122 Critical Watersheds and Watershed Classification

Module 1: Basics of Watershed Management	Bio-Physics

Chapter 1.2.2: Critical Watersheds and Watershed Classification

General

It is most likely for watershed management to achieve a positive and measurable impact in watersheds where essential watershed functions are critically impaired or are likely to become critically impaired through human intervention. These are for example watersheds where there already is, or there is likely to be a significant negative impact on water quality and / or quantity. Such watersheds can be considered to be “sensitive” or “critical”. This includes for instance watersheds with high rates of deforestation, land use change and population growth [2].

Box 1: Critical watersheds are watersheds where essential watershed functions are already critically impaired or are likely to become critically impaired through human intervention. In such watersheds the need for watershed management is the most urgent [3].

An earlier approach that was used to identify critical watersheds is the *concept of priority watersheds*. It emerged in India at the end of the 1960s and was widely instituted and acknowledged during the 1970s. Priority classification depended on the so-called “sediment yield index” which was composed of measures of erosion intensity (terrain, slope, soil class, susceptibility to erosion, vegetation cover and extent of the erosion process) and a delivery ratio indicating transportability of sediments to reservoirs [6].

However nowadays, there is no universally accepted definition of a critical watershed, but the following *alternative definitions* have been given:

- An area considered as critical regarding the risk of soil erosion, typically an area with watershed classes 1 or 2 (see details below) that lacks permanent forest cover [1].
- Sensitive cross-border areas and other areas where the interests of the Mekong Basin as a whole are impacted or potentially impacted [7].
- Watersheds that are in a critical condition, where critical condition could mean steep slopes, a high rate of land use change or deforestation and high increases in the population, etc. [4].

There are two broad classes of criteria that can be used to define and identify critical watersheds:

- *Static criteria:* These are criteria that do not change easily over time. They include elevation (high), slopes (steep), landforms (prone to erosion) and absence of permanent forest cover.
- *Dynamic criteria:* These are criteria that may change quickly over time, which are typically expressed as rates of change. Such rates of change could reflect changes in the water quality and quantity, in the forest cover and land use (“deforestation rate”) and in the number of people (“population growth”).

Using dynamic criteria or a combination of static and dynamic criteria to identify critical watersheds seems more appropriate than solely using static criteria [2]. The logic here is simple: watershed functions are impacted on by human interventions that are undertaken to use natural resources. Dynamic criteria are direct or indirect indicators for such human interventions and change, and thus indicate areas where human activities do actually or are very likely to influence and critically impair essential watershed functions. Watersheds identified as critical using static criteria alone do not necessarily require watershed management interventions. For instance, there would be little scope for watershed management interventions in watersheds with steep slopes and without forest cover, but which are otherwise in a stable condition due to the absence of human induced changes.

In any case, recent and reliable geographically referenced information is required to actually identify critical watersheds using criteria that have been agreed upon.

An Overview of Watershed Classification

Watershed classification is one approach that can help to identify critical watersheds, by mainly using static criteria. It should be noted though that methods to classify watersheds differ around the world, as the method will depend on the intended use of the results. For instance, the classification of a watershed for the purpose of hydropower generation will look rather different from one that addresses erosion issues. The watershed classification that will be outlined here provides a regional example that was developed by the MRCS's *Watershed Classification Project* (WSCP), a basin-wide initiative supported by the *Swiss Agency for Development and Cooperation* (SDC) and the *Centre for Development and Environment* (CDE) at the *University of Berne* (Switzerland) [1]. According to the WSCP:

Box 2: Watershed classification is a method of dividing a landscape into different watershed classes on the basis of selected topographic features. It describes the potential topographic soil erosion risks of a landscape on the basis of its physical and / or environmental features [5].

The aim of the WSCP was to provide an indication of the vulnerability of watersheds with regard to water resources degradation mainly through soil erosion. It established a watershed classification system and corresponding watershed classification data and maps. On the basis of the topography of the landscape, five watershed classes were calculated by means of statistical analysis (see details below), and were then indicated on watershed classification maps. These classes describe the potential degradation risk one encounters when land is cleared of its original vegetation cover. When applying the watershed classes, class 1 is the most sensitive and class 5 the least sensitive to water resource degradation through erosion. Additionally, general recommendations for sustainable land uses were given for each watershed class [1]:

Watershed class 1 (protection forest): Comprise areas with very steep slopes and rugged landforms, which are commonly upland and headwater areas that are critical for water and soil resources management. These areas should be under permanent forest cover. The other existing land uses that are based on traditional rights and practices should be considered carefully with regard to their impact on water and soil conservation.

