Sustainable Development Indicators of Some European & Asian River Basins

Compilations of comparative data for a bioregional set of river basins might have value in assembling similar information for river basins around the world to aid in sustainable river basin management.

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A group of 24 river basin specialists, representing a range of disciplines, gathered in Moscow from October 21 to 24, 1997, for the "NATO Advanced Research Workshop on Sustainable Management of Transboundary Watercourses: Theory and Practice." International environmental lawyers, scientists, engineers, economists and policy specialists were represented. The workshop provided a unique opportunity to review the theory and practice of integrated and sustainable river basin management and to discuss and compare transboundary river basin issues for the following major river basins in West, Central, and Eastern Europe and Western Asia:

- Rhine,
- Danube,
- Odra,
- Douro,
- Dneiper,
- Dneistr,
- Amu-Darya, and,
- Sry-Darya.

Presentations during the first day provided the conceptual framework. Integrated and sustainable river basin management was approached from the general perspectives of the New European Directive and the World Bank. Water law principles, ecosystem orientation and climate change impacts on water resources were also among the key themes.

Presentations given on the next day addressed transboundary watershed issues in each of the individual river basins. The workshop was organized so that at least one, and possibly several, specialists from the Rhine, Danube, Odra, Douro, Dneiper, Dneistr, Amu-Darya and Sry-Darya river basins gave presentations.

The last day involved discussions of three working groups: scientific, policy/management and legal, and a closing plenary session in which a summary and conclusions were offered.

Participants in the scientific working group recognized that, together, they represented a wealth of information and knowledge of major river basins in West, Central and Eastern Europe and Western Asia. They agreed that it would be useful to summarize this information and knowledge in the simple format of fact/sustainability indicator sheets for each river basin. A sample fact/sustainability indicator sheet for the Rhine basin is provided in Table 1 to show the general format for these sheets.

Historical Developments in the Study of River Systems

The scientific working group was aware of the historical development in the study of river systems, beginning in the early 1900s, when most scientific studies were conducted on small river segments or reaches. By the late 1950s, there was a shift to more holistic views of flowing water, and in the 1960s and 1970s emphasis was placed on watersheds as the logical basic unit for river studies as well as on land-water interactions. Next, a major shift occurred in the 1980s, with the recognition that many aspects of river dynamics could only be understood through an integrated spatial and temporal perspective.[1] In the 1990s, with attention being directed at human impacts on the global environment (such as global climate change), there has been an ever-increasing impetus towards extending the scale of focus from micro-scale (river reach), to meso-scale (river basin) to macro-scale (bio-regional). The NATO Advanced Research Workshop provided the opportunity to address river basin issues at the meso- and macro-scales.

Sustainable Development & Sustainability Indicators

Since the concept of *sustainable development* was first articulated in the 1970s, made widely known by the 1986 Brundtland Report, *Our Common Future,* and internationally embraced at the United Nations Conference on Environment and Development (the so-called Rio Earth Summit) in the document "Agenda 21," scores of people in fields ranging from architecture to industry to zoology have been discussing sustainable development. Principles for sustainably managing water resources were first articulated by people from more than 100 countries during the 1992 International Conference on Water and Environment. These "Dublin Principles" (see Table 2) were subsequently endorsed by major international conferences, including the 1992 "Rio Earth Summit."

An extensive review of sustainable development definitions, principles, criteria, indicators, conceptual frameworks and information systems was presented at the 1997 American Association for the Advancement of Science (AAAS) annual conference as part of an International Institute for Applied Systems Analysis seminar.[2] That presentation included a compilation of 29 sets of sustainability indicators, dating from 1972 through 1997. The web site, www.sustainableliving.org, covers portions of the AAAS presentation, including:

- Over 50 definitions of sustainable development;
- 17 sets of sustainable development principles;
- 12 sets of sustainable development criteria;
- The 29 sets of sustainability indicators (noted above); and,
- 17 sustainable development conceptual frameworks.

This information was compiled from materials written by many of the major leaders in the sustainable development movement (for example, the United Nations [UN], non-governmental organizations [NGOs], the World Bank, the Organization for Economic Cooperation and Development [OECD], etc.). The "raw materials" included on this web site are intended to aid visitors in understanding the complex notion of sustainable development.

