REFLECTIONS ON SOUND WATERSHED MANAGEMENT

Sound watershed management aims at securing and maintaining a desired flow of water over space and time, both in terms of water quantity and quality, with a view to optimise the supply of water for the different uses that exist in a given region, including the functions water fulfils in ecology and nature.

Water satisfies a wide variety of uses. While it is generally accepted that the provision of water for drinking is the top priority in terms of development, there is considerable debate about the relative importance of its other uses, which encompass agriculture, industry, services, particularly tourism, fisheries, hydropower, navigation, etc. For some communities, water is not simply an economic resource, but also provides the place where people reside; these communities do not only live from the water, they literally live on the water, having made it their home. This is the case in mainland Southeast Asia.
Asia, especially in the middle and lower reaches of the Mekong. Water is therefore a key natural resource in the Lower Mekong Basin and hence sound watershed management is a key issue in Basin development.

Sound watershed management is not exclusively a question of scientific expertise and databases. Of course these are important prerequisites for fact-finding and decision-making, but in essence, sound watershed management is as much concerned with policy as it is with science and data, since science has neither the mandate nor the legitimate authority to decide a desirable flow of water. Science can work out alternative scenarios for water use, but it does not have the criteria to decide which of these are better or more desirable for the communities concerned: this is an entirely political question, which must be solved in negotiation processes between all stakeholders involved, including local populations.

It is often heard that watershed management is concerned with conserving upstream areas for the benefit of downstream areas. There is some truth in this statement, but it is not the whole truth. Especially in the case of the Mekong Basin, the greatest share of water originates from the Lower Basin, more precisely, from the lowland Plateaus of Thailand and from the lowlands of the Lao P.D.R., Cambodia, and Vietnam. Hence, sound watershed management must not only be practised by upland communities for the benefit of lowland communities, but it must also be practised by the lowland communities themselves, for their own benefit.

**WATERSHED CLASSIFICATION: THE EXAMPLE OF THE MEKONG RIVER COMMISSION**

There are as many watershed classifications as there are aims for which the classification is used. A classification for the purpose of hydropower generation will look different from one dealing with forestry and agriculture. The watershed classification which is presented here aims at giving an indication of the sensitivity of watersheds with regard to water resources degradation mainly by soil erosion. On the basis of the topography of the landscape (parameters: slope, elevation, landform), 5 watershed classes are calculated by means of watershed equation and are depicted on the watershed classification maps at the scale of 1:250,000. Watershed Class 1 is the most sensitive, and Watershed Class 5 the least sensitive to water resource degradation by erosion. For each watershed class, general recommendations for sustainable land uses are given:

**Watershed Class 1: Protection Forest**
Areas with very steep slopes and rugged landforms, commonly uplands and headwater areas. Critical areas for water and soil resources management. Recommended land use: as a rule,
these areas should be under permanent forest cover. Other existing land uses 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**
Areas with steep slopes, usually at higher elevation. Landforms are in general less susceptible to water and soil degradation than under WSC Class 1. Recommended land use: forest (conservation and production forests), agro-forestry and grazing, if accompanied by strict conservation measures.

**Watershed Class 3: Agro-Forestry**
Areas with moderate to steep slopes and less erosive landforms. Includes uplands and foot zones of slopes. Wider range of land use tolerable than in WSC Classes 1 and 2 from point of view of water and soil conservation. May be used for commercial forest, grazing and combinations of trees and agricultural crops, if appropriate conservation measures are applied.

**Watershed Class 4: Upland Farming**
Gently sloping lands. Moderate need for water and soil conservation depending on local conditions. Wide range of land use possible from point of view of water and soil conservation: agriculture and forest.

**Watershed Class 5: Lowland Farming**
Gently sloping land and flat areas. Suitable for a wide range of land use from point of view of water and soil conservation: paddy rice, other agricultural uses and forest.

It is important to note that other land uses are not excluded, provided that adequate care is given to soil conservation.

For instance for areas in Class 1, the recommended land use is forest cover, but there are many examples, which clearly show that forest cover is not the only solution for conserving steep watersheds. Other land uses such as crop production on terraces, production of perennial crops, and permanent grassland have shown to be viable land use options for sensitive watersheds in many parts of the world. The same is true for well managed shifting cultivation systems with fallow periods long enough to allow natural forest re-growth and replenishment of soil nutrients.

