UNEP

CONVENTION ON BIOLOGICAL DIVERSITY

Distr.
GENERAL

UNEP/CBD/SBSTTA/10/INF/19
17 December 2004

ENGLISH ONLY

SUBSIDIARY BODY ON SCIENTIFIC, TECHNICAL
   AND TECHNOLOGICAL ADVICE
Tenth meeting
Bangkok, 7-11 February 2005
Item 5.4 of the provisional agenda*

INDICATORS FOR ASSESSING PROGRESS TOWARDS THE 2010 TARGET: WATER QUALITY IN AQUATIC ECOSYSTEMS

Note by the Executive Secretary

I.   SUMMARY

1.   Water quality is systematically monitored at the local level, particularly for urban water supply, and for major water bodies. Water quality data therefore represent one of the most comprehensive sources of indicator data for aquatic systems. They are multi-functional and indicate both major threats to the sustainability of freshwaters and unsustainable activities outside that ecosystem. The health and integrity of freshwaters is an excellent indicator of the health of terrestrial ecosystems. [1] The indicator is also very useful in that it can, and in some cases already does, indicate the impact of responses to environmental problems (e.g., successful policy interventions leading to improved water quality). Limitations include the indicator being composed of a multitude of potential sub-indicators, for which data vary widely regionally, in quality, quantity and availability.

2.   Water quality should be monitored on the basis of at least three parameters for which data exist, are regularly updated and can be disaggregated or aggregated as required:

    (a)   Biological oxygen demand;

    (b)   Nitrate concentrations; and

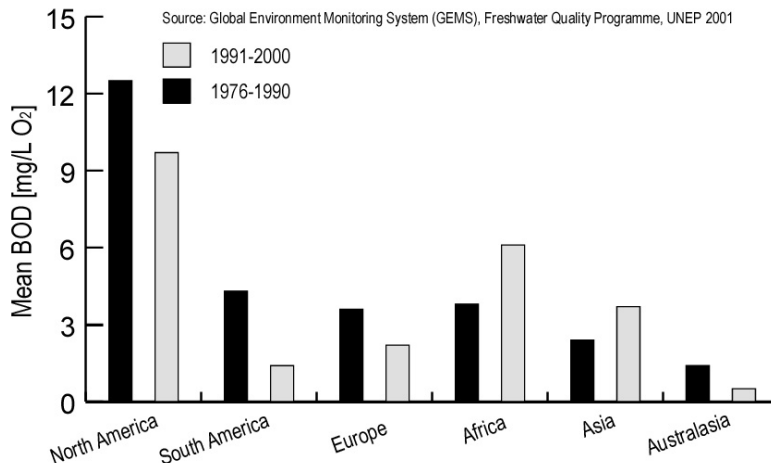   (c)   Sediment loads in rivers/turbidity.

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*   UNEP/CBD/SBSTTA/10/1.

[1]   For example, an increase in sediment loads indicates soil erosion in the catchment area. An increase in pollutants indicates increased runoff of harmful substances.

3.   Biological oxygen demand (BOD) is an indicator of the organic pollution of freshwater. Over the past two decades, BOD has increased in some areas, whereas rivers in Europe and Australasia show a statistically significant reduction in BOD. 2/ Although the reduction is not particularly large, it is indicative of positive trends in the quality of inland waters (figure 1).

Figure 1. Changes in biological oxygen demand (BOD) of major water bodies on a regional basis

4.   Other parameters of water quality include sediment loads in rivers, concentration of pollutants in water, nitrogen loads and other nutrients (particularly phosphorous). 3/ The natural sediment load discharged through river systems is correlated with runoff volumes. Data for the early 1990s are available on a region-by-region basis (figure 2). 4/ Significant increases in sediment load are indicative of soil loss, mostly from unsustainable land use practices. Additional data are available from the Global Nutrient Export from Watersheds project under the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the UNEP Global Environment Monitoring System (GEMS), the World Resources Institute (WRI), the United States Geological Survey (USGS), the European Environment Agency (EEA); as well as national and regional institutes.

