433 Watershed Assessment

Module 4: Planning	**Watershed Level**

Chapter 4.3.3: Watershed Assessment

General

Good planning depends on the availability of good information and therefore planning processes include steps to gather and assess information [1]. Watershed assessments can be carried out with different degrees of intensity, and they are usually one of the first steps conducted during planning [8].

Box 1: A watershed assessment is a process for analysing a watershed's current condition and the likely causes of these conditions, which lead to a better understanding of watershed processes and conditions and the reason why the watershed is in that condition [10].

In a watershed context, assessments can serve the *purpose* of [2]:

- Determining the nature and extent of use impairments in the watershed
- Identifying the causes of use impairments
- Identifying potentials to enhance sustainable resources uses

Watershed assessments can be broad or focused, depending on their purpose and the context in which they are carried out during the planning process [10].

- A broad *baseline inventory*, including reconnaissance and baseline surveys, assesses the conditions of all processes and features in a watershed, and is usually carried out before or parallel to the problem analysis and scoping (Problem analysis and scoping is one of the first activities during the planning process. See also: Chapter 4.3.1: Introduction and Planning Process Overview). It provides a broad and representative overview of the watershed's condition and the existing problems within the watershed – often in form of watershed profiles (See also: CS: Watershed Baseline Survey – An Example from the Krong Ana Watershed, Dak Lak Province, Viet Nam [4.3.3]). They especially provide a basis to decide which problems or issues are in most urgent need of being addressed during the problem analysis (See also: Chapter 4.3.2: Problem Analysis and Scoping) [2].
- Focussed *in-depth inventories" render an intense assessment of specific issues, which have been identified during the problem analysis and scoping. They provide information to understand the cause and effect relationships of problems and interactions of watershed elements, as well as for the later development of realistic objectives in the planning process. They may also generate data with which predictive models for evaluating the impacts of development options (See also: Chapter 4.3.6: Evaluation of Options) can be created [4].*

Box 2: Rapid Hydrological Appraisal

An assessment approach that is mainly characterised by the features of baseline surveys, but which does include a specific focus, was developed by the *World Agro-forestry Centre* and applied in Indonesia. It is known as the rapid hydrological appraisal[a] approach, and it helps to characterise the hydrological situation and the perception of stakeholders to assess the opportunities of applying environmental reward mechanisms[b] to promote sustainable land use practices in the upland areas [5].

[a] See also: TA: Introduction to Rapid Hydrological Appraisal in the Context of Environmental Service Rewards [5.5]

[b] See also: Chapter 5.5: Payments for Environmental Services

Assessments commonly comprise a sequence of the following steps [10]:

- Organise a multi-disciplinary assessment team
- Define the purpose and develop a plan for the assessment, including a realistic schedule, budget, definition of necessary data and the identification of sources

- Collect data and information
- Analyse the data
- Report data or integrate it into decision-making

The remainder of this chapter will provide further information related to the scope of the data collection, data categories, methods and instruments, as well as the analysis, interpretation and integration of assessed data.

Scope of Data Collection

In a general sense assessments in the watershed context provide *information* on the bio-physical and socio-economic conditions, processes such as erosion and land use changes, as well as problems and concerns [1]. The following list includes the key categories of information that need to be collected [10]:

- Data on human activities and land uses: the location, type, intensity, extent, and proximity to or linkage to waterways
- Data on the physical, chemical, and biological properties and potential sources of impacts in the watershed: in-stream and riparian habitat characteristics, water quality data, animal / plant population diversity, etc
- Data on alterations in watershed processes: changes in the hydrological cycle, nutrient cycling, etc., particularly as they are affected by past and current water and land uses and also by climate change
- Data on the potential effects of potential impacts on watershed functions
- Data on upstream / downstream relations and external impacts
- Data related to the problems and concerns of stakeholders

Beside this, a further requirement is more detailed information related to the natural and human systems in watersheds (See also: Chapter 1.2.1: Watershed Elements) so as to understand watersheds for which planning takes place ([1], [2], [4], [11], [14]).