**THE WATERSHED CLASSIFICATION METHODOLOGY**
The method is based on a watershed classification originating and used in Thailand in the late 1980s. The method developed for watershed classification in Thailand applied a multivariate statistical analysis for establishing relationships between a number of variables and watershed class numbers. It is based on the best currently available data for the variables of slope, elevation, landform, geology and soil. During the classification effort the variable forest cover was included at a later stage for different reasons.

However, the methodology and the watershed classes are the same as originally used by the Thai authorities. The rationale behind this decision was to establish a basin-wide classification that would allow, and promote, cross-boundary watershed management as well as basin-wide modelling.

As there was no soil and geology data readily available when the project started in the early 1990s, the variables were reduced to only three, which are slope, landform and elevation.
Involving the experts who had developed the method for Thailand, pilot areas were chosen in the Lao P.D.R. and Vietnam (Cambodia joined the project later), and the coefficients for the equation and their relation to the watershed classes were established.

**WSC equation**

\[ WSC = 1.79 - (0.035 \times \text{slope}) + (0.163 \times \text{landform}) + (0.002 \times \text{elevation}) \]

Based on the contours, rivers and spot heights taken from the 1:50,000 American topographic maps, a Digital Terrain Model (DTM) was calculated for more than 750 mapsheets with a Geographic Information System Software (Arc/Info). In order to overcome the correction problems with the standard algorithms of Arc/Info (terrace effects and over-exaggeration of the terrain surface) a sophisticated programme package was developed, which helped minimise such undesired effects.

From the resulting DTM, which had a resolution of a 50-metre cell size, the three parameters of elevation, slope and landform were derived and fed into the WSC-equation. The resulting numerical values were then classified and brought into a generalised and easy-to-read format with the help of filter operations.

**WHAT IS A DIGITAL TERRAIN MODEL?**

A Digital Terrain Model (DTM) is a computer based continuous representation of the topography, or in other words, of the landscape. The elevation information in a DTM is not measured in reality but calculated from altitude information (contours and spot heights), and often by adding the river network.

Through interpolation, the DTM attributes elevation information to each and every point, or cell of the area, which it covers. A DTM is thus digitally stored topographic information, which contains such parameters as slope, landform, aspect, and shape. In combination with other data sources a DTM provides the most important spatial basis for a wide range of simulations in natural resource management.

**PRODUCTS OF THE WSCP**

The products of the WSCP can be divided into three categories:

- The WSCP has elaborated and compiled over the last few years one of the most comprehensive GIS databases for natural resources management in the Lao P.D.R. and in the Lower Mekong Basin. This database not only comprises over 25 Gigabytes of WSC data, but it contains other data such as land use, natural resources, infrastructure, political boundaries and socio-economics, all in different resolutions.

- In addition to the digital database, different map products are available. Standard WSC maps on a scale 1:250,000 (see map excerpt) are available at the WSC Project office. Additionally, Provincial maps in A1-format can be obtained. For specific areas, the WSC Technical Team can
produce WSC maps upon request in different sizes and map scales.

- The WSCP also prepares custom-made products such as statistics, analysis, and provides GIS software and hardware support. Since 1997, the WSCP has supported a great number of government authorities as well as national and international organisations and projects, and its database and products are now widely used. Data provision often includes conceptual and technical advice. Finally, the WSCP provides conceptual and topical support in natural resources management and watershed management.

MANY USES FOR THE PRODUCTS OF THE WSCP

For a detailed account of the possibilities and potentials of the WSCP, the reader is referred to the WSC Map User’s Guide mentioned above.

The following paragraphs give a brief summary of the many potential uses and applications of the WSCP and of its digital database.

WSCP maps

The WSCP maps allow spatial priority settings for watershed management, because they show sensitive areas in terms of water resources degradation. By overlaying the Watershed Classes with the Forest Cover data (such as e.g. those produced under the Forest Cover Monitoring Project (MRCS-GTZ), critical areas with regard to degradation can be identified.