Figure 2. Suspended sediment discharge per region (in million tonnes per year)


2/   http://www.unep.org/vitalwater/09.htm.
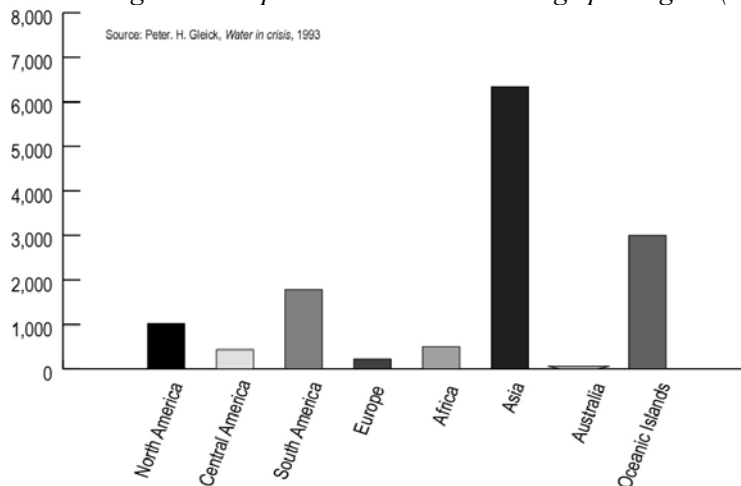
3/   See document UNEP/CBD/AHTEG-2010-Ind/1/INF/6 for further details.

4/   P.H. Gleick. 1993. *Water in Crisis*. Oxford University Press, New York.

5.   Nitrate concentrations in major river mouths are particularly high in Europe, southern Asia and parts of the United States of America. While between 1976 and 2000 nitrate concentrations have decreased in a number of rivers including the Danube, Mississippi and Senegal, nitrate loading has increased in the Indus, Ganges and Yangtze Rivers. Figure 3 shows nitrate concentrations in major rivers during two time periods.

Figure 3. Average nitrate concentrations at major river mouths for the periods of 1876-1990 and 1991-2000 (modified from UNEP-Vital Water Graphics) 5/
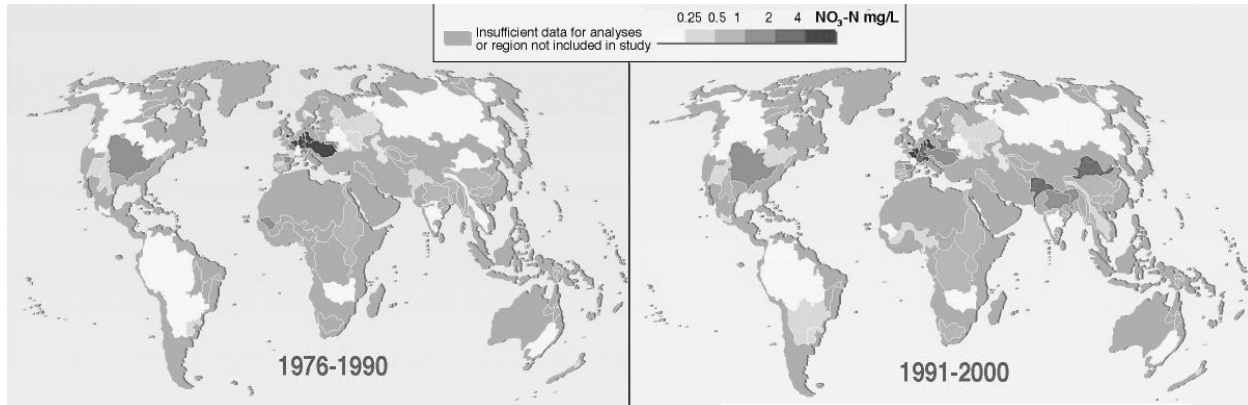
II.   RELATION OF THE INDICATOR TO THE FOCAL AREA