Water Resources

Water resources are subdivided in surface and ground water resources. The surface water is quantified as runoff or stream flow through water level observations and flow velocity measurements. Groundwater is the water that has passed through the land surfaces into underlying rocks and soils and is quantified with the help of ground water table measurements. *Parameters* to be assessed in this case are the ground water table below the surface, the water quality and heavy metals. For the surface water flow, the flow volume, the stored volume, the water quality, the sediment transport and accumulation rate as well as flood risks (See also: TA: Assessment of Water Resources [4.3.3]) should be included.

Almost all water users are affected by the quality of water. This is measured in a variety of ways, which may include measuring the physical or chemical features of the water. *Parameters* to be assessed are: total suspended solids, dissolved oxygen, pH, biochemical oxygen demand, total organic carbon, dissolved organic nitrogen and phosphorus (See also: Chapter 6.2: Indicators).

Land Use and Land Use Systems

The term land use implies both the current and the potential use by humans. Human use may change the landscape through various interventions such as resource extraction, housing, transportation as well as other means. When compiling data on current land uses, existing topographic and thematic maps, satellite images or aerial photograph's are helpful tools. *Parameters* to be assessed are: the extent of current land uses (e.g. natural forests, plantations, agro-forestry and pasture) (See also: Chapter 1.2.4: Land Use Systems in the Region) and land capability.

Vegetation, Plant and Animal Species (Biodiversity)

Biodiversity provides important information about the state of the watershed (e.g. natural state, disturbed, degraded) and indicates the need for the protection and conservation of habitats or certain species. Vegetation impacts and regulates hydrological processes (See also: Chapter 1.2.5: Impacts of Vegetation and Land Use on Water Resources), influences water quality and plays an important role in preventing soil erosion. *Parameters* to be assessed include:

vegetation types, plant and animal species present in a watershed area and the number of individuals of each species. Included also are endangered or threatened species and the interrelationship between the species and their environment.

Physical Features and Landforms

Planners also need to understand the bedrock and surface geology. The nature of the underlying rock determines the character of the overlying soils and influences water movement through the drainage of soils. The chemical properties of the rock are important in the instance of rock weathering processes, in which water flowing over the rock is affected by the chemistry of the rock. *Parameters* to be assessed are: location, elevation, geological formations, land forms, slopes and drainage patterns (See also: TA: Geology and Soils [1.2.1]).

Climate

Climate, including temperature, wind speed and direction, as well as precipitation influences water resources and biological processes in a watershed. Simple rainfall measurements record the volume of rainfall over a certain time period. Moreover, advanced methods collect information about the duration and volume of a rainfall event and thereby describe its intensity, which is important in understanding erosion processes and flood events. Wind conditions may affect land and water processes, particularly evapo-transpiration [1] and wind erosion. *Parameters* to be assessed are: precipitation, wind, evapo-transpiration, temperature and humidity (See also: TA: Climate [1.2.1]).

Soils, Infiltration and Runoff

The ability of a soil to transport water depends on the size and condition of pores and channels in the soil layer. These depend on the size of soil particles, the degree to which individual soil particles are aggregated into larger masses, the arrangement of individual particles and aggregates and the abundance of organic material. *Parameters* to be assessed are: soil types, soil texture, soil structure, infiltration rates, soil fertility and erosion risks (See also: TA: Geology and Soils [1.2.1]).

Socio-economic Systems

They comprise human systems and infrastructure that overlay the natural environment. These systems affect people's attitudes and values and influence the support of stakeholders which is central to the implementation of watershed management. *Parameters* to be assessed are: demography, land tenure, education, employment, marketing, labour, income, local institutions / organisations, service systems, traditions, as well as cultural and land management practices (See also: Chapter 1.1.7: Methods and Instruments for Watershed Management).