Watershed class 2 (commercial forest): Comprise areas with steep slopes, usually found at a higher elevation. In general the landforms are less susceptible to water and soil degradation than those categorised under class 1 of the watershed classification (WSC) system. Some of the recommended land uses are forests (conservation and production forests), as well as agro-forestry and grazing, if they are accompanied by strict conservation measures.

Watershed class 3 (agro-forestry): Comprise areas with moderate to steep slopes that have less erosive landforms, located in upland areas and on foot slopes. Recommendations include a wider range of acceptable land uses than those for WSC classes 1 and 2. Areas may be used for commercial forests, grazing and combinations of trees and agricultural crops, if appropriate conservation measures are being applied.

Watershed class 4 (upland farming): Comprise areas with gently sloping lands, where there is a moderate need for water and soil conservation. In these areas a wide range of land uses related to agriculture and forestry are possible.

Watershed class 5 (lowland farming): Comprise areas with gently sloping land and flat areas that are suitable for a wide range of land uses such as the cultivation of paddy rice, other agricultural uses and forests.

It should be noted that these are recommendations and they do not exclude other land uses, provided that adequate care is given to soil conservation. As an example of this, the recommended land use for areas in class 1 is forest cover. However there are many cases which clearly show that forest cover is not the one and only solution for conserving steep watersheds. There are other land uses such as crop production on terraces, production of perennial crops, and permanent grassland that have shown themselves to be viable options for sensitive watersheds in many parts of the world. The same is true for well managed shifting cultivation systems with adequately long fallow periods to allow natural forest re-growth and replenishment of soil nutrients [1].

Box 3: There are varying ways in which different countries classify watersheds. Viet Nam for example uses three levels of watershed classification consisting of less critical, critical and very critical. This method of classification is now also applied to categorise Viet Nam's protection forests.

Watershed Classification Methodology and Products

The watershed classification approach used by the WSCP was based on a methodology that was developed and applied in Thailand in the late 1980's. The approach used statistical analysis to establish relationships between a number of variables (slope, elevation and landform) derived from topographic maps, and the watershed classes (see figure 1). The methodology and the watershed classes were the same as those originally used by the Thai authorities [1].

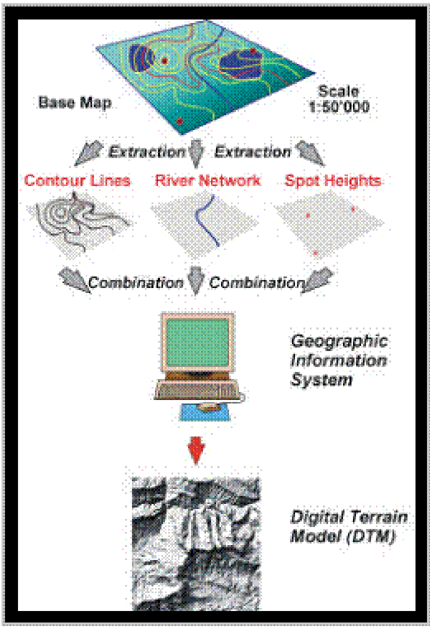

Figure 1: DTM Creation Process [1]

Together with the experts who had previously developed the method for Thailand, pilot areas were chosen in Cambodia, the Lao PDR and Viet Nam. Here, the coefficients were established for the statistical analysis that was later used to delineate watershed classes.

A digital terrain model (DTM) was created with geographic information system (GIS), which was based on the elevation data and the rivers taken from topographic maps. This DTM was then used as the input for the statistical analysis that resulted in the delineation of watersheds.

Maps at reconnaissance level scales of 1:250,000 were produced, showing the watershed classification and the geographic distribution of watershed classes [5].

Watershed Classification: Use and Limitations

The watershed classification maps (see figure 2) and data enable geographical priority settings for watershed management, because they show areas that are potentially sensitive to water resources degradation by soil erosion. By overlaying these watershed classes with land cover data, it is possible to indicate areas where degradation is currently taking place. These are those localities where potentially sensitive areas (watershed classes indicating steep land and high risks) are bare of significant vegetation cover [1].

However, the following points should be observed when using watershed classification maps and data [1]:

- The maps and data are designed for reconnaissance use at the macro-level (basin-wide, national and provincial levels). In order to use them at the micro-level they have to be refined and complemented with additional information, including that resulting from field investigations.
- The maps and data should be placed in context of the complex reality of watershed management and therefore they should never be used as a separate entity. Rather they should always be utilised as input into the participatory decision making process during planning and management.