6.   Water quality is both a direct and indirect indicator of stresses to biodiversity in inland waters. It also indicates unsustainable practices occurring outside of the aquatic system since most drivers of water quality change arise from land-based activities. Water quality is also an issue in coastal and marine areas. However, most of the pollutants (etc.) entering these environments originate from inland waters (from river run-off). Therefore, efforts designed to improve water quality in coastal areas must focus on improving or sustaining water quality in inland waters. However, water quality data for coastal and marine regions can be used as proxy indicators of water quality in relevant inland areas.

7.   Water quality impacts the species composition and data on population trends of wetland-dependent species, including threatened species, must be seen in the context of water quality. Excessive sediment loads in rivers, for example, disturb the life-cycle of fishes, through interfering with breathing and impacting spawning areas, and when deposited can smother benthic organisms. It also disturbs nutrient cycles in wetlands, and in particular estuaries. However, significant reductions in natural loads, through sedimentation behind dams, can be equally harmful by reducing nutrient availability downstream. Various pollutants have differing effects ranging from simulating catastrophic mortality to chronic illness, in addition to the effects of bio-accumulation through the food chain.

8.   Invasive alien species have serious ecological consequences for inland waters and polluted nutrient-rich waters are likely to be more vulnerable to the spread of invasive alien species than natural systems. Moreover, in many inland waters intentionally introduced species have directly altered or benefited from polluted ecosystems.

9.   Other indicators related to ecosystem integrity and ecosystem goods and services complement information on water quality: dams, levees, canals, and other infrastructure have contributed to the fragmentation of rivers and led to the reduction of sediments destined for the coastal zone. Pollution and eutrophication can lead to reduction in oxygen levels, increased temperatures, algal blooms and mass mortalities of biota. The indicator on human-induced ecosystem failure would capture such incidences. If the trophic index can be applied to freshwaters it would provide additional complementary information.

5/   http://www.unep.org/vitalwater/20-nitrate.htm

Data for nitrate concentrations in freshwaters globally also complement the indicator on nitrogen deposition for terrestrial systems.

III.   GENERAL DESCRIPTION

10.   Trends in water quality often represent trends in human impacts on freshwaters. Water quality can deteriorate indicating unsustainable water use, or improve, indicating progress towards environmental sustainability due to improved management efforts. Both trends can be expected depending upon the region and parameters selected.

11.   "Water quality" is an indicator made up of several parameters each describing the chemical composition of water, and other characteristics, as referred to a desired natural state. As shown in Table 1, there are a large number of substances, which enter and pollute freshwaters and these indicate unsustainable activities in various areas, according to the substance selected.

Table 1. Some examples of substances, which are regularly monitored in freshwaters.

Substance	Main source of substance	Driver	Parameter of interest mainly to:
Bacteria: - total coliform - feacal coliform Pathogens Parasites	Human waste (mainly) Animal wastes	Poor sanitation	Public health authorities
Nutrients: - nitrogen - phosphorus	Agriculture	Unsustainable agriculture	Agriculture Natural Environment
Salinity (increased salts)	Naturally occurring	Unsustainable water use (salinity intrusion in estuaries, salination of floodplains/wetlands). Unsustainable land use	Water resources management. Natural Environment
Chlorophyl-a	Naturally occurring	Increases indicate eutrophication – caused by excessive nutrients and decreased water discharges.	Water resources management. Natural Environment
Heavy metals (numerous ctypes)	Naturally occurring at low levels.	Industry Mining.	Mining/Industry. Natural Environment Human health
Persistent Organic Pollutants (POPs)	Agricultural chemicals.	Unsustainable agriculture.	Agriculture. Natural Environment Human health

12.   Different requirements and water use need different degrees of water quality. The needs of the aquatic ecosystem are the most important. If the ecosystem is healthy, then the services provided by freshwaters can be maintained.

