Technical Advisory Paper No. 3

Future Needs in Water Quality Monitoring and Assessment

UNEP GEMS/Water Programme

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Future Needs in Water Quality Monitoring and Assessment

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The target audience for this paper is national focal points, collaborating focal points and partner agencies. Readers are encouraged to send comments, feedback and suggestions to info@gemswater.org.

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PART I: Introduction

The role of the Technical Advisory Group (TAG) is to convene every eighteen months to examine in detail a wide range of technical aspects of, and projects for, UN GEMS/Water Programme. The group is composed of members of the GEMS/Water Steering Committee, as well as representatives of other GEMS/Water partners. The TAG is chaired by a senior UNEP official.

Usually, the Technical Advisory Papers serve to provide background information as a guide for the discussions of the TAG meetings. The present paper is an exception, as it has been based on the recommendations and outcomes of the meeting. It still represents the "corporate view" of the TAG on global water quality monitoring, and the most salient issues facing GEMS/Water. It forms the basis for determining partnership activities: on one hand, the most constructive ways in which partner organizations can contribute to the successful implementation of core activities; and, on the other hand, the best ways for meeting partners' data and service needs.

This paper, being developed in that context, is divided into three main parts. Part I outlines the global context in which GEMS/Water works, and its roles.

For each of the four core activity area, there are several emerging issues identified for consideration by the TAG. The intent of Part II is to develop strategic recommendations to take advantage of opportunities, and to mitigate challenges. This section also focuses on key projects in which GEMS/Water is, or should be, actively engaged. The broader international scientific and technical context helps to identify the most constructive ways in which partner organizations can contribute to the successful implementation of the core activities. Part III introduces future needs in water quality monitoring and assessment and briefly addresses them. This paper will be used to guide the technical aspects of GEMS/Water for the near future.

Context— Core Activities and Results

1. Water Quality Advocacy, Assessment
Enhanced awareness of the state of water quality, importance of water quality monitoring, and problems and emerging issues through cooperation, among governments and the public, to better support sustainability.

A leading source of data, monitoring information, and analysis of inland water quality, for global and regional environmental **assessments and indicators** development for better understanding and decision-making of inland aquatic environmental issues related to global environmental change, and in support of MDG/WSSD targets.

2. Water Quality Data, Information
Development and maintenance of global water quality data and information systems to improve accessibility to credible and comparable data and, contribution to accessibility and interoperability with other environmental information systems.

GEMStat: global inland water quality **database** and information system, and GEMSoft support software.

3. Data Integrity, including Technical Tools, QA/QC, Alternate Technology
Increased reputation as a credible and reliable source for global water quality data and information, to add value to local-level data collection, and appropriate monitoring and observation technology.

Data Integrity (**QA/QC**) **tools** and resources, such as manuals and reference materials and an international laboratory performance evaluation system.

4. Capacity Building, Regional Development
Increased participation or involvement in water quality monitoring, assessment, research and reporting in developing countries and countries with economies in transition

Build the **capacity** of developing countries to collect, manage and analyze water quality information.

5. Organizational Performance Cross-cutting Function
Improved internal calibre of the Programme to deliver results 1 to 4 and products by strengthening human, financial and information management; and by institution building.

A cross-cutting function of measuring the achievement of the four other result areas through key **performance** indicators. This core activity was not addressed by the group.

Part II: Emerging Issues and Recommended Actions

1.0 Global Water Quality Assessments

- How can GEMS/Water best contribute to global and regional assessment results?
- What should GEMS/Water be anticipating in terms of future needs of assessment processes and governments?
- What is the correlation between scientific monitoring/assessment and the health of an ecosystem?

The Global State of Water Quality Monitoring:
The essential question for GEMS/Water is whether or not the water quality of lakes, reservoirs, rivers and ground waters throughout the world is improving or deteriorating. This question drives the role for GEMS/Water in data collection and assessment. This question should help guide GEMS/Water in providing services governments need to improve their capacity (as per the Bali Strategic Plan).

GEMS/Water annually reports on the global state of the GEMS/Water global monitoring network, alongside the Annual Report. The purpose is to create linkages within the network and to encourage participation and regional development.

The GEMS/Water global network now totals 2,743 stations, and the list of countries not participating is shrinking over time. The number of data points in GEMStat is now 2,323,026 and continues to grow.

