Final Report of the
Expert Group on Indicators, Monitoring, and Data Bases (EG-IMD)

including

Proposed programme to mobilise information to support decision making about water resources

July 2009

United Nations World Water Assessment Programme (WWAP)

Programme Office for
Global Water Assessment, UNESCO
Villa La Colombella - Località di Colombella Alta
06134 Colombella (PERUGIA) – Italy

The financial support of the Danish Government for the work of the Expert Group is gratefully acknowledged as is the administrative and logistical support of the DHI-Copenhagen, UNESCO-IHE in Delft and WWAP-Perugia.
SUMMARY

In June 2008, the WWAP Expert Group on Indicators, Monitoring, and Data Bases initiated a process to identify the key dimensions and indicators of water resources and their management as well as the work required to be able to produce such indicators on an ongoing basis.

After a structured review of the issues, the conclusion reached was that, given the many different interests of decision makers and managers, the principal challenge in the field of monitoring water resources at global, regional and national level is not the identification of a set of key indicators for water resources and their management. It is rather the systematic generation of a set of core data items that will allow a wide range of such indicators to be calculated to meet the many different needs of the potential audiences.

Currently, many of these data items are not reliably or systematically collected, which makes it difficult to generate any useful indicators on a regular and comparable basis. This constrains the monitoring of significant dimensions of performance and of trends in the water resource sector.

It is therefore recommended that WWAP should, in execution of its mandate, undertake a programme of work with appropriate partners to generate a limited set of such data items on a regular and systematic basis. This should be done in collaboration with the work of the UN Statistical Division to standardise and systematise national water accounting and reporting systems.

By adopting this strategy, WWAP would be emulating the successful approach of the WHO/UNICEF Joint Monitoring Programme which has transformed the approach to water supply and sanitation coverage information and generates information which is widely accepted and used by policy makers and managers at global, regional and national level.

A separate recommendation is made in respect of indicators of water resource governance at national level. During the proceedings of the Expert Group, it was noted that the highly context specific nature of water resource management, the greatly varying extent of water use and the necessarily different management responses within different systems of public administration render a “checklist” type of assessment of water governance inappropriate. It was therefore recommended that a country assessment approach be developed based on peer reviews undertaken at a regional level and that WWAP should work with partners to further develop this approach, which has already been piloted in a number of regions.
BACKGROUND AND PROBLEM STATEMENT

It is widely recognised that, over the next few decades, the world’s water resources will be significantly impacted upon by global drivers ranging from climate change to population growth and the changing diets of the world’s people. It is also recognised that the resultant pressures will require intelligent and innovative policy and management responses at many levels to sustain both human activities and the environment and to support the poor communities that will bear the brunt of the impacts. To guide and monitor those responses, indicators are required that are underpinned by a flow of reliable information.

At present, this information flow is weak, particularly at the national and regional level on which WWAP focuses. This has been well documented, notably by WWAP itself, in the World Water Development Reports. The first edition, published in 2003, included an extensive compilation of information drawn from many agencies and individuals, and reported on more than 160 indicators, ranging from the global quantum of water available and withdrawals for human use to compliance with water quality standards for key pollutants and governance mechanisms to support water management.

Three years later, when the next edition of the World Water Development Report was published, the problem of poor ongoing data availability was already evident. Information on only 62 indicators was presented because there was no systematic process for updating the data used for most of the indicators presented in the first report. In 2009, the production team for the third World Water Development Report reported that new data was available for only 30 of the indicators included in the second report.

This situation reflects a number of problems. At its simplest, data collection systems are deteriorating due to underfunding, particularly, although not exclusively, in poor countries, which face many more immediate challenges. In some countries, water resource data is seen as a commercial product to be paid for, not shared; in others, it is considered to be a matter of national security, access to which must be restricted. On the vital dimension of water use, some corporate users are unwilling to share data about their performance because of concern about legal liability; weak management institutions often fail to collect and report data on a systematic basis; this is aggravated by the absence of a formal framework for data collection and reporting. As a result, information about actual water use, which is fundamental to any assessment of progress or problems in water resource management, is also very limited.

Global information repositories work on shoestring budgets and depend on national reporting, which is often of doubtful quality for some of the reasons outlined above. They do not have the resources to verify the data or to help countries to improve its production. Finally, while huge volumes of potentially relevant data are routinely collected by remote sensing and related mechanisms, this is often not processed to provide management and policy relevant information due to technical challenges and the costs involved.
As has been demonstrated by the experience of producing the World Water Development Report and for the reasons outlined above, it is increasingly difficult to provide policymakers at the national, regional and global levels with insight into the trends of key indicators such as water use efficiency, the linkage between water and social and economic development, or even about changes in water availability and whether available resources are being unsustainably depleted.

Policy formulation and decision making thus depend on what has been characterised as an “inverted pyramid”, with a great deal of analysis undertaken on the foundation of a limited and shrinking set of data points. This point was further emphasized at the 5th World Water Forum where, in all three sessions of the Data For All Theme, there was a repeated message that “the challenges faced in the water sector are growing but the data available to provide the information to guide and monitor the responses is not; indeed in many regions, availability is decreasing”.1 At that meeting, it was also agreed that a collaborative programme of work needed to be initiated to address the challenges.

EXPERT GROUP MANDATE AND APPROACH

In response to this challenge, the UN-Water consortium established a Task Force on Indicators, Monitoring and Reporting, chaired by the coordinator of WWAP, to identify key global indicators of the state of water resources to meet the needs of policy- and decision-makers at all levels. To support WWAP and the work of the Task Force, WWAP established an Expert Group on Indicators, Monitoring and Databases tasked inter alia, with

- Preparing a short list of key dimensions and indicators
- Drafting a proposal on the future work required to report on a useful, feasible and sustainable set of indicators on key water resources issues on an ongoing basis

To address these tasks, the Expert Group first conducted a scoping exercise through a series of teleconferences which identified and characterised the three main dimensions for which indicators were required, namely:

- The status of the water resource itself
- The different uses of water
- The governance system

Recognising that the identification, production and use of water resource indicators involved many different actors and interests, a three stage consultation process was developed to engage their different perspectives.