13.   An issue for water quality and biodiversity is to establish which substances and parameters yield the most information about biodiversity health and ecosystems, and trends.

14.   Based on data availability and relevance to trends in biodiversity and human well-being the following three parameters are considered to be particularly useful:

(a)   Biological oxygen demand;

(b)   Nitrate concentrations; and

(c)   Sediment loads in rivers/turbidity.

IV.   POLICY RELEVANCE

15.   Inland water ecosystems are amongst the most threatened on Earth and subject to the most pressing requirements for improved attention to sustainable use (largely because of the rapidly increasing demand for water). Water quality indicates the impacts of activities in other sectors. Most other work programmes of the Convention on Biological Diversity have direct and intimate linkages to inland waters.

16.   Water quality has direct relevance to the following goals and sub-targets of framework of assessing progress towards the 2010 target of the Convention on Biological Diversity (decision VII/30):

(a)   *Goal 5*: Pressures from habitat loss, land use change and degradation, and unsustainable water use, reduced.

> *Target 5.1: Rate of loss and degradation of natural habitats decreased*

(b)   *Goal 7*: Address challenges to biodiversity from climate change, and pollution

> *Target 7.2: Reduce pollution and its impacts upon biodiversity*

(c)   *Goal 8*: Maintain capacity of ecosystems to deliver goods and services and support livelihoods

> *Target 8.1: Capacity of ecosystems to deliver goods and services maintained*
>
> *Target 8.2: biological resources that support sustainable livelihoods, local food security and health care, especially of poor people maintained.*

17.   Water quality is also relevant to other global development targets including:

(a)   MDG goal 7: Ensure environmental sustainability, in particular the following targets:

> *(i)   Halve by 2015 the proportion of people without sustainable access to safe drinking water;*
>
> *(ii)   Reverse the loss of environmental resources*;

(b)   The Plan of Implementation of the World Summit on Sustainable Development:

> *(i)   Halve, by the year 2015, the proportion of people who are unable to reach or to afford safe drinking water (as outlined in the Millennium Declaration) and the proportion of people who do not have access to basic sanitation;*
>
> *(ii)   Develop integrated water resources management and water efficiency plans by 2005.*

18.   Water issues have remained high on the international environment agenda since the Millennium Summit. At the 2002 World Summit on Sustainable Development (WSSD), protection and management of water resources was recognized by world leaders as fundamental for all three pillars of sustainable

development. The Water, Energy, Health, Agriculture and Biodiversity (WEHAB) Initiative targets actions to facilitate sustainable development in five key areas—water and sanitation, and energy, health, agriculture and biodiversity—in which water resources also play a significant part. The World Summit reaffirmed the Millennium Development Goals target on water and added two more development targets related to water: the aforementioned targets for integrated water resources management and improved sanitation. This reflects the growing severity of water problems and the urgent need for solutions. International attention to water will continue, particularly with the water and sanitation theme of CSD12 and the recently declared United Nations International Decade of Action on Water between 2005–2015. This will build on the efforts made in 2003: the International Year of Freshwater.

19.   This indicator or index should respond to the common needs of the Ramsar Convention, the World Water Development Report assessment process (where the World Water Development Report 2 has already chosen nitrogen and BOD as relevant indicators), the Convention on Biological Diversity and others.

V.   TECHNICAL INFORMATION

A.   Brief definition

20.   Water quality is the extent to which the chemical, and other, characteristics of water approach a pre-defined desired state. The technical aspects of that state vary according to the parameter in question.

21.   However, common use of the term the "desired state" is not necessarily a natural one. For example, water quality standards for drinking water can require the water to have levels of certain chemicals below that which naturally occur in the source water in question. However, this is a matter of interpretation of the data, not for data collection. For the present purposes standards for water quality can be determined as those which sustain as near natural levels as possible of biodiversity (that is, levels of the parameter approach the natural state).