Water Assessment Reports:
Linkages with the WHO/ UNICEF Joint Monitoring Programme would also be strategic, as focusing on water quality can contribute to the Millennium and WSSD goals. There are data on faecal coliform, for example, that demonstrate that the water and sanitation targets can be met.

Over the past year, GEMS/Water has contributed new data and assessments to the Global Environmental Outlook-4, the Global Biodiversity Outlook-2 and the World Water Development Report-2. Work is also underway on indicators, and developing a source drinking water index.

Forthcoming is a new and independent publication entitled *Water Quality for Ecosystem and Human Health*. This is the first report of its kind produced by GEMS/Water, and the target audience includes academia, research scientists, and water practitioners. Drawing on examples

from around the world, the report presents assessments of current status and trends in water quality. It also provides an introduction to a diverse range of issues of concern in global water quality, and approaches to their detection and resolution.

Indicators and Composite Index Development:
The 2005 Environmental Sustainability Index Report reported that:

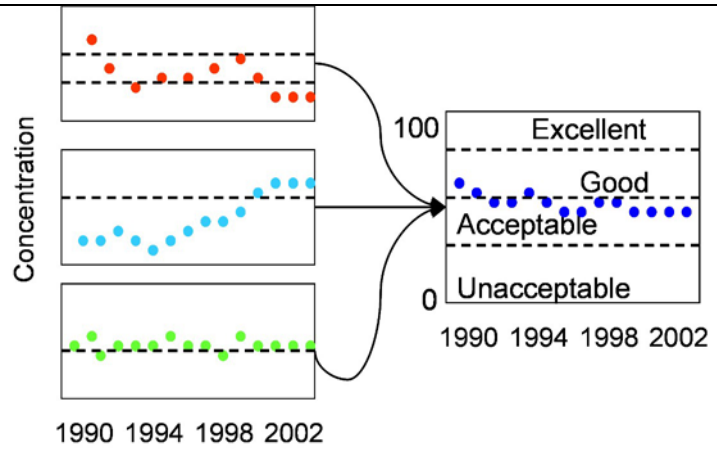
> The Global Environmental Monitoring System Water Program (GEMS/Water) has been an important source of data for the ESI because it is the primary source of comparable international information on surface water quality. The ESI reports were straightforward in their assessment that the suitability of the GEMS Water data for comparing water quality across nations was very low. In the past, very few countries provided data to the program and the data were difficult to obtain. When the 2003 World Water Development Report reprinted the 2002 ESI water quality indicator data, it drew attention to water quality data issues. Some governments were unhappy with the fact that the data table included only estimates of water quality where data was missing from GEMS/Water. Others were dissatisfied with the fact that some countries reported data from a large number of water monitoring stations whereas others reported only a small number. These complaints drew high-level attention to the serious deficiencies in the GEMS/Water program, and played a significant role in a strategic effort to build the program into a more robust repository of relevant water quality data. A major drive was launched to bring new countries into the program. The approach shifted from passively receiving data from countries to actively requesting data updates on a regular basis. In addition, the data was made much more easily accessible. As a result of these changes, participation in GEMS/Water has grown from less than 40 countries when the ESI first started using the data to over 100 countries today, although data coverage is still low. While the ESI cannot take credit for this shift, it did contribute to it by aggregating the GEMS Water data into national indicators and raising those indicators to high prominence.

GEMS/Water has become increasingly engaged in indicators development work within UNEP, and also with the WWAP and the Convention on Biological Diversity. Three water quality indicators are being developed:

- Source water quality indicator (SWQI);
- Biodiversity indicator – a GEF funded project, with UNEP-WCMC; and
- Eutrophication indicator.

Progress is also being made towards a Global Water Quality Index. The index calculation is based on important water quality variables compared to appropriate guidelines; results combined to produce a single number categorizing WQ as excellent, good, fair, marginal, poor.

$$\textit{WQ Index} = 100 - \frac{\sqrt{(F1^2 + F2^2 + F3^2)}}{1.732}$$



Where:
F1 = percentage of failed variables (scope)
F2 = percentage of failed tests (frequency)
F3 = amount by which failed tests exceed guidelines (magnitude)

UNESCO-IHP:
Participation between GEMS/Water and IHP continues to be very active, and a new MoU which was signed in July 2006. The main results from implementing the MoU are anticipated to:

- strengthen cooperation between UNESCO-IHP and GEMS/Water Programme, particularly with Ecohydrology and the International Sedimentation Initiative;
- maintain closer linkages with the World Water Assessment Programme as well as with Ecohydrology;
- increase the scientific aspects of the World Water Development Report in close cooperation with GEMS/Water Programme; and
- ensure collaboration with the new European Centre for Ecohydrology, Lodz, Poland.