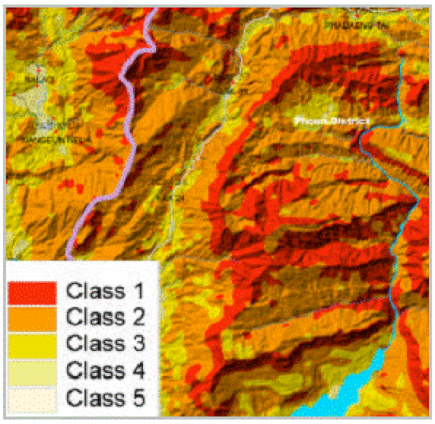

Figure 2: Watershed Classification Map [1]

- The watershed classification approach is to some extent incomplete because the soil types and the bedrock have not been considered collectively. In fact however these do have a profound influence on the risk of degradation through soil erosion.
- The boundaries of watershed classes are abstract and not really readily recognisable on the ground. One should consider for instance, that class boundaries may be located halfway up a homogenous slope (see above map).
- The concept of watershed classes is often difficult to communicate to the actual on site resource users. Even though an illiterate farmer will have a clear understanding of the idea of slope, most resource users will not so readily grasp the somewhat abstract logic behind the identification of watershed classes.

Example: Combination of Static and Dynamic Criteria

The MRC's *Watershed Management Project* has gone through a process of identifying pilot watersheds so that MRCS could support the development of innovative watershed management approaches. This was carried out at the Lower Mekong Basin-wide reconnaissance level. The approach was to identify watersheds in which watershed functions are currently likely to become critically impaired or are likely to be in the near future. The approach used a combination of static and dynamic criteria, geared towards identifying watersheds where: (a) access to agricultural land is constrained by biophysical parameters (static criteria); while (b) human induced change is currently highly intensive (dynamic criteria).

Since the approach was applied at the Lower Mekong Basin-wide level, the criteria had to be based on data that allowed a basin-wide comparison of watersheds. Data on water quality / quantity could not be used due to their sparse and inhomogeneous coverage. After evaluating various data sets and sources, it was decided to finally use the following criteria:

- The conversion from forest to non-forest land uses during the observation period, which is expressed in % per year (dynamic). This process is typically caused by logging, land clearing and burning.
- The establishment of new agricultural land during the observation period, which is expressed in % per year (dynamic). This includes the temporary or permanent establishment of new agricultural land in areas that previously had other land uses (forest, shrub lands, lying fallow, etc).
- The availability of flat or gently sloping lands per capita (watershed classes 4 and 5), considered to be suitable for agriculture (static, indicating constrained access to natural resources).

These criteria were combined and ranked using a multi-criteria analysis (See: TA: Multi-criteria Analysis [4.2.1]) and the ranking indicated the immediate risk of a watershed's functions being impaired. Please refer to a technical annex which shows the results of this approach (See: TA: Map Reconnaissance Level Identification of Critical Watersheds in the Lower Mekong Basin [1.2.2]).

References and Sources for Further Reading

- Breu, T. 2000: The Watershed Classification Project (WSCP) and GIS as a tool for sound Watershed Management. http://www.mekonginfo.org/mrc_en/doclib.nsf/0/A917F8B98167AAC4472569290016E966/$FILE/FULLTEXT.pdf [1]
- MRC / GTZ Watershed Management Project, 2003: Critical Watersheds. [unpublished]
- MRC / GTZ Watershed Management Project, 2004: Watershed Management Component. Glossary. [unpublished]
- MRC / GTZ Watershed Management Project, 2002: Watershed Management in the Lower Mekong Basin. Appraisal Report. Volume 1: Main Report, Volume 2: Country Reports. [unpublished]
- MRC / Centre for Development and Environment (CDE), 1997: The Watershed Classification Data Users Guide. [hardcopy]
- Tideman, E.M. 1996: Watershed Management – Guidelines for Indian Conditions. Omega Scientific Publishers, New Dehli. [hardcopy]

- MRC, 2000: Agriculture, Irrigation and Forestry Programme for 2001–2005. Sustainable Land and Water Use for Basin Health and People. MRCS, December 2000. [hardcopy]

References

[1] http://www.mekonginfo.org/mrc_en/doclib.nsf/0/A917F8B98167AAC4472569290016E966/$FILE/FULLTEXT.pdf

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