22.   The natural chemical characteristics of water vary widely within and between aquatic systems and temporally (e.g., seasonally, or after flash flooding events). The desired state of water quality for some parameters will therefore be range of values with both spatial and temporal dimensions.

B.   Data availability

23.   Water quality data are routinely available for major waterways in a large number of countries. Water quality data are one of the most comprehensive data sources for inland waters. The Global Environment Monitoring System (GEMS) Water Programme (www.gemswater.org) maintains a database for water quality, which compliments a second database for hydrological data (under the Global Runoff Data Centre of WMO). It currently collects data from 902 stations worldwide. Over 100 water quality parameters are included with over 2 million data points with a good time series (table 2). Regional coverage is good (figure 4).

Figure 4. Distribution of over 900 water monitoring stations reporting water quality data to the GEMS-Water Programme.

Table 2. Global data coverage for the GEMS-Water database for water quality (January 2004).

Region	Number of Stations	Number of data points	Physical/ chemical	Major ions	Metals	Nutrients	Organic contami nants	Micro- biology	Date range
Africa	74	12,287	2,024	3,921	970	1,914	4	339	1978-2000
Americas	114	182,852	33,269	35,320	31,316	27,224	3593	9389	1976-1999
W. Asia	189	62,094	13,181	16,798	10,691	10,333	366	3150	1979-2003
Europe	296	815,759	140,836	132,720	145,457	107,930	13,036	24,401	1971-2002
S.E. Asia	189	362,937	84,619	109,300	20,148	58,681	267	18,337	1978-2002
E.Asia/ Pacific	148	408,807	63,206	45,587	55,229	73,692	6,649	10,624	1979-2003
Total	902	1,844,736	337,135	343,646	263,811	279,774	23,915	66,240	1971-2003

24.   The GEMS-Water Programme has recently initiated a major effort to improve data availability through the "Great Water Quality Data Drive" which is a global call to action for water quality monitoring and data from all types of water resources". Given sufficient support, the prospects of improved data availability are good. Much data are already available but not reported.

25.   Regarding sediment loads, the UNESCO led "International Sediment Initiative" is improving monitoring, data availability and reporting.

C.   Data quality

26.   By comparison to some indicators, data are of generally high quality. For most parameters well established, standard and accurate methods of analysis are available. The accuracy and extent of coverage, however, vary considerably between different water quality parameters. However, the degree of error is largely known.

27.   A brief overview of needs for improvement is provided in Box1.

/…

Box 1: Water quality data

Existing water quality data collection and monitoring systems are inadequate because of:

- incomplete data coverage (spatial and temporal);

- slow reporting and sharing of data; and

- insufficient training and capacity of local water authorities to collect data. The main steps to invest in monitoring, assessment, and information systems are to:

- include monitoring programmes in water management plans, and invest in data collection and analysis capacity in countries, particularly in Africa, SIDS and Central Asia;

- encourage country participation in regional and global water quality monitoring and assessment programmes, such as GEMS/Water; and

- ensure that data and information about water quality are collected frequently and regularly using comparable methods.

- Over 800 stations for freshwater monitoring worldwide have contributed data to the UNEP GEMS/Water Programme (see map below). Of these, 98 are measuring water quality in lakes and reservoirs. There are four types of stations:

Baseline stations are located in areas where there is little or no effect from point sources of pollutants and removed from obvious anthropogenic influences;

Impact stations are located at sites with at least one major use of the water such as drinking water supply, irrigation, or conservation of aquatic life; **Trend stations** are primarily located on large rivers that are representative of large basins in which human activity is high; and **Flux stations** are monitoring at the mouths of major rivers upstream from estuarine effects.

By the end of 2003, the GEMS/Water database contained more than two million data points covering over 100 water quality parameters, including physical/chemical parameters, such as temperature, pH, major ions, nutrients, metals, microbiological parameters, and organics. As the requirements for assessment and identification of national, regional and global water quality issues of concern increase, the need for data that accurately reflect environmental conditions becomes greater.