Ecohydrology:
Also with UNESCO-IHP, GEMS/Water has strengthened its participation with the European Regional Centre for Ecohydrology. Very simply described, Ecohydrology is the rejection of extra nutrients, and reallocation of remaining nutrients (manipulating the water). Points of collaboration between IHP Ecohydrology and GEMS/Water focus on greater efficiency generated from investment in Ecoyhdrology for problem solving.

2.0 Global Water Quality Data

- How can divergent views on access to data be reconciled?
- How can GEMStat be expanded?
- How can data reporting become more efficient?

Access to Data:
It has been increasingly recognized that access to information and the sharing of tools and resources are vital to achieving results. Open access needs to be balanced with the wishes of data providers regarding use of their data. With these and other considerations in mind, GEMS/Water has expanded the global water quality online database, GEMStat, (www.gemstat.org), as an open web service. This action was launched on World Water Day, March 22nd 2006, at the World Water Forum IV in Mexico. A policy of open source has been equally applied to GEMSoft (forthcoming data submission software) to increase utility and interoperability.

GEMStat and Google Earth:
GEMStat monitoring stations are now mapped using Google Earth. This capability allows users to see the physical setting of every station, and its surroundings. With Google Earth all 2,743 GEMStat stations can be geospatially located with 3-dimentional satellite pictures. This means that the physical features and characteristics of each GEMStat monitoring station are visible, such as land use, deforestation, proximity to a factory or a city.

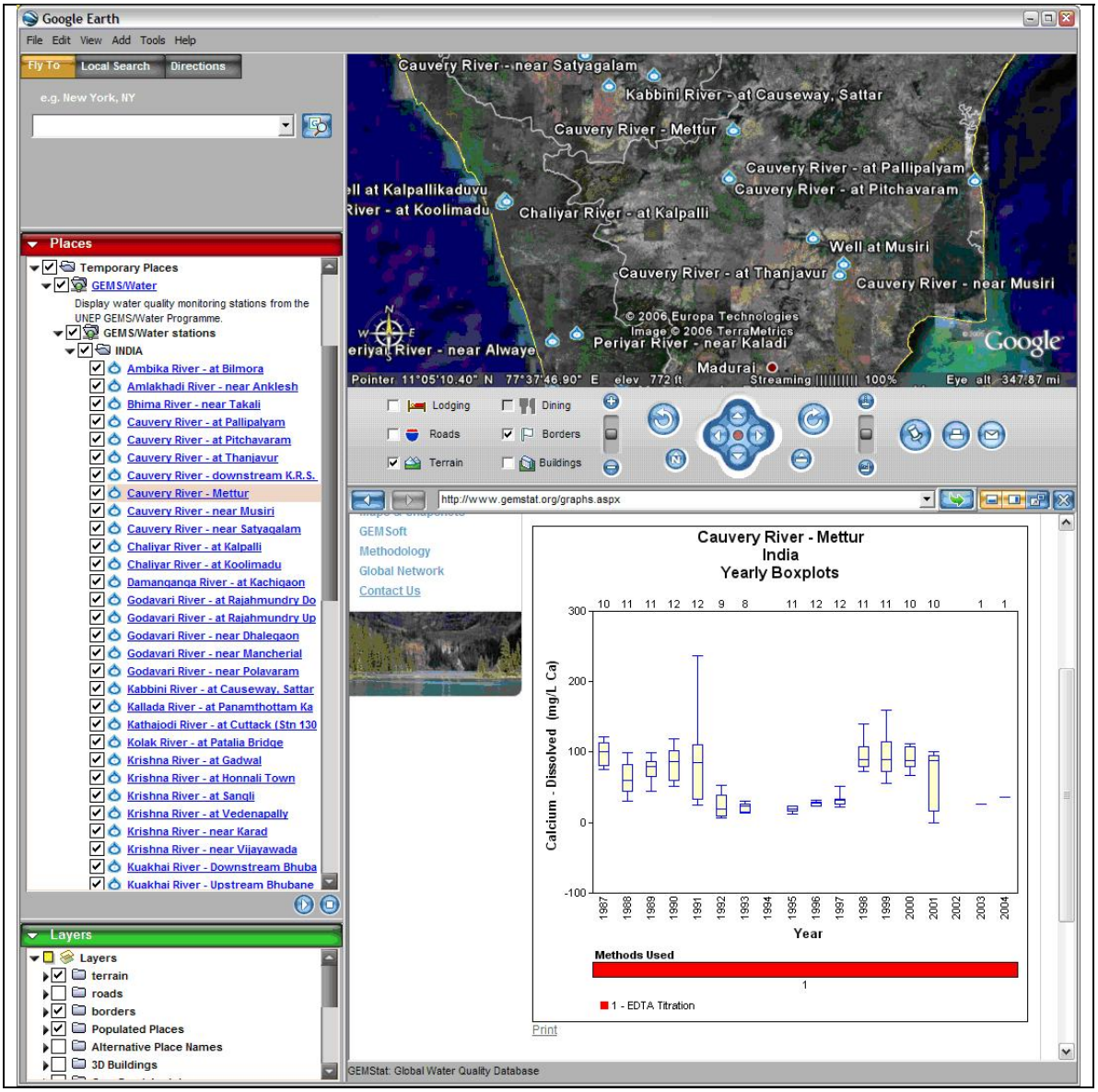
Since Google Earth is available free of charge, there are particular benefits to researchers and water quality managers in developing countries. Open standards are being promoted for this leading edge technology, as is similar capacity with WMO-GRDC, in line with UNEP-DEWA's strategy for increasing data service interoperability.