This was as follows:

- A dialogue session was held with key users of water resource information from different sectors, including government, business, financial institutions and non-governmental organisations working in the fields of poverty and environmental protection, to consider their indicator needs.

- Following this, a second dialogue session was held with representatives from communities of data providers and interpreters, which focused on the availability of data to populate the key indicators proposed on a sustainable, ongoing basis as well as possible innovative sources of data. This included representatives from the leading global organisations responsible for different dimensions of water resource data monitoring, systems modellers, and representatives from water using sectors such as urban utilities and environmental managers as well as from the government statistics community.

- Finally, a synthesis session was held which brought representatives of indicator users together with data providers to make recommendations on an approach to indicator production that would be feasible, sustainable and meet the priority needs of key users. Where existing data streams were not adequate, specific proposals were sought to address the gaps.

Participants in the initial telecons and subsequent meetings are listed in Annex 1.

OUTCOMES AND RECOMMENDATIONS

Following the Expert Group teleconferences, there was general agreement amongst the participants about the key dimensions within which indicators were sought, namely

- Water resource status, subdivided into
  - WR availability
  - WR quality

- Water resource use

- (Water resource governance and performance)*

(* An early conclusion was that the assessment of governance requires a substantially different methodology to that for the other areas. This is currently being addressed through a separate process of collaboration between WWAP and the Global Water Partnership. However, it was noted that the availability of reliable data about water resources and water use are in themselves powerful indicators of the quality of water governance and some numeric indicators of performance are proposed).
Within these dimensions, a set of key indicators was proposed (see Annex 2) which is consistent in most respects with that developed by the UN Water Task Force with which the EG collaborated and which have been further developed by the Task Force. Consideration was given to details of data definition as well as to the time periods over which data should be collected and reported.

However, it was recognised from the outset that the availability of relevant data would be a factor in the choice of useful indicators which could reliably and systematically be reproduced and compared over time. It was confirmed that, at present, very few of the proposed key indicators could be calculated in a reliable and repeatable manner to enable trends to be determined because there was a lack of reliable and ongoing reporting of certain key “variables” or “data items”.

It was therefore concluded that its initial priority should be to identify a set of key “data items” and then to focus on the actions needed to produce them consistently and systematically in the future. The proposed “data items” are listed in Annex 3.

This conclusion is directly related to the original task of choosing key indicators. However, the focus on the production of “data items” will achieve considerably more than simply to facilitate the calculation of those indicators that are considered to be “core” to the users of the WWDR. Importantly, it will also enable a wide range of other indicators to be generated that may be useful to other parties.

Indeed, during the Expert Group’s deliberations, it became clear that little consensus could be reached on a simple limited list of indicators because of the very different objectives of different “users”. Many sought indicators for particular social and environmental advocacy purposes, or to support information systems and frames of analysis that were different to those of the main-stream water sector such as to guide corporate investment in fields as disparate as food production and mining.

A key recommendation is that, since WWAP is a neutral platform, its output should be sufficiently generic that it can be used to provide a range of indicators relevant to the many different interest groups that seek to track trends in water resources. A focus on the production of core “data items”, in addition to the core indicators that WWAP itself uses, would achieve this purpose.

Examples of the application of “data items” in the indicator realm:

The data items will be interesting in themselves to provide, for instance:-
- Trends in precipitation (including extremes of drought or excessive precipitation)
- Trends in available water resources (TARWR²)
- Trends in species, wetland condition and water quality

² Total Actual Renewable Water Resources
If the identified “data items” are determined, they can also be combined with socio-economic data sets (such as population and livelihoods as well as national and regional GDP) to calculate a wide range of indicators. These would include standard items such as:

- TARWR as a proportion of precipitation (“conversion ratio”)
- Water availability per capita
- GDP per unit water (for economy, and for specific sectors) (“water productivity”)  
- Employment per unit water (for economy, and for specific sectors)  
- Available potential storage as a proportion of TARWR  
- Water use as a proportion of TARWR (“water use intensity”)

This would become even more useful if the socio-economic data was available on a basin scale as well as according to national and sub-national administrative boundaries.

It will also be possible to produce “combination indicators” such as

- Trends in water quality in relation to trends in water use intensity
- Water productivity in agriculture in relation to rainfall variability
- Trends in water use intensity in relation to GDP

While WWAP would report on all of these in its regular assessments and select the most important indicators to support its key messages, this approach will also enable the production of interactive data sets enabling potential users to determine their own relationships between data items. This will greatly expand its usefulness and potential application.
PROGRAMME FOR THE PRODUCTION OF KEY “DATA ITEMS”

Based on these conclusions, the EG considered the identification of the key “data items” and the approach required for their production.

In this regard, the contribution to the EG from the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation was important and the proposed programme mirrors the process that was initiated in the water supply and sanitation sub-sector which transformed the quality of data for decision-making.

Briefly, when global Millennium Development Goal targets were set, first for water supply and later for sanitation, the sub-sector confronted similar problems to that now faced in water resources. Available data about access to services, their quality and reliability depended on national reporting which was notoriously unreliable and of little value for programme design and monitoring.

The response, led by WHO and UNICEF was to start a Joint Monitoring Programme which focused on developing new sources of data, in this instance, by cooperating with existing systems of national household surveys, usually undertaken by national statistical services. The data provided transformed the understanding of the challenges and contributed significantly to the design of effective programmes to address them. Most of the other MDGs also depend on the management of water resources for their accomplishment. The current proposal to improve water resource information seeks to follow a transformative approach similar to that used for water supply and sanitation.