There is a tendency to collect more data than necessary in one area and insufficient information in another. Therefore, preparatory work is required to determine data needs, prior to the data collection process [11]. As the task is not to collect as much data as possible, it should instead be limited to the quantity of data that is absolutely essential, verifiable and can be analysed economically [2].

Data Characteristics and Categories

Collected information and data should be recent, detailed, reliable and representative as a basis for planning in the watershed context [2]. In general, data can either be collected as secondary (already existing data) or generated as primary data.

Secondary data: Collecting data from existing databases and sources is usually the first step when conducting an assessment. Especially broad baseline surveys depend on the availability of secondary data. In many cases surveys (e.g. soil, geology) and inventories (e.g. forests) have already been carried out and therefore relevant data can be derived from different national and international organisations in form of reports, statistical records, maps and digital data bases. It is also often possible to acquire historical data and materials such as aerial photos, satellite images or different maps from these sources. A little research will avoid the duplication of efforts and will also save time and financial resources [12].

Primary data: It may not be possible to obtain sufficient detailed information to characterise the watershed solely through secondary data and direct observation. In such cases the collection of primary data is necessary, which is especially the situation for focused in-depth assessments [6]. Information requirements identified during the problem analysis and scoping stage and the analysis of existing secondary data can help to plan such assessments [12]. The task of the planning team is to determine the focus, level of detail and degree of intensity of the assessment, and also to agree on the methods to be applied as well as the process of data analysis. This depends on the information requirements, as well as the financial, human and technological resources that are available [2]. The collection of primary data is typically based on varying intensities of random or systematic sampling [15]. Survey forms or tables should be concise, practical, well designed and checked in the field before use [11].

Methods and Instruments

Two important methods to collect primary data are through surveys that can be categorised as either informal / manual, using for example various participatory rural appraisal (PRA) techniques or as formal / technical, such as land use inventory. These can be briefly outlined as follows:

Informal participatory surveys are usually carried out by applying different participatory planning and assessment approaches such as rapid rural appraisal (RRA), participatory rural appraisal (PRA), or farming system analysis (FSA) (See also: Chapter 1.1.7: Methods and Instruments for Watershed Management ; TA: General Description and Application of Selected Participatory Techniques [1.1.7] ; TA: Technical Description of Selected Participatory Techniques [1.1.7]). Through their application it is possible to rapidly collect bio-physical and socio-economic baseline data in relatively small areas such as villages or catchments. The most common techniques used in these approaches include: observations, transect walks, interviews with key informants (semi-structured), community workshops / group meetings, diagramming, ranking, resource mapping, and livelihood analysis. The outputs and results are often used to produce [2]:

- Sketch / resource / land use maps
- Cross-sections / transects (indicating topography, vegetation and land use, etc.)
- Historical profiles, time lines
- Trend analysis
- Indigenous knowledge profiles
- SWOT (strengths, weaknesses, opportunities, threats) analysis charts
- Problem-tree / objectives-tree analysis charts
- Community vision plans
- Case studies
- Charts related to ranking, rating and sorting (of wealth / income, problems / concerns etc.)
- Diagrams (seasonal activities, institutional relationships, income-expenditure flows etc.)

Technical survey methods include, for example geological surveys, as well as forest and land use inventories that often combine field surveys and the application of remote sensing technologies such as satellite images and aerial photographs. Data collection is possible on a small (e.g. catchments) and on a larger scale (e.g. river basin) and is often based on a specific sampling design. They apply advanced data measuring and recording methods, such as global positioning system (GPS) and computer-based analysis technology as for example GPS and the geographic information system (GIS) (See also: 1.1.7: Methods and Instruments for Watershed Management). In some applications, as in soil and water surveys, it is also necessary to carry out the laboratory analysis of field samples.