To display GEMS/Water stations in Google Earth:

1. Visit http://earth.google.com/ , download and install Google Earth freeware.
2. Start up Google Earth.
3. Go to the GEMStat web site at http://www.gemstat.org.
4. Click on the link "Search for Data" from the menu down the left side.
5. Select a Region from the drop-down menu (optional).
6. Set the "Select by" option to Country.
7. Select a Country from the drop down menu.
8. Click on one of the links just below the map to show
    - stations in selected country, or
    - all stations (world).

9. Depending on your browser settings, clicking on a link will
    - automatically display the stations in Google Earth, or
    - prompt you to Open with Google Earth or Save to Disk. The saved file can then be opened in Google Earth using File → Open from the main menu.

More information can be found at http://www.gemstat.org/kmz.aspx.



Access to Raw Data:
There is a demand that GEMS/Water provide raw (disaggregated) data, rather than just statistical (aggregated) data through GEMStat.

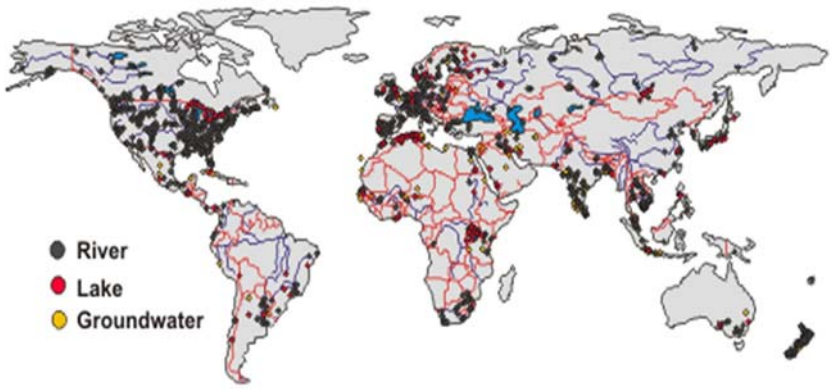
GEMS/Water's overall position regarding data access is that access should be as open and free as possible. There are pros and cons to the open provision of raw data, such as:

Pros	Cons
If GEMS/Water data were included in journals and publications, then that would strengthen GEMS/Water's credibility.	The administrative burden of obtaining permission from NFPs and CFPs to openly share their raw data.
Benefits to those providing data by giving them credit.	Staff time in preparing new data files and web development (download utilities);
Academics do not give us their data before publishing. In this way too, it allows GEMS/Water to cite the publication with details on sampling protocols.	Academics often wish to publish findings before raw data is made available.
Transparency – governmental data have been made possible by public funds and should be available to the general public.	Other web developments to GEMStat are more of a priority, such as search by parameter and list sources.
GEMS/Water should not be more restrictive than governments.	Some governments would object, thereby producing a "positive" versus "negative" view of participating countries.

It is recommended that GEMS/Water research policy and ownership issues, and evaluate guidelines on how to share data.