The geographic distribution of the data contained in the GEMS/Water database is widespread with a higher concentration of stations in European countries, India and Japan.

Source: UNEP GEO Yearbook 2003, p 43.

D.   *Data sustainability*

28.   Prospects for data sustainability are excellent. Water quality monitoring and assessment are a high priority for most countries. The availability and quality of data are in fact likely to significantly increase. Indicator development under the Convention on Biological Diversity will also create a demand for these data and help support improved resources to obtain them.

29.   There are a number of international and regional organizations dealing with water quality data. The GEMS-Water Programme might be the lead agency in the United Nations system, although a number of other agencies can be involved including the UNESCO-IOC Global Nutrient Export from Watersheds Project, Word Resources Institute, United States Geological Survey, European Environment Agency and other national and regional institutes.

E.   *Limitations*

30.   Limitations include that the quantitative relationship between water quality and biodiversity are not particularly well understood for some parameters - except for the most severe cases of poor water quality (e.g., deoxygenation of rivers or lakes, localized pollution spills etc.). It is however known that a reasonable level of water quality is required in order to sustain the biodiversity of inland waters although this is rarely quantified. In general, improving or sustaining water quality remains high on the agenda of most management agencies and is often back-up at the policy level.

31.   The indicator is complicated by the fact that water quality depends on a number of associated, and important, variables. In particular, water extraction from rivers reduces flow rates, which in turn concentrates chemicals in the remaining water.

32.   Although water quality is an important indicator of the condition of inland waters it is probably not the most important. Unfortunately, the indicator on water quality provides limited information on the quality of habitat for biodiversity and no indication of habitat extent. It is, for example, quite feasible to have inland waters with high water quality but low biodiversity values. Other parameters of importance are, particularly in rivers, hydrological conditions (especially ecological flows), fragmentation and loss of habitat (wetlands). For these reasons water quality data must be complemented by data that reflect the biodiversity values of inland water habitat—without there being a danger that positive trends in water quality will mask negative trends in biodiversity.

33.   One problem is amalgamating different sub-indicators into a global indicator or index of water quality. Trends in different parameters have different implications for biodiversity. This problem can be partly addressed by presenting the data for different trends in a composite way (in one figure) and this can be done on a regional basis, as appropriate.

34.   The main problem with definitions is determining the desired state of water. This differs between various objectives for water management and differs considerably from location to location (habitat type) within ecosystems. Whilst this is less of a problem with the presence of un-natural chemicals in water (e.g., agricultural chemicals) it is problematic for naturally occurring chemicals or substances (e.g., sediment loads).

VI.   APPLICATION OF THE INDICATOR AT NATIONAL/REGIONAL LEVEL

35.   The indicator on water quality for specific parameters such as biological oxygen demand (BOD) is in widespread, and long established, use at national level.

36.   Freshwater invertebrates are excellent indicators of water quality and can be, and are, used locally as a proxy measure of water quality. Unfortunately, such data are not currently compiled at the regional level. While the link between water quality and biodiversity is complex, information is often available, particularly at the national/regional level, on the consequences of most pollutants on major taxonomic groups.

VII.   SUGGESTIONS FOR THE IMPROVEMENT OF THE INDICATOR

37.   Water is central in terms of poverty alleviation, consumption, production, sanitation, human settlements and biodiversity. Transboundary water resource issues are important in terms of international governance and sustainability. Water sustains all life and links environmental issues on land to coastal and marine areas. It is, therefore, essential that freshwater, including groundwater, and coastal issues are considered as part of an integrated system. Water quality is, therefore, also a good ecosystem based approach to indicator use.