The process adopted by the EG to develop this proposal was therefore as follows:

- Areas in which data deficiencies seriously impede the production of key indicators were identified
- Potential approaches to improve data availability, either by resort to traditional methods or through the application of innovative methods were considered
- Target areas in which substantial progress could be made in the short term with relatively limited resources were chosen
- In the selected target areas, outline proposals for programmes of work to deliver global sets of data items were prepared with indicative costings
- Potential institutional partners were identified.
Proposal for a programme to generate a flow of data about water resources to enable key indicators of the state of the world’s water to be produced on a regular, consistent and sustainable basis

The proposed areas of focused work include the following:

1. Resource availability (TARWR)
   The establishment of a system to produce an annual estimate of total available renewable water resources by country and major river basins (DrWRI), using the best available data and agreed methodologies to “patch” the record from remote observations where direct observation is not possible; to be led by Charles Vorosmarty of CUNY working with the GCOS-GTOS Global Terrestrial Networks for Hydrology, which the proposers coordinate on behalf of World Meteorological Organization (WMO).

2. Remote sensing index of water quality
   The initiation of a project, in collaboration with NASA and other agencies involved in remote sensing, to interpret data about water quality from remote sensing sources to enable trends to be established to complement existing data which focuses on known “hotspots”.

3. Wetland status and environmental services
   The remote sensing work above will also be linked to systematic ongoing monitoring of the extent of wetlands whose shrinkage is in many places a good indicator of the state of environmental protection. This will be led by CDB, in collaboration with Ramsar. (It is also proposed that a “sub-expert group” will be established with these partners to review methodologies for assessing freshwater ecosystem services).

4. Resource use
   A project, in collaboration with the UN Statistical Division, FAO, the International Water Association and organised business, to support countries to collect and report data on water use within a common and consistent framework; this will include the promotion of partnerships to encourage key water users such as urban water utilities and manufacturing industry, which already collect a great deal of data, to make it available on a regular basis.

Note: more detailed indicative proposals for each of these four activities as submitted by their proponents are appended in Annex 5

5. Trends and variability in precipitation
   Precipitation is the best signal of climate input into the hydrological system. A moving 30yr average of precipitation will need to be developed in order to support data item #1 above. This will require a re-analysis of historical data (WMO) to ensure comparability with a similar moving average to be developed for the runoff series. An assessment of variability, necessary for motioning
trends in extremes, would require a study of changes in annual distributions at national and large river basin scales. Both activities would benefit daily-level data. An initial indicative proposal is still to be developed by WWAP and the WMO.

Additional activities have either been proposed or are ongoing. These would serve to complement some of the activities outlined above and future indicator development overall. These complementary activities include:

6. Groundwater Storage Indicator
   Collaboration with IGRAC to produce data in an appropriate format to support a groundwater storage indicator (for this purpose IGRAC also will require additional funding and support).

7. Management/governance efficiency
   Complementary action with GWP to support regional peer reviews of water management and benchmark the effectiveness of national water management.

If successfully implemented, the proposed programme will ensure that the next World Water Development Report can report substantive progress and answer key questions about whether and how changing water resources endowments affect countries and regions, whether the efficiency of water use for national socioeconomic development is improving and whether degradation of the water environment has been slowed. It will also report on the ongoing programme to improve the flow of data and information needed to establish and monitor key trends in water resources.

In order to ensure that all dimensions of a minimum global monitoring programme are producing the outputs required, a strategic management capability will be needed. It is proposed that a Project Management Unit (PMU) be established in association with WWAP that will:

- identify and work with potential partners to identify key gaps in the data and analysis system and opportunities to address them;

- promote and manage projects with existing and potential partners to fill the information gaps; and

- continuously review the federated systems that produce the information, to identify opportunities for improvement and synergy.

Through this work, the Project Management Unit will support WWAP to maintain a coherent and consistent flow of relevant information relevant to the policy community and decision makers in, and affected by, water resource management. It will also provide funders with the assurance that their resources will be effectively employed.
**Budget estimate**

An indicative project-based budget is appended *in Annex 4.*

The initial budget to initiate the projects is estimated at: US$ 2,125,000

The annual budget to sustain the projects estimated at: US$ 1,000,000

For the programme to be successful, it should be sustained for a period of at least four but preferably 10 years, i.e. through 3 cycles of production of the WWDR, allowing for an initial year of preparation.

**Alternative approaches:**

It was recognised that there are alternative strategies to the achievement of the goals that the EG was tasked to investigate. These are outlined below and may require further investigation if the current proposal is not found to be acceptable or practicable.

**WWAP as a UN Water Information Agency**

A potentially effective approach would be to charge WWAP with full responsibility for mobilising available water resource data and undertaking activities to provide it where it was not available. This would be a substantial task, essentially providing technical assistance and project support for the information dimensions of water resource management as well as developing in-house competence to generate and interpret data, particularly from remote sensing sources. Detailed costing would depend on the agreed scope of work but would be unlikely to be less than US$2 500 000 annually and could be considerably more if its mandate included supporting national administrations to improve their data production.

**WWAP as water data champion**

Should the resources for the programme proposed not be available, WWAP will face substantial challenges in delivering on its reporting mandate. To address these, it is proposed that it establish a unit to promote data collection and reporting, essentially performing a catalytic and exhortatory role. The minimum cost for this would be about US$250 000 annually with success very dependent on the quality of staff appointed. However, it is noted that this approach has not been particularly successful to date.
ANNEX 1  Participants in the consultation process