GIS is an essential tool for planning in the watershed context and has been widely used for the assessment of watershed conditions. Data gathered from GPS surveys and from environmental remote sensing systems can be integrated with GIS for advanced assessments of watershed functions and conditions [13].

Many previous experiences in watershed management and its related interventions have shown that the *combination of both methods" does have its advantages ([2], [6], [7], [8]). This is illustrated by an example with a combination* *of manual and technical mapping which was applied during a land use planning procedure in Cambodia (see box 3).*

Box 3: Participatory village mapping is an indispensable tool for participatory land use planning (PLUP) in order to actively involve stakeholders in planning. However it should be **combined with technical mapping** for the following reasons [8]:

- Technical maps provide a picture of the sizes and interrelations of different land use categories that is accurate and to scale. This is important for example in boundary areas where the claims of villages or communes may overlap. In the case of manual village mapping, the magnitude of such overlaps quite often remains unclear, making it difficult to find solutions that are accepted by all parties.
- Technical mapping eliminates ambiguities and uncertainties and provides a clear reference for registration. It is for this reason that the authorities recognise technical maps much more than manual village maps. This is an important issue when PLUP is used to prepare maps that register existing and propose long-term future user rights, which need the approval and signature of the authorities.
- Manual village mapping and technical mapping are not mutually exclusive. It may for example, be highly beneficial to use technical maps, such as enlarged aerial photos or 3-dimensional terrain maps, as base materials on which manual village maps can be drawn.
- Every developed country has land administration and cadastral systems, which are always based on technical mapping. Omitting technical mapping now only means that it will have to be done later, and will cause the duplication of efforts and increased costs.

Analysis, Interpretation and Integration of Data

The last phase of an assessment includes the analysis, interpretation and integration of data. It should be examined and analysed in an informal way (*exploratory data analysis*), before the commencement of any formal statistical analysis. One method that can be employed is descriptive statistics those being simple calculations that can be done on an Excel spreadsheet. It usually involves the calculation of the mean or average value, as well as the standard deviation (or range of variation), and the creation of a frequency distribution if sufficient data exists. These actions will lead to a better understanding of the data, and these simple statistics are sometimes all that is needed, especially if dealing with a small dataset [10].

The results of such an informal data analysis might determine whether it would be useful to perform a *formal statistical analysis* in order to identify significant changes and trends over time or space within the watershed. At this stage it would be useful to consider the following questions [10]:

- Is the data of sufficient quality to be utilised?
- Does the data meet appropriate official standards and practices for collection?
- Are the data collection methods documented adequately so that it is possible to assess their quality?
- What statistical tests, if any, are going to be used? Some screening level assessments do not necessarily require statistics. Additionally, if the datasets that have been collected are limited in scale, they might not be suitable for statistical analysis.

The next step would be to incorporate or integrate all the information into an *integrated analysis*. In order to do this we need to combine or link information about the various watershed processes and attributes in a way so that it leads to conclusions about the overall condition of the watershed and the possible causes. There are many possible ways to integrate information, which can range from qualitative to highly quantitative and from informal to formal methods. Often a group of experts from varying disciplines are involved in the evaluation of information. Other watershed assessments rely on computer modelling for most of the information processing and evaluation [10].

GIS has emerged as powerful tool in the management and analysis of a large amount of basic data in a spatial format. It can be used, in a flexible, versatile and integrated manner to generate maps, tables and textual reports. The use of GIS results in the rapid generation of thematic maps and area estimates and enables many of the analytical operations to be carried out in a spatial format. This is achieved by combining different sets of information in various ways to produce overlays and interpreted maps [3].

The highly complex nature of human and natural systems in watersheds, and the ability to understand them and project future conditions has increasingly taken a geographic dimension. GIS technology therefore plays a critical role in the process [13], but this also requires considerable investment in computer hardware and staff training if it is to be effective [3].

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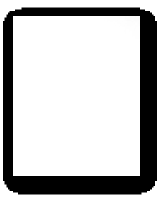
Handout



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