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