundary between land that is flooded or saturated at some time during the growing season each year.

1.2. Methods for building the VWCS

The VWCS should be viewed as an iterative approach, involving the initial choice of a framework as a hypothesis, validation with univariate and multivariate statistical techniques, and subsequent modification to create new classes or combine existing classes (wetland classification of Ramsar, Mekong River Commission, IUCN, etc.)

The VWCS creation process is appropriate when input is collected from a range of experts through frequent group meetings that are held with multi-sector participants (management, legal advisers, researchers, local government representatives, etc.) to exchange their ideas and comments and to have face-to-face communications that will lead to an agreement among users.

After building the draft of the VWCS, GIS and remote sensing technology were used for mapping the wetland. Further, field survey is necessary to check the status and boundary of wetland types. Any potential problems during mapping and surveying will be used to revise and complete the VWCS.

2. The Vietnamese Wetlands Classification System

The structure of VWCS is hierarchical and progresses from *Systems* at the most general level, to *Sub-systems*, *Classes*, and *Types*. Table 1 illustrates this classification structure.

Here, the term "system" refers to a collection of wetlands that share the influence of the salinity of water and marine factors. That is why, in this term, wetlands are divided into two systems: marine/coastal wetland (salty/brackish wetlands) and inland wetland (freshwater wetlands). We further divide "system" into subsystems based on main origin of wetlands, due to human activities or natural processes. Thus, a system is divided into two sub-systems: Natural wetlands and Artificial wetlands. It is not difficult to find the boundary of a system in the field: we can take the water salinity measurement by equipment or ecosystem characteristics.

The "class" is the highest taxonomic unit below the sub-system level. The class is determined based on the hydrological condition. As a result, a sub-system is divided into two classes: permanent and non-permanent saturation (or covered by water).

Under class in VWCS is the "type". It is a very important unit in the classification. The type describes general appearance of the habitat in the terms of the either dominant life form of vegetation or physiography and composition of substrate features, geomorphologic, geologic features and origin of wetland, which can be recognized without any environment measurement.

Table 1. The Vietnamese Wetland Classification System

Systems	Sub-systems	Classes	Types		
			Symbols		Name of wetland types
			Vietnam	Ramsar	
Marine/coastal wetland (salty/brackish wetlands)	1.1. Natural wetlands	1.1.1. Permanent	Vb	Aa	1. Permanent shallow marine waters less than six meters deep at low tide
			Vv		2. Gulfs and bays
			Tv	B	3. Marine sub-tidal aquatic beds, includes kelp beds, sea-grass beds, tropical marine meadows
			Sh	C	4. Coral reefs
			Dp	J	5. Lagoons
			Cs	F	6. Estuaries
			Cns	Fa	7. Submerged estuarine sandy islets
		1.1.2. Non-permanent	Cbs	Fb	8. Estuarine barrier islands
			BD	D	9. Rocky marine shores, includes rocky offshore islands, sea cliffs, benches
			Bc	Ea	10. Beaches
			Bcs	Eb	11. Intertidal shingle or pebble shores
			Bcb	Ga	12. Intertidal muddy sand shores
			Bbc	Gb	13. Intertidal sandy mud shores
			R	I	14. Mangrove forests
			Dl	H	15. Intertidal marshes
			Kb	Zk(a)	16. Marine/coastal karsts and other subterranean hydrological systems,
	1.2. Artificial wetlands	1.2.1. Permanent	Tl	1a	17. Salty/brackish aquaculture ponds
			Tvk	10	18. Sedge farms
		1.2.2. Non-permanent	Tlk	2	19. Aquaculture tidal flats
			Mu	5	20. Salt exploitation sites
Inland wetland (freshwater wetlands)	2.1. Natural wetlands	2.1.1. Permanent	S	M	21. Permanent rivers/streams/creeks
			H	O	22. Permanent freshwater lakes (over 8 ha)
			D	Tp	23. Permanent freshwater marshes/pools (below 8 ha)
			O	Y	24. Freshwater oases
			Nk	Zg	25. Geothermal wetlands, hot springs, mineral springs
		2.1.2. Non-permanent	Sk	N	26. Seasonal/intermittent/irregular rivers/streams/creeks
			Tb	U	27. Non-forested peatlands
			Tbr	Xp	28. Forested peatlands
			Cl	Xf	29. Freshwater, tree-dominated wetlands
			Cn	Ts	30. Seasonal/intermittent freshwater marshes/pools
			Cb	W	31. Shrub-dominated wetlands
			Kn	Zk(b)	32. Karsts and other subterranean hydrological systems, inland
	2.2. Artificial wetlands	2.2.1. Permanent	Tn	1b	33. Freshwater aquaculture ponds
			Km	3a	34. Channels, canals
			Tr	6	35. The other water storage areas
			X	8	36. Wastewater treatment areas
		2.2.2. Non-permanent	Nn	3b	37. Cultivated wetlands
			Mo	7	38. Excavations, mining pools

The life forms of vegetation, such as trees, shrubs, mosses, lichens are used to define the type level in the classification. And, if the vegetation covers 30% or more of the substrate, we distinguish the type of a wetland based on the life form of the plant that constitutes the upper most layer of vegetation that possesses an areal coverage of 30% or more. For example, an area with 50% areal coverage of mangrove trees over the shrub layer with 60% areal coverage would be classified as a mangrove forest (R).