Country/Government Participation:
As a United Nations, intergovernmental body, GEMS/Water has a vested interest in strong country participation. There is a strategy to recruit National Focal Points (NFPs) and Collaborating Focal Points, as well as guidelines describing roles, benefits and expectations for both them and for GEMS/Water. There are, however, still gaps in data coverage and many countries for which an official NFP has not been identified.

As mentioned above, The GEMS/Water global network now totals 2,743 stations, with 2,323,026 data points, and continues to grow.



It is recommended that GEMS/Water adopt a systematic approach to data collection, to ensure that the database remains up-to-date and comprehensive, for example regular calls for data updates coordinated on a regional basis.

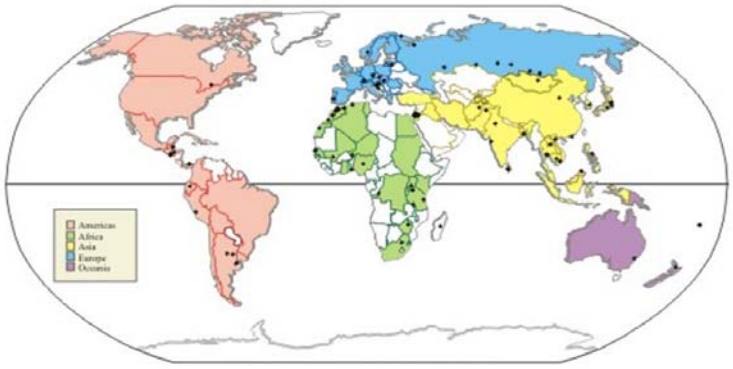
Groundwater:
The International Groundwater Resources Assessment Centre (IGRAC) of WMO is dedicated to providing groundwater information. The question was raised of how UNESCO can help GEMS/Water strengthen the groundwater data resources. GEMS/Water and IGRAC could form

an advisory body for countries to design groundwater monitoring networks and promote international cooperation for riparian countries. Groundwater monitoring can also be related to the MDGs and the JMP. Some of the countries that are farthest away from reaching the goals are very groundwater dependent, in particular Africa, and Small Island Developing States. The client base within the UN system will be increasingly concerned about groundwater resources especially in relation to trans-boundary aquifers. And as the EU Framework Directive points out, the scientific community knows far less about the connections between groundwater and surface than is needed.

3.0 Data Integrity (QA/QC)

- What are the key questions for the Laboratory Performance Evaluation studies?
- Who should be participating so that they are regionally representative?

Laboratory PE Study No. 6:
The sixth laboratory performance evaluation study is nearing completion and involved 97 laboratories in 50 countries. The results of the study will be published in a report.



New Tools and Resources: Analytical Methods Wiki
A new online resource is being developed at www.openh2o.org. The purpose is to provide an interactive forum for researchers to discuss and debate analytical methods that are "tried but not true," that is, are known, but have not been widely tested in unconventional situations.

4.0 Building Water Quality Monitoring Capacity

At the 23rd Governing Council, a new capacity building plan was adopted, including:

> The plan supports the implementation of the relevant outcomes of the intergovernmental consultation on strengthening the scientific base of UNEP, held in Nairobi on 14 and 15 January 2004, which specify a number of important capacity building needs. These include the need to strengthen national capacities for data collection, research, analysis, monitoring and integrated environmental assessment; developing institutional capacities, staff training and support for appropriate and adaptable technologies and methodologies; support for assessments of environmental issues of regional and sub-regional importance and for the assessment and early warning of emerging environmental issues; support for scientific exchanges and for the establishment of environmental and inter-disciplinary information networks; and promotion of coherent partnership approaches.
>
> UNEP should help reinforce the capacities of national Governments to collect and analyze environmental data for use in decision-making and for participation in broader assessment processes, including, among others, the Global Environment Outlook.[1]

1 Bali Strategic Plan for Technology Support and Capacity-Building: Report of the Executive Director: UNEP/GC.23/6/Add.1, paragraphs 22 and 23.

GEMS/Water Japan:
The National Institute for Environmental Studies, GEMS/Water-Japan, continues their Mekong River project, a monitoring plan for the five riparian countries including station location selection, and requirements for parameter selection.