38.   Sound water management is important for the environment, for reducing human vulnerability resulting from degradation of water quality and water scarcity, and for enhancing human security and well-being through strategic and effective management responses. Water is a key component of all ecosystems. These provide critical goods and services to people, including materials, food and other organic products, water storage and purification, biogeochemical cycling and waste removal.

39.   There is considerable worldwide interest in water and its availability (quantity) and quality. Hence, large databases occur, and with good time-series data. Whilst there is significant scope for improving the quality and coverage of the data an adequate set already exists together with systems for monitoring and reporting regionally and globally. Certainly, for inland waters, water quality data, if not perfect, are by far the best currently available.

40.   Advantages of these data, in addition to coverage and availability, is that they indicate a number of things simultaneously. Whilst most signal the health of aquatic systems, they also indicate unsustainable practices in various sectors. For example, increasing sediment loads are a threat to freshwaters – but also indicate unsustainable land use. Water quality, therefore, is a very good indicator of broader ecosystem health.

41.   A major problem with "water quality" as an indicator is that it is composed of a large number of potential and optional sub-indicators. Any effective "water quality indicator" must, therefore, use a suite of sub-indicators. Choosing those indicators will be problematic because their importance, and data availability, differ considerably between regions. Equally problematic is that it is difficult, if not impossible, to amalgamate several sub-indicators into one global indicator (e.g., how to add together sediment load data with those for levels of POPs?) However, an agency could be responsible for compiling a suite of indicators into a global overview. The results may not be quantifiable (as a single numeric indicator) but it is more important to identify trends rather than absolute values.

42.   Water quantity and flow rates in rivers are excellent predictors of biodiversity. Because of the extreme importance of freshwater to most countries, both for its *in situ* uses and extractive uses for agriculture, industry and urban supply, there is a significant amount of data available globally on water resources, supply and use. Strictly speaking, this is not a "water quality" issue but deals with the quantity, location and timing of availability of freshwater. However, water "quantity" (use) and "quality" are closely related since disturbances in hydrological conditions, e.g., the amount of water available in systems influences the concentration of pollutants present.

43.   For example, the uses of water globally by sector can be illustrated using widely available existing data (figure 5). Increasing use (extraction) of water takes water away from other users – in particular the natural environment. Current assessments indicate that water quality is potentially a very good indicator for the present purposes. A "water use" indicator would be a useful enhancement to any adopted water quality indicator and should be developed as quickly as possible.

Figure 5. Water use by various sectors 1970-2000.
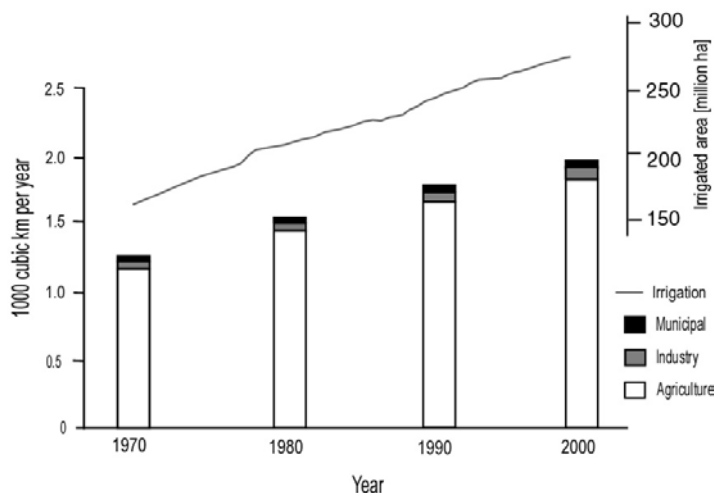
44.   It should be noted that a number of global, regional and national initiatives have set targets for water use. For example, the Challenge Programme on Water and Food under the Consultative Group on International Agricultural Research (CGIAR) has the target of maintaining extractions for agriculture at year 2000 levels (www.cgiar.org). A number of agencies have or are developing databases on global water use including the International Water Management Institute (www.iwmi.org).