Participants in initial scoping teleconferences

<table>
<thead>
<tr>
<th>Name</th>
<th>Location/Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mike Muller</td>
<td>South Africa /GWP-TEC</td>
</tr>
<tr>
<td>Roland Schulze</td>
<td>South Africa/ UKZN</td>
</tr>
<tr>
<td>Charles Vorosmarty</td>
<td>USA /UNH</td>
</tr>
<tr>
<td>Gunilla Bjorklund</td>
<td>Sweden/GIWA</td>
</tr>
<tr>
<td>Bob Brackenridge</td>
<td>USA/Flood Observatory</td>
</tr>
<tr>
<td>Casey Brown</td>
<td>USA /IRI</td>
</tr>
<tr>
<td>Stuart Bunn</td>
<td>Australia/ NWC</td>
</tr>
<tr>
<td>Wolfgang Grabs</td>
<td>Switzerland/WMO</td>
</tr>
<tr>
<td>Guy Hutton</td>
<td>Switzerland/ WSP</td>
</tr>
<tr>
<td>Amithirigala Jayawardena</td>
<td>Sri Lanka/UHK</td>
</tr>
<tr>
<td>Henrik Larsen</td>
<td>Denmark /DHI</td>
</tr>
<tr>
<td>Peter LeTitre</td>
<td>Netherlands/ IGRAC</td>
</tr>
<tr>
<td>Gordon McGranahan</td>
<td>UK/IIED</td>
</tr>
<tr>
<td>Michel Meybeck</td>
<td>France/CNRS</td>
</tr>
<tr>
<td>LeRoy Poff</td>
<td>USA/CSU</td>
</tr>
<tr>
<td>Aaron Salzberg</td>
<td>USA/ State Dept</td>
</tr>
<tr>
<td>Alex de Sherbinin</td>
<td>USA /CIESIN</td>
</tr>
<tr>
<td>Eugene Stakhiv</td>
<td>USACE</td>
</tr>
<tr>
<td>Willi Struckmeier</td>
<td>Germany/BGR</td>
</tr>
<tr>
<td>Kuniyoshi Takeuchi</td>
<td>Japan/ICHARM</td>
</tr>
<tr>
<td>Ingrid Verstraeten</td>
<td>USA/USGS</td>
</tr>
<tr>
<td>Albert Wright</td>
<td>USA/Ghana</td>
</tr>
<tr>
<td>Daniel Zimmer</td>
<td>France/WWC</td>
</tr>
</tbody>
</table>

(Contributions were also received from a range of other colleagues)

Users of water resource information (Perugia, January 29-30)

<table>
<thead>
<tr>
<th>Name</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bruce Hooper</td>
<td>DHI</td>
</tr>
<tr>
<td>Domitille Vallee</td>
<td>WWAP</td>
</tr>
<tr>
<td>Enrique Cabrerra</td>
<td>IWA</td>
</tr>
<tr>
<td>Giovani Ruta</td>
<td>World Bank</td>
</tr>
<tr>
<td>Michela Miletto</td>
<td>WWAP</td>
</tr>
<tr>
<td>Mike Muller</td>
<td>EG-IMD</td>
</tr>
<tr>
<td>Rick Connor</td>
<td>EG-IMD</td>
</tr>
<tr>
<td>Stacy Noel</td>
<td>SEI</td>
</tr>
<tr>
<td>Umberto Triulzi</td>
<td>Roma U.</td>
</tr>
<tr>
<td>Vanessa King</td>
<td>Unilever</td>
</tr>
</tbody>
</table>

Communities of data providers and interpreters (Delft, April 20-21 2009)

<table>
<thead>
<tr>
<th>Name</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bram Edens</td>
<td>UNSD/SEEAW</td>
</tr>
<tr>
<td>Eva Zabey</td>
<td>WBCSD</td>
</tr>
<tr>
<td>Inam Ullah</td>
<td>UN-Habitat</td>
</tr>
<tr>
<td>Jaroslav Vrba</td>
<td>UNESCO-IHP (GW Indicators)</td>
</tr>
<tr>
<td>Markku Puupponen</td>
<td>WMO Contact</td>
</tr>
<tr>
<td>Marloes Mul</td>
<td>UNESCO-IHE</td>
</tr>
<tr>
<td>Michael Nagy</td>
<td>Austrian Environment Department</td>
</tr>
<tr>
<td>Mike Muller</td>
<td>EG-IMD</td>
</tr>
<tr>
<td>Name</td>
<td>Organisation</td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Petra Doell</td>
<td>Frankfurt Univ. (Hydrology)</td>
</tr>
<tr>
<td>Pieter Vanderzaag</td>
<td>UNESCO-IHE</td>
</tr>
<tr>
<td>Richard Robarts</td>
<td>GEMS</td>
</tr>
<tr>
<td>Rick Connor</td>
<td>EG-IMD</td>
</tr>
<tr>
<td>Rolf Luyendijk</td>
<td>JMP/UNICEF</td>
</tr>
<tr>
<td>Sjoerd Schenau</td>
<td>UNSD Contact</td>
</tr>
<tr>
<td>Stefan Uhlenbrook</td>
<td>UNESCO-IHE</td>
</tr>
<tr>
<td>Ulrich Looser</td>
<td>GRDC</td>
</tr>
</tbody>
</table>

**Synthesis session** (Copenhagen, June 1-2 2009)

<table>
<thead>
<tr>
<th>Name</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alessandra Alfieri</td>
<td>UNSD</td>
</tr>
<tr>
<td>Beate Werner</td>
<td>EEA</td>
</tr>
<tr>
<td>Charles Vorosmarty</td>
<td>UNH</td>
</tr>
<tr>
<td>David Coates</td>
<td>CBD</td>
</tr>
<tr>
<td>Domitille Vallee</td>
<td>WWAP</td>
</tr>
<tr>
<td>Enrique Cabrerra</td>
<td>IWA</td>
</tr>
<tr>
<td>Eva Zabey</td>
<td>WBCSD</td>
</tr>
<tr>
<td>Giovani Ruta</td>
<td>World Bank</td>
</tr>
<tr>
<td>Henrik Larsen</td>
<td>DHI</td>
</tr>
<tr>
<td>Inam Ullah</td>
<td>UNHabitat</td>
</tr>
<tr>
<td>Jaroslav Vrba</td>
<td>UNESCO-IHP (GW Indicators)</td>
</tr>
<tr>
<td>Mampiti Matete</td>
<td>Southern Africa Water Accounting</td>
</tr>
<tr>
<td></td>
<td>Project</td>
</tr>
<tr>
<td>Markku Puupponen</td>
<td>WMO nominee</td>
</tr>
<tr>
<td>Mike Muller</td>
<td>EG-IMD</td>
</tr>
<tr>
<td>Rick Connor</td>
<td>EG-IMD</td>
</tr>
<tr>
<td>Ted Engman</td>
<td>NASA</td>
</tr>
<tr>
<td>Ulrich Looser</td>
<td>GRDC</td>
</tr>
</tbody>
</table>
ANNEX 2  PROPOSED INDICATORS