If the vegetation covers less than 30% of the substrate, the physiography and composition of the substrate are principal characteristics to distinguish the type of wetland. The nature of the substrate reflects regional and local variations in geology and dynamic condition (wind, waves, current, tide, erosion, deposition). For example, we classified the sea shore into four types of wetland based on substrate material: rocky marine shores (includes rocky offshore islands, sea cliffs, and benches); beaches (intertidal shingle or pebble shores); intertidal muddy sand shores; intertidal sandy mud shores. Each type of the shore indicates a distinct habitat, the regional geological or dynamic condition.

Similarly, hydrological and geomorphologic characteristics associated with wetlands are described in more detail at the wetland type levels as the main criteria to recognize some types of wetlands. For example, gulfs and bays, lagoons, estuary, submerged estuarine sandy islets, estuarine barrier islands, marine/coastal karsts and other subterranean hydrological systems are classified by those criteria.

In some situations, wetland types are created by human activities, such as agriculture (Nn, Km, Tvk), aquaculture (Tn, Tl, Tlk) and others (Mu, Tr, X, Mo). Over time, these sites evolve into naturally functioning wetland systems and are classified accordingly.

Some of the modifiers are an integral part of this system and their use is essential; others are used only for detailed application or for special cases. The modifiers must be used at all lower types level in the hierarchy and some suggested criteria to define wetland modifiers are listed in Table 2. Special modifiers should be added where they are appropriate in the VWCS.

Table 2. Proposed criteria to define some wetland modifiers (sub-styles)

Wetland types	Criteria
Permanent shallow marine waters less than six meters deep at low tide	Composition of substrate (rocky, gravel, sandy bed,...)
Gulfs and bays	
Coral reefs	The shape of the reefs (fringing, ring...)
Lagoons	1. Vegetations or non-vegetations
	2. The enclosure of lagoons
	3. The salinity of the water
Estuaries	Main dominant factors and interaction (waves, tides or river energy)
Rocky marine shores, includes rocky	1. Geomorphology: cliffs or benches

offshore islands, sea cliffs, benches	2. Lithology (magma, sediment, metamorphic rock)
Intertidal sand shores	Placers and non-placers bearing
Mangrove forests	1. Lithology features of sediments
	2. Tidal submerged level (low, mean, high)
Intertidal marshes	Vegetations or non-vegetations
Karsts and other subterranean hydrological systems, marine/coastal	The feature of shape (karst plain, karst valley, karsts)
Permanent freshwater marshes/pools (below 8 ha)	Vegetations or non-vegetations
Geothermal wetlands, hot spring, mineral spring	The feature of spring (hot spring, mineral spring,...)
Forested peatlands	Forested types
The other water storage areas	Utilization (water reservoir, waste water treatment,...)
Cultivated wetlands	The crops in one year (one crop, two crops...)
	Seasonal submergence and non-seasonal submergence

3. Use and application of the Vietnamese Wetlands Classification System

The VWCS was designed for use by individuals or organizations with varied interests and objectives. It looks quite complex when viewed in its entirety, but use for a specific purpose at a local site should be simple and straightforward. Before attempting to apply the VWCS, the user should consider some important points:

Information about the area to be classified must be available before applying the VWCS. This information can be historical data, aerial photographs, brief on-site inspection, soil maps, general field reconnaissance, detailed knowledge about the site and discussions with local people, or other detailed studies. If the provided data is not sufficient for the needs of the user, additional data gathering is mandatory.

Below the level of style, the VWCS is open-ended and incomplete. The users may identify additional modifiers and determine where these fit into the classification hierarchy based on the criteria showed in table 2. In detailed studies, the need for additional modifiers (sub-types) is apparent.

The VWCS serves to ensure uniformity throughout the whole country. It is important that users pay attention to the definitions of the classification. Any attempt of modification of these definitions will lead to lack of uniformity in application.

The VWCS will be used to do in inventory and mapping of wetlands. A classification used in mapping is scale-specific, for both minimum size of units mapped and the degree of detail attainable. So, it is necessary for the users to develop a specific set of mapping conventions for each application and to demonstrate their relationship to the generalized classification described here.

The VWCS is most easy to be learned through use, similarly to Ramsar Wetland Classification System. So, it is convenient for mapping and international integration.

4. Conclusion

The Vietnamese Wetland Classification System was built based on legal matters, specific research results and reality in order

to ensure uniformity throughout the whole country and to be useful for individuals and organizations with varied interests and objectives related to wetland. Specially, the VWCS is an important basis for wetland management in Vietnam.

The structure of VWCS is hierarchical with two systems at the most general level, four sub-systems, eight classes, down to 38 types of wetlands. The units in VWCS were classified based on geomorphologic, geologic features and origin of wetlands, the dominant life form of vegetation or physiography and composition of substrate features.

The VWCS is open-ended system, more modifiers can be added by users to serve special objectives. The VWCS is most easy to be learned through use and it is convenient for mapping and international integration.

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