The practical application of sustainable development concepts must be based on an

TABLE 1.
Fact/Sustainability Indicator Sheet for the Rhine Basin

River Length (km)	1,320
Basin Area (km^2)	188,000
Population (millions)	50
6 Riparian Countries	Switzerland, France, Germany, Austria, Liechtenstein, The Netherlands
6 + 2 Basin Countries	Switzerland,* France,* Germany,* Austria, Liechtenstein, The Netherlands* + Luxembourg,* Belgium
Principal Uses	Discharge of water sediment & ice; ecological backbone; potable, industrial & agricultural water supply; navigation; power generation; cooling water; recreation, tourism, swimming; fisheries; nature; landscape; receiving water for treated wastewater; source of building materials
Existing System of Data Collection	There is an international monitoring network. As far as possible, ISO standards are applied. In other cases, harmonized measurement & analysis methods are applied.
Existing System of Data Exchange	Water levels. For emergency situations: discharges of instantaneous water quality parameters are required immediately after becoming available; otherwise, these data are made available on an annual basis.
Major Transboundary Conflicts	Major conflicts do not exist at the moment
Major Watershed Problems	Non-point source pollution, especially nutrients, heavy metals & organic micro-pollutants; flood protection in the long run.
Average Flow at Transboundary (million m^3/yr)	Basel: 1,000 m^3/s (Switzerland, Germany, France) Lobith: 2,200 m^3/s (Germany, Netherlands)
Peak Flow at Transboundary (million m^3/yr)	Basel: 4,000 m^3/s Lobith: 12,800 m^3/s
Minimum Flow at Transboundary (million m^3/yr)	Basel: 350 m^3/s Lobith: 600 m^3/s
Number of Dams/Weirs	450
Live Storage Capacity (million m^3/yr)	Above Basel: 1.8 billion Below Basel: 0.7 billion
Water Quality (% Clean)	90% Clean
Water Quality	at Lobith (Germany, Netherlands)
TSS	50 mg/l
TSS (annual load to ocean)	0.7** × 10^6 tons/yr
TDS (mg/l)	600**
TDS (annual load to ocean)	44.7** × 10^6 tons/yr
Dissolved Oxygen	10 mg/l
BOD5	2.8 mg/l
Total Phosphorus	0.25 mg/l
Nitrate	4 mg/l
Toxins	0.03 mg/l (extractable organic halogens = sum parameter)
Percent Wastewater Treatment	90-95% biological treatment (implementation of phosphorus & nitrogen removal)
Annual Precipitation (mm/yr)	1,100
Annual Evapo-transpiration (mm/yr)	580 mm/l
Irrigated Area (ha)	Unknown (depends on precipitation & evapotranspiration)
Commerical Fish Catch	
Legal (million tons/yr)	70 (Netherlands Guilders)
Illegal (million tons/yr)	
Number of Endangered Species From Red Book	Objective is to return disappearing species such as salmon, etc.
River Flow Diversion to Other Catchments (km^3/yr)	Small amount
Length of Diking (km)	approximately 2,500
Water Consumption	
Drinking (l/day)	130 (Netherlands); 400 (Switzerland)
Industrial (million m^3/yr)	1,000
Irrigation (million m^3/yr)	5,000
Cooling (million m^3/yr)	12,000

Notes: * Contracting parties to the Agreement of Berne in 1963, covering 98 percent of the river basin.
**Global Environmental Monitoring System (GEMS): www.cciw.ca/gems/atlas-gwq/gems1.html.

TABLE 2.
The "Dublin Principles"

Principle No. 1: Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.

Since water sustains life, effective management of water resources demands a holistic approach, linking social and economic development with protection of natural ecosystems. Effective management links land and water uses across the whole of a catchment area or groundwater aquifer.

Principle No. 2: Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels.

The participatory approach involves raising awareness of the importance of water among policy-makers and the general public. It means that decisions are taken at the lowest appropriate level, with full public consultation and involvement of users in the planning and implementation of water projects.

Principle No. 3: Women play a central part in the provision, management and safeguarding of water.

This pivotal role of women as providers and users of water and guardians of the living environment has seldom been reflected in institutional arrangements for the development and management of water resources. Acceptance and implementation of this principle requires positive policies to address women's specific needs and to equip and empower women to participate at all levels in water resources programs, including decision-making and implementation, in ways defined by them.

Principle No. 4: Water has an economic value in all its competing uses and should be recognized as an economic good.

Within this principle, it is vital to recognize first the basic right of all human beings to have access to clean water and sanitation at an affordable price. Past failure to recognize the economic value of water has led to wasteful and environmentally damaging uses of the resource. Managing water as an economic good is an important way of achieving efficient and equitable use, and of encouraging conservation and protection of water resources.

agreed upon set of sustainability indicators. Generally speaking, indicators simplify and briefly represent (qualitatively and quantitatively) essential, complex and dynamic information — for example, weather forecasts, economic indicators such as inflation rate and gross national product (GNP), population statistics, such as birth, death and life-expectancy rates, and so forth. The overall purpose of any indicator is to present complex information in a simple way. The identification of an agreed upon set of river basin and water-related sustainability indicators is merely one element of an integrated and sustainable approach to river basin management. Just as the identification, for example, of low life-expectancy rates is not to be confused with public health programs to increase life expectancy, so, too, river basin and water-related indicators are not intended to substitute for actions necessary to maintain or restore water quality or river basin functions. They are simply a first step in providing basic information.