About the resource:

- Water resource availability (Total Available Renewable Water Resources - TARWR) on regular basis, at seasonal, annual and long term average time frames.
- Storage in the system
  - ideally, both surface reservoirs and groundwater
  - Within that, data that could indicate depletion on an annual and long term basis
- Precipitation data on similar time frames.
  - Ideally, the division of that precipitation (as runoff, infiltration, Evapotranspiration) to be able to determine
    - “conversion ratio”
    - “Green water”
    - Soil storage (assuming that it is not possible to monitor both saturated and unsaturated zone)
- Environmental quality measure (seasonal, annual and long term average), one of
  - Salinity?
  - COD?
  - Eutrophication (using a remote sensing base for definition)?
  - Freshwater species?

About use:

- Use by abstraction by main sector (at least agriculture, industry and urban domestic/household)
- Use by source (at least by groundwater versus surface water)
- It would also be desirable for policy purposes to be able to provide:
  - agricultural and forestry use of water (ET) from precipitation (green water)
  - water flows used for the production of hydropower (in cascading systems this could be difficult to define, perhaps the largest flow at the end of a system)
  - water flows reserved for environmental purposes (wetlands, lakes and rivers)
  - water flows required to maintain navigation

About governance:

- The budget of governments and public institutions on water resource management as opposed to water infrastructure investment and operation) as a % of total budget.
- An assessment of the quality of WRM (by a review / verification process)

About performance:

- Proportion of urban wastewater treated/capacity for treatment
- Average cost of water resource supply (as a proxy, the average price paid for “bulk raw water”)
ANNEX 3  PROPOSED KEY DATA ITEMS

In the domain of water resource availability:

- TARWR (new, 30 year moving average; replacing fixed 1960-1990 data) (Remote Sensing - RS + synthesised)
- Storage (Available man-made storage capacity and actual long-term changes in surface and groundwater storage)
- Long term (30 year) average precipitation (new, to match new TARWR series)
  - Basic indicators of variability
    - Frequency of specific extremes (new)
    - Values of specific extremes (new)

(It was noted by the WMO nominated expert that the production of these “data items” will require reference to daily precipitation data as well as sufficient information about river discharge and storages. In addition, the treatment of variability will require further elaboration.)

In the domain of water quality and environment

- Eutrophication of selected freshwater water bodies (new, using RS to assess chlorophyll and dissolved organic matter)
- NO3 and salinity in
  - Groundwater (new)
  - Freshwater (new)
- Freshwater species (subsector of living planet index by WWF)
- Extent and condition of selected wetlands (new, using RS)

In the domain of water use

- Water use by sector (existing classifications)
  - Agriculture
  - Industry
  - Domestic
  - Energy
ANNEX 4  Budget considerations and estimates

For the current items which just address total water availability and some measures of quality, we estimate a cost of roughly US$1,200,000 to start and US$350,000 annually to continue. Including precipitation data (to address variability) and groundwater quantity/quality, both of which are key elements of estimating TARWR, and the dimensions of water use would raise these costs to roughly US$2,500,000 for start up and US$1,100,000 a year for ongoing monitoring and reporting.3

Ideally, one would not want to start something like this without some assurance of a 10 year life (three reporting cycles) so the commitment sought would be around US$10 million. The institutional structure could be a programme office (WWAP?) contracting functions to specialist partners.

The "high" estimate would involve the establishment of a water resources agency (standalone or as a branch of something like UNEP, UNESCO or WMO) which would undertake more of the work itself, building an operational capacity to manage and analyse available data streams in addition to doing the basic work programme outlined above.

The activities proposed for the "low" estimate will be pretty much the same as the basic work programme but will assume that the only way forward is exhortatory - to persuade current institutions and their supporting agencies to reprioritise their work and budgets. This will be a loser for WWAP since it will be perpetually dependent on goodwill and the vagaries of other organisations.

If we worked on the basis that the PMU would seek to mobilise separate funding for the individual projects, its core funding would be much less. For the first three years, you could say (250, 500, 500), but then you would have to make clear that achieving outcomes will depend on the success of mobilising other funding for the implementation activities. One should try to avoid that and rather concentrate on getting enough to initiate activity in the first three years - at least there will then be visible outputs to back up ongoing funding.

---

3 This is a revised assessment of the estimated budget for the development of a strategic management capability to ensure that all dimensions of a minimum global monitoring programme are producing the outputs required, as presented in Annexe 2 of the Indicative Work Programme and Budget for UN-Water, 2010-2012 – First Draft Version (June 2009).
## Estimated Budget