Recent activities in Latin America, particularly the La Plata workshops, highlight new work done on modeling, and the innovative Brazilian technique of collecting water quality data with a small aircraft. GEMS/Water Japan is leading on creating a regional office for Latin America with the Agencia Nacional de Aguas (ANA) in Brazil. GEMS/Water Japan is planning to send an intern to Burlington and a second one to UNEP-Nairobi. The high level of support that Japan provides to GEMS/Water makes NIES a world leader in GEMS/Water activities both in Japan and developing regions.

Part III: Future Needs in Water Quality Monitoring and Assessment

This discussion draws from a recent publication suggesting the following future needs:

1. Understanding the relationships between water quality conditions and the natural landscape, hydrologic processes, and the human activities that take place within watersheds;
2. Assessing water quality in a "total resource" context;
3. Evaluating water quality in concert with water quantity;
4. Evaluating water quality in concert with biological systems;
5. Monitoring over long time scales;
6. Moving from monitoring to prediction -- applying our understanding of the hydrologic system and water quality conditions to unmonitored yet comparable areas;
7. Investing resources to gather ancillary information on landscape and human factors controlling (influencing) water quality; and
8. Advancing monitoring technology, such as measuring water quality in real time.

Source: Hirsch et al. (2006), J. Environ. Monitoring

On Point 4, it was suggested that there could be new ideas generated for protected areas as one form of land use. The interoperability between GEMS and WCMC data services could link issues of water quality with land use patterns and deforestation, to see if there are correlations and see where gaps are. This proposal ties in with using open standards and Google Earth technology as above, Both GEMS/Water and WCMC will follow-up at the UNEP-DEWA Developing the Environmental Data Infrastructure meeting, taking place next week (2 to 4 October 2006).

With Point 5, monitoring should be over different spatial scales as well as time scales.

Point 6 should include problem-solving, that is, move from monitoring to prediction and problem-solving, bearing in mind that the main point is the use of modeling.

In relation to Point 8, there was discussion about new sampling and analysis devises which would reduce the need for in-depth training and costs of deployment. It is important to promote low-cost sampling tools and technology, which do not require large laboratories or infrastructure to conduct effective monitoring.

ANNEX: Agenda 21 – Calls to Action in GEMS/Water

Chapter 18 – Freshwater

18.39. All States, according to their capacity and available resources, through bilateral or multilateral cooperation, including the United Nations and other relevant organizations as appropriate, could set the following targets:
(d) To participate, as far as appropriate, in international water-quality monitoring and management programmes such as the Global Water Quality Monitoring Programme (GEMS/WATER), the UNEP Environmentally Sound Management of Inland Waters (EMINWA), the FAO regional inland fishery bodies, and the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention);

18.43. Monitoring and assessment of complex aquatic systems often require multidisciplinary studies involving several institutions and scientists in a joint programme. International water-quality programmes, such as GEMS/WATER, should be oriented towards the water-quality of developing countries. User-friendly software and Geographical Information Systems (GIS) and Global Resource Information Database (GRID) methods should be developed for the handling, analysis and interpretation of monitoring data and for the preparation of management strategies.

Chapter 40 – Information for Decision-Making

40.13. Institutional capacity to integrate environment and development and to develop relevant indicators is lacking at both the national and international levels. Existing institutions and programmes such as the Global Environmental Monitoring System (GEMS) and the Global Resource Information Database (GRID) within UNEP and different entities within the system wide Earthwatch will need to be considerably strengthened. Earthwatch has been an essential element for environment-related data. While programmes related to development data exist in a number of agencies, there is insufficient coordination between them. The activities related to development data of agencies and institutions of the United Nations system should be more effectively coordinated, perhaps through an equivalent and complementary "Development Watch", which with the existing Earthwatch should be coordinated through an appropriate office within the United Nations to ensure the full integration of environment and development concerns.

The UNEP GEMS/Water Programme is a multi-faceted water science centre oriented towards knowledge development on inland water quality issues throughout the world. Major activities include monitoring, QA/QC, assessment and capacity building. Organizational goals are to improve water quality monitoring and assessment capabilities in participating countries, and to determine the status and trends of regional and global water quality.

GEMS/Water was created in 1978. Its role is highlighted in *Agenda 21*, Chapters 18 — *Freshwater*, and 40 — *Information for Decision Making*. While the programme belongs to the whole UN system, it functionally fits into the Division of Early Warning and Assessment (DEWA), UNEP.

This series, published by the UN GEMS/Water Programme Office, has been created to disseminate the perspectives and recommendations of the Technical Advisory Group. ♦

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