Since the idea of sustainable development indicators first gained attention, a number of river basin and water-related indicators have been put forward. Table 3 provides a compilation of river basin and water-related sustainability indicators, grouped under three headings: water use, water quality, and ecosystems and natural resources.

Sustainability Indicators

Cognizant of river basin and water-related sustainability indicators such as those listed in Table 3, the scientific working group proposed fact/sustainability indicator sheets for each of the river basins under discussion. Individual river basin fact/sustainability indicator sheets were generated by a designated participant and reviewed by collaborators. These sheets are intended to briefly present basic scientific information concerning each particular river basin. (A sample fact/sustainability indicator sheet for the Rhine basin has been provided in Table 1.) Common parameters are used to allow comparisons across river basins. The parameters selected represent data from the various different disciplines.

Numerous efforts to collect and present data on a regional or global set of river basins have been made in the past.[3-7] One such effort was the Global Environmental Monitoring System (GEMS). The GEMS program was established in the mid-1970s by the United Nations Environment Program (UNEP) as a follow-up to the 1972 UN Stockholm Conference on the Environment. As a collective effort to monitor the world environment in order to protect human health and preserve essential natural resources, it involves the participation of numerous UN agencies and the collaboration of several organizations around the world. One program component of GEMS, called "Water," focused on monitoring and assessment of freshwater quality in all regions of the world. Since December 1977, as the lead agency for the implementation of this program, the World Health Organization (WHO) has coordinated a wide group of activities in collaboration with water-related units of UNEP — the World Meteorological Organization (WMO) and UNESCO. The main objectives pursued under GEMS/Water are:

- Determination of the status and trends in quality of freshwater in various parts of the world; and,
- Improvement of water quality monitoring and assessment capabilities in all countries in support of sustainable environmental management practices in their respective water resources sector.

However, participants at the Moscow workshop did not believe that fact/sustainability indicator sheets showing comparative data for a bioregional set of river basins had been previously assembled. They became convinced that the kind of information presented in these sheets not only provides useful overviews of the river basins covered at the October 1997 NATO Advanced Research Workshop, but also might be relevant to similar reviews of sustainability factors affecting other major river basins around the world.

TABLE 3.
River Basin & Water-Related Sustainability Indicators

Water Use
- Qualitative description of uses of water resources
- Percent of population served by treated water supply
- Percent of population served by sanitary services
- Daily household water use per capita
- Rates of water withdrawal & consumption by key economic sectors (agriculture, industry, commercial, domestic)
- Rates of water recirculation by key industrial sectors
- Total water withdrawal compared to growth in GNP
- Degree of utilization of freshwaters
- Groundwater reserves where withdrawal exceeds recharge
- Occurrence of contaminated groundwater

Water Quality
- River quality — entering a country, leaving a country
- Concentrations of dissolved oxygen, phosphorus & nitrogen in freshwater
- Pesticide concentration in freshwater
- Concentration of fecal coliform in freshwater
- Number of people with unacceptable domestic water quality
- Percent of municipal wastewater treatment
- Municipal discharges of BOD, TSS & phosphorus to freshwater
- Pulp & paper mill discharges of BOD & TSS to freshwater

Ecosystems & Natural Resources
- Wetlands of international importance that are highly protected/little disturbed
- Index of watershed naturalness
- Percent of streams one can drink from safely
- Groundwater reserves
- Number of threatened & endangered species
- Fish harvest in relation to sustained yield

Note: This compilation draws on indicator sets from the International Union for the Conservation of Nature and Natural Resources (IUCN), 1980; the Organization for Economic Cooperation and Development (OECD), 1991; CSIRO, Australia, 1992; the World Bank, 1995; and www.sustainableliving.org.

NOTE — *Aided by a grant from BSCE's John R. Freeman Fund, the author spent five days in Moscow in late October 1997 attending the NATO Advanced Scientific Workshop, where she presented a paper entitled, "The Danube River Basin: A Model of Integrated and Sustainable Watershed Management?" She was also the invited leader of the Scientific Working Group, summarizing its work for the benefit of the overall meeting. This article provides an overview of the entire event. Copies of Murcott's Danube paper and the fact/sustainability indicator sheets on the other river basins are available upon request from the author (Susan Murcott, Ecosystems Engineering, 58 Orne St., Marblehead, MA 01945). All of these materials — Danube paper and the sustainability sheets — are planned for publication in 1999 by Kluwer Academic Press in The Netherlands (Wouters, P., & Vinogradov, S., eds., "Sustainable Management of Transboundary Watercourses: Theory and Practice," NATO Advanced Research Workshop).*

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