<table>
<thead>
<tr>
<th>Data Item</th>
<th>Establishment</th>
<th>Operation (annual)</th>
<th>Notes on costing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. TARWR</td>
<td>400</td>
<td>100</td>
<td>150-200K USD per year for an initial 2-year development period, followed by $100K/yr.</td>
</tr>
<tr>
<td>2. Water quality (RS)</td>
<td>500</td>
<td>100</td>
<td>More the $100K but less then $1 M. Once developed it could be operated almost automatically at an annual cost of less the $100K.</td>
</tr>
<tr>
<td>3a. Wetland status</td>
<td>200</td>
<td>100</td>
<td>Review of existing pre-analysed datasets and basic re-analysis (12 man months = US$ 100K); Fill the gap on wetland extent (12 man months = US$ 100K)</td>
</tr>
<tr>
<td>3b. Biodiversity - ecosystem benefits</td>
<td>75</td>
<td>50</td>
<td>Review of current information availability (9 man months = US$ 75,000/yr); Expert group on improving data and indicator availability ($50K/yr)</td>
</tr>
<tr>
<td>4. Water Use</td>
<td>250</td>
<td></td>
<td>Gap analysis; liaison and survey development; workplan development</td>
</tr>
<tr>
<td>4a. Utility reporting</td>
<td>100</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>4b. Industry</td>
<td>100</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>4c. Agriculture</td>
<td>500</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>4d. Energy</td>
<td>100</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>4. e National stats offices (pilots)</td>
<td>100</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>5. Precipitation</td>
<td>100</td>
<td>50</td>
<td>Estimates to be revised</td>
</tr>
<tr>
<td>6. Groundwater storage</td>
<td>100</td>
<td>50</td>
<td>Development and operation of the information and reporting system</td>
</tr>
<tr>
<td><strong>Estimated Total</strong></td>
<td><strong>2525</strong></td>
<td><strong>1100</strong></td>
<td></td>
</tr>
</tbody>
</table>
ANNEX 5 Indicative proposals for the development of key Data Items

5.1 The Dynamic Renewable Water Resources Inventory (DrWRI):

Operationalizing Estimates of the Annual Renewable Water Resource Base

Charles J. Vörösmarty\textsuperscript{1,2,3} and Balázs M. Fekete\textsuperscript{1,2}

\textbf{Rationale:} At the heart of any modern assessment of the global water resource base must be an articulation of the available renewable supply. A well-known limitation of current inventories is their fragmentary nature over both space and time and with ongoing attrition of streamflow monitoring networks, privatization of information sources, delays, and legal restrictions on the use of such information, the water resource assessment community faces a severe obstacle in constructing a definitive and timely picture of this important strategic resource (1-4). In contrast, modern Earth system science data sets from sources as diverse as telemetered \textit{in situ} discharge gaging stations, satellite remote sensing, modeling and data assimilation have the capacity to provide information across otherwise data-poor parts of the globe (5,6).

\textit{DrWRI:} If appropriately synthesized, these capabilities can be used to operationalize water resource inventory, as demonstrated recently as part of the WWAP Pilot Study on Indicators (7). This synthesis on behalf of the Assessment will take the form of the Dynamic Renewable Water Resources Inventory. The goal is to:

\begin{itemize}
  \item Create the Dynamic Renewable Water Resources Inventory (DrWRI) as a means to update on a regular basis the estimation of national-scale statistics on the water resource base determined by both natural potential (climate, climate variability) and modified by human interventions (e.g., abstractions, interbasin transfers).
\end{itemize}

DrWRI will combine water budget estimates based on state of the art climate data records (historical \& present) with river discharge observations. DrWRI applies the data assimilation technique described in (8) in combination with an updated version of the Water Balance Model. DrWRI will deliver state-of-the-art depictions of water resources globally in a quasi near real-time together with reference statistics based on historical records. DrWRI will use the latest version of Water Balance Model (WBM), now with explicit treatment of human activities (irrigation and reservoir operation) (9-12), permitting an articulation of human-induced limits to the water resource base. WBM has a fully coupled routing scheme allowing the propagation of estimated runoff along a digital river channel network between monitoring stations, with gap-filling (13). Using updated records from the Global Runoff Data Center, initial tests will be made using a 30' resolution gridded network, which will be replaced with 3' and 6' networks derived from HydroSHEDS. Several forcings will be used, some from proposed WWAP indicator activities (e.g. for precipitation) and in conjunction with the GCOS-GTOS Global Terrestrial Networks for Hydrology (GTN-H), which the proposers coordinate on behalf of the World Meteorological Organization (WMO). Initial tests determining the pollution-limited resource base will also be attempted.
DrWRI Products and Activities:

- A sequential, updated information product from gridded estimates of water budgets, integrated to construct the available water supply component of National Water Accounts;

- Intercomparison and dialogue with reported statistics, as found in AQUASTAT TARWR records;

- Estimation of uncertainties, based on comparison to other models and validation targets from GRDC observational records; and,

- An historical archive of baseline hydrography, expressed as a moving 30-year average climatology to assess long term trends and to place year-by-year anomalies into context.

Chief Affiliates: City University of New York’s Environmental Cross-Roads Initiative; Global Runoff Data Center (Koblenz), FAO-AQUASTAT; GTN-H, GEMS-Water.

Estimated Costs (direct): From 150-200K USD per year, for an initial 2-year development period followed by $100K/yr.

References


A REMOTE SENSING INDEX OF WATER QUALITY

Modern remote sensing offers a here-to-fore underused and for the most part unused technology for monitoring the water quality in lakes and reservoirs. Current satellite remote sensing techniques enable us to quantify the color of lakes and reservoirs. The breaking down the reflected light into spectral bands allows us to quantify the intensity of color in these different spectral bands which gives us a powerful tool for quantifying the water quality characteristics of water bodies.

There have been a large number of regional demonstration studies that have successfully used satellite measurements to quantify water quality characteristics in lakes and reservoirs. All of these are based on empirical studies that relate in situ sampling of various water quality variables (primarily turbidity, total suspended soils, and chlorophyll a) to various combinations of satellite spectral bands. The bottom line here is that remote sensing can be used to monitor the health of lakes and reservoirs. However to do this on a global and repeatable scale there are several steps that need to be taken, as listed below:

1. Selection of lakes for monitoring: Initially use the 600+ large lakes currently being monitored for water surface elevation changes by the USDA-FAS.
2. Verify that use of MODIS data would be suitable: Could develop a history of water quality changes starting at about 2000.
3. Select appropriate algorithm(s): These would range from very simple single band algorithms, to more complex combinations and ratios, to existing Ocean Color algorithms designed for use with MODIS data.
4. Choose the spatial resolution needed: This would be a trade off between relatively broad spectral bands at 250m to much narrower bands at 1000m.
5. Choose an atmospheric correction approach: One must consider the atmospheric effects when looking at temporal series of satellite images. MODIS data can be obtained with an atmospheric correction, but it would have to be ascertained that this is adequate for this application.
6. Identify lake locations: Probably this would involve constructing georeferenced masks of the central portions of the lakes to eliminate the effects of shore lines and shallow waters.
7. Select cloud free scenes for analysis
8. Run the chosen algorithm(s) and record changes in the index

This approach would be able to answer the basic question, “Are our water bodies getting better or worse?” This would be based on a global sampling of 600 or so lakes. However, this approach could also be expanded to include other lakes or to focus on regional issues.