### WSCP Products

#### Countrywide digital data:
- Watershed Classification (raster / vector)
- Digital Terrain Model (raster)
- Hill shade relief (raster / image)
- Elevation (raster and vector)
- Slope in degree and per cent (raster / vector)
- Landform (raster)
- Flow direction (raster)
- Flow accumulation (raster)
- River network (vector)
- Contours (vector)
- Subcatchments (vector)
- National boundary (vector)

*All data are based on the maps 1:50,000 and are available in various degrees of generalization*

#### WSC maps:
- Provincial WSC maps
- WSC maps 1:250,000
- Country maps 1:1 Mio.
- WSC, Slope and Elevation
- WSC Map User’s Guide in English, Lao, Khmer and Vietnamese
- WSC Data User’s Guide in English

#### Services
- Conceptual support on Natural Resources Management and Watershed Management
- Custom-made maps
- Statistics and analysis upon request
- Data provision for government agencies and projects
- Modelling of hydrological features
- GIS and hardware support
DTM (Digital Terrain Model)

The digital terrain model can be used for three main purposes: Firstly, for statistical analysis (size of watersheds, distribution of slopes for individual watersheds, etc), and secondly, for modelling (hydrological modelling, dam site reconnaissance modelling, alternative road alignment reconnaissance, telecommunications, etc.), and thirdly, for mapping purposes (e.g. hillshaded relief representation, rectification of aerial photographs and satellite imagery). The DTM thus has an extensive potential, which goes far beyond watershed management.

FRAME OF REFERENCE FOR COMPLEMENTARY DATA SETS AND OVERLAYS

The WSCP database is derived from two layers, the river network and the contours. These two layers provide a frame of reference, which is the basis of almost every map, including thematic maps. The WSCP database can thus be used as a basis for the overlay of almost any other type of spatial information, such as e.g. soils and geology, climate (rainfall, temperature), forest cover/natural vegetation, agroecology, demography, land use, political and administrative boundaries, infrastructure and settlement, protected areas, logging concessions, to name but the most important thematic overlays. The resulting maps can then be used for inventorying, monitoring, modelling, and project planning.

HUMAN RESOURCE DEVELOPMENT: TRAINING IN GIS AND IN WATERSHED MANAGEMENT

Training of the main partners and users of the WSCP data (MRCS, riparian counterparts and other main partners) in both GIS technology and the WSC approach is of course necessary and indispensable in order to secure proper and adequate utilisation of the database.

However, the potential of the database for human resources development goes much beyond this specific form of training, because the WSCP also has a great potential as a training module in GIS and natural resources management at institutions of higher learning and at universities. Students interested in GIS or in watershed management, including modelling (modifications of the WSC-equation, changes in class boundaries, etc.) could address a wide range of questions in specific studies. Moreover, students could prepare large-scale extracts for local level studies or local level planning exercises, or for overlay with aerial photos or satellite images.
AWARENESS CREATION FOR DIFFERENT TARGET GROUPS

The WSCP data have a great potential for awareness creation among policy makers and the general public for issues relating to sound watershed management. However, awareness creation implies extraction of the main issues at stake and transformation into clear and intelligible messages, which can be absorbed by the targeted audience.

MICRO-LEVEL USES (LOCAL LEVEL, VILLAGE AND COMMUNITY LEVEL)

By its nature, the WSCP database is of the reconnaissance type. It is designed for strategic, basin-wide and national utilisation (planning of the planning). Despite this clear focus on reconnaissance, the data can be used for local-level applications, provided that they are refined and complemented.

With regard to refinement, users will find it necessary to have a higher resolution of the WSC data, then the original 50-metre cellsize.

By adding more contour lines and refining the river network, a high-resolution WSC database can be created.

Experience in Northern Laos and in Xieng Khouang Province has shown that approximately 15 days of work are needed to create the refined database and the maps on a scale 1:25,000 for an area of 100 sq km. In the examples given above, the resulting large scale 1:25,000 maps were used for participatory land use mapping and for the elaboration of a pilot Watershed Management Framework.

Local level uses will need complementation of the WSCP data with additional information. Some of this information can be derived from aerial photographs (forest cover, land use categories, settlement) or from documents available at provincial, district, or local levels (population figures, livestock numbers, etc.). Other information, however, will have to be taken directly from the field. This includes specific thematic information such as present land use, farming systems, and local needs, development priorities and initiatives of the local target groups, which include land users and administrators. This means that local level use of the WSCP data can be prepared from the office, but has to be complemented with field-based information. Field exposure and discussion at the local level are thus an absolute necessity if the WSCP data are to be used at the local level.

PRINCIPLES OF USE AND RESTRICTIONS FOR USE OF WSCP DATA

The following principles summarise the points discussed above about the proper utilisation of the WSCP data:

♦ The WSCP database is designed for reconnaissance information at the macro-level (basin-wide, national, and provincial levels). For micro-level use, the database has to be refined and complemented with other information including field investigations.

♦ The WSCP data must be put in context with the complex reality of watershed management. The WSCP data should be integrated into the participatory decision making process which is necessary for sound watershed planning and management.

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