**Costs**: More the $100K but less then $1 M. Once developed it could be operated almost automatically at an annual cost of less the $100K.
"Biodiversity" indicators: wetland status, biodiversity, and ecosystem benefits

"Biodiversity" is often regarded as "species of animals and plants" and from a conservationist perspective. Neither aspects are key to WWAP and WWRD4-. The relevant context of biodiversity is its role in supporting ecosystems and the goods and services they provide. In this sense, several of the "other" indicators being considered or in use by WWAP are already biodiversity related. For example: "green water" is such because it is transpired through plants (living things); some water quality indicators give messages about deteriorating ecosystem functions (nitrogen deposition and chlorophyl levels both indicate problems with the ability of ecosystems to recycle nutrients, resulting in eutrophication). Even water supply (for drinking, irrigation etc.) has a biodiversity dimension because water is supplied largely by the ecosystem. It is also difficult, and often unfruitful, to separate "biodiversity "and "environment" issues and indicators.

What WWAP needs to track (and WWDR4 report) in relation to both biodiversity and the "environment" is what is happening to the ecosystem which water not only impacts but depends upon.

One option the WWAP- EG-IMD approach could take in order to improve reporting contexts is to cluster the relevant indicators under "ecosystem functioning (or quality) indicators", which in practice, depending on the final list, would put physical/chemical properties (water quality – including nitrogen/chlorophyl), freshwater species (if used), and several of the "other" potential indicators in the same basket. It would also put "environment" and "biodiversity" indicators in proper context. A number of the "process" indicators could also be included in this grouping – in particular indicators of "environmental flows" and IWRM (if used) since both in reality indicate approaches to maintaining ecosystem functioning.

"Biodiversity indicators"

Terminology as such should be de-emphasised, even dropped – for the above mentioned reasons.

Regarding indicators for "Biodiversity/freshwater species" (as per the draft list in the annex to the briefing note) – most of the potential indicators mentioned (referring to growing use of biomonitoring, microbes etc.) are not feasible in the short to medium term for WWAP purposes.

Indicators for "trends in freshwater species" are available - the main one widely used being the Living Planet Index (LPI) produced by WWF. The data upon which this is based is a compilation of published trends in populations of species. This is global and updated regularly (normally every two years). Data could be analysed globally, regionally or nationally. The index is normally represented graphically showing the trend in the indicator itself. There are problems with interpretation: (i) it does not capture the most important species indicators for water-related purposes; (ii) it represents only the "species" side of biodiversity, which is not the aspect most relevant to WWAP; and (iii) it is difficult to link the trend with causes (for example some of the
threats driving the listing of species in the database are not "water resources" related – e.g., invasive alien species).

More relevant indicators for WWAP/WWDR4 purposes would relate to overall trends in ecosystem functioning – that is, the ability of freshwater ecosystems to continue to support relevant ecosystem services.

**Conclusion:** The indicator of most use to WWAP would be "Wetland status".4

**Background:** A wetland status indicator ideally would be a composite index based on sub-indicators which would reflect the overall status of wetlands. These indices would include trends in: biota (species), ecosystem integrity (e.g. fragmentation), wetland extent and wetland condition. Global "Wetland Status" would likely be expressed in general terms to indicate to WWAP the key trend: "is it getting better or worse". Such an overall expression of trend can be produced. A quantitative index can be produced which would likely have most value when expressed by region and for key wetland types.

**Databases and indices:** A qualitative index can be calculated based on country reports to the Ramsar Convention. For a preferred quantitative index: data are already on-hand for many aspects of the index, including population trends of key species groups. In addition, when Ramsar Sites are listed by Parties (some 159 countries) they include descriptions of the extent and ecological status of the wetland site in question. Parties report (about tri-annually) on trends in these wetlands. In addition, the Ramsar reporting includes basic assessments of the status of all wetlands within the countries in question (that is, not only those wetlands designated as protected areas). Ramsar also tracks several other indices including trends in wetland dependent species. Some data/information sets also allow for the analysis of drivers of change to wetland extent and status. Most datasets can be disaggregated by region (if necessary) and many cover time periods from the 1970's (some even earlier).

A critical gap is quantitative information on trends in wetland extent (area). Data sources exist – largely based on remote sensing sources with records spanning as far back as the 1970's (i.e., a similar situation/approach the WWAP-IMR task force is considering for water quality-chlorophyl-a).

**Partners:**

The Ramsar Convention is the major source of data, expertise and information on this. The Ramsar Convention has a permanent scientific body (STRP) – one task of which is to develop tools to report on trends in wetlands. Ramsar International Organisation Partners (IUCN, IWMI, Birdlife International, Wetlands International and WWF) also maintain various relevant databases and periodically publish relevant analyses. The Ramsar Convention, its Secretariat

---

4 Noting that the CBD uses the Ramsar definition of "wetland" which includes almost all inland water body types including rivers, lakes, floodplains, peatlands, swamps, etc. whether artificial or man-made. The Ramsar definition also includes coastal and marine wetlands – although the index in question can be based on a sub-set of wetlands primary affected by freshwater use.
and STRP, are the lead partner for wetlands for the CBD. Ramsar is already providing information in these respects to the CBD in relation to assessing progress towards the 2010 biodiversity target under the Ramsar-CBD joint work plan. Progress in this has been good. The 2010 biodiversity target and the sub-targets related to wetlands etc. are currently being considered for the post-2010 period. The CBD Secretariat is represented in the WWAP Indicators, Monitoring and Reporting task force, and is also a full-member of UN-Water, and will therefore "lead" on this subject in terms of liaison with Ramsar and other partners and facilitating the input of the most relevant information to the WWAP.

The Group on Earth Observations (GEO) would be a potential partner for remote sensing data and analysis. The GEO 2009-11 workplan includes a number of relevant considerations related to ecosystem monitoring in Section 2.7 – although these are mainly land based. It has not as yet identified appropriate approaches to monitoring wetland (freshwater ecosystem) status. The GEO "biodiversity" monitoring in the same work plan, in Section 2.9, has limited utility for WWAP as it focuses on animals, plants and genes.

There is potential for the collaboration between the teams working on wetland extent indices and water quality indices (chlorophyl-a) since both rely on remote sensing approaches and at the very least image acquisition and areas of survey/focus could be coordinated. This would enable both wetland condition (water quality) and extent to be tracked and compared for the same regions using the same data sources.

**Budget/resource requirements:**

(i) to compile relevant information for WWDR4 based on review of existing pre-analysed datasets and basic re-analysis for WWAP purposes (excluding wetland extent):
   - 12 man months (US$ 100,000)

(ii) to fill the gap on wetland extent - using archived remote sensing imagery, develop analytical approaches and summarise the findings (based on existing remote sensing records)\(^5\):
   - 12 man months (US$ 100,000)

**"Other" related indicators**

The meeting discussed the need for information on many "other" areas such as navigation, tourism and recreational benefits, nutrient recycling, soil deposition, climate regulation, flood mitigation etc. All of these represent other services that freshwater ecosystems provide. Some are extremely important for WWAP. A full list of these services should be compiled and a checklist made for indicator availability. For current purposes it is a reasonable assumption that the provisioning services (e.g., drinking water supply, agricultural food production, fisheries, energy etc.) would be better covered by indicators whereas for many of the less direct uses of

---

\(^5\) This is a critical gap for WWAP purposes.
water (in particular the regulating, supporting and cultural services) indicators are poorly developed.

**Conclusion:** A sub-expert group should be established to assess which freshwater ecosystem services are under-represented in WWAP considerations, assess available indicator information for these and propose ways and means to improve longer-term indicator availability.

The CBD Secretariat would be willing to lead on this (subject to resource availability) since most of these "other" services represent currently under-valued biodiversity/ecosystem benefits.

**Budget/resource requirements:**

(i) review of current information availability  
- 9 man months (US$ 75,000)

(ii) expert group meeting on ways and means to improve data and indicator availability  
- US$ 50,000
5.4

**Project to improve the quality of water use data needed to produce water resource indicators**

Data and information concerning water use by different sectors are at the core of any comprehensive assessment of water resources. Yet, much of the data currently available on sectoral water uses are either unreliable or out of date. In many cases, consumptive use is estimated using assumptions about the variables that policy makers seek to monitor, such as sectoral water use efficiency. In other cases, the data is based on incomplete reports from official sources. These data gaps make it nearly impossible to track trends in water consumption over time, which is an essential tool to determining whether the efficiency of water use for national socioeconomic development is improving.

The WWAP EG-IMD determined that a more robust method of country level reporting was required to develop key indicators such as: the impacts of national economic policy – including trade policy – on water resources; current and potential impacts of water use on the environment; and the overall efficiency of water uses in terms of socioeconomic performance.

The data items required to fulfill these objectives include:

- water use data (withdrawals and consumptive) for the domestic, industrial, agricultural, and energy sectors
- "wastewater produced" and "treated volumes" (which have direct implication on human health and the environment)

The existing FAO database on water and agriculture (AQUASTAT) offers a compendium of the best data available on uses. Furthermore, the UNSD-SEEAW provides a statistical framework to integrate hydrological, environmental and economic information with water use data.

Starting from this existing dataset and framework, a project is proposed to support countries, industries, water utilities, and other important user groups to collect and report data on water use within a common and consistent framework. Such a project, in collaboration with the UN Statistical Division, FAO, World Bank and the International Water Association (in partnership with WBCSD, and UN-Energy and IEA for water uses for energy) will include the promotion of partnerships to encourage key water users such as urban water utilities and the manufacturing industry, which already collect a great deal of data, to make it available on a regular basis and national statistical agencies to include it in their reporting.

Recognizing that water utilities and major water users from the industrial and energy sectors represent untapped potential sources of information, it is believed that structured surveys can help generate a valuable amount of additional, complementary data. The project would therefore undertake the following activities (with indicative budgets).
Short-term activities PMU (1st year):

i) To assess gaps in existing datasets and opportunities to acquire existing data: 4 person months (US$ 35K)

ii) To liaise with various collaborators, including user groups and national statistics offices, and initial survey development: 8 person months (US$ 65K)

iii) Workplan development, including meetings of key collaborators (US$ 50K)

Medium-term activities (three-year and beyond):

Although the detailed approaches taken will depend on the outcomes of the initial phase, the following activities are proposed:

- Improving urban utility reporting of water sales (or distribution) and wastewater disposal (IWA, in partnership with the World Bank and others) (US$ 100K to establish, 50K/yr to run)

- Systematic collection of industrial water use data (with WBCSD and other business partners) (US$ 100K to establish, 50K/yr to run)

- Further development of agricultural water use models, to link with remote sensing initiatives in water resource domain, with a specific focus on informal irrigation and crop yields from irrigated and non-irrigated agriculture (FAO) (US$ 200K to establish, 150K/yr to run)

- Pilot regional programme with national government statistical offices to link sector survey methods to formal statistical processes and include water use statistics within the government statistical reports (with UNSD and relevant Regional Economic Commissions) (US$ 100K to establish, 50K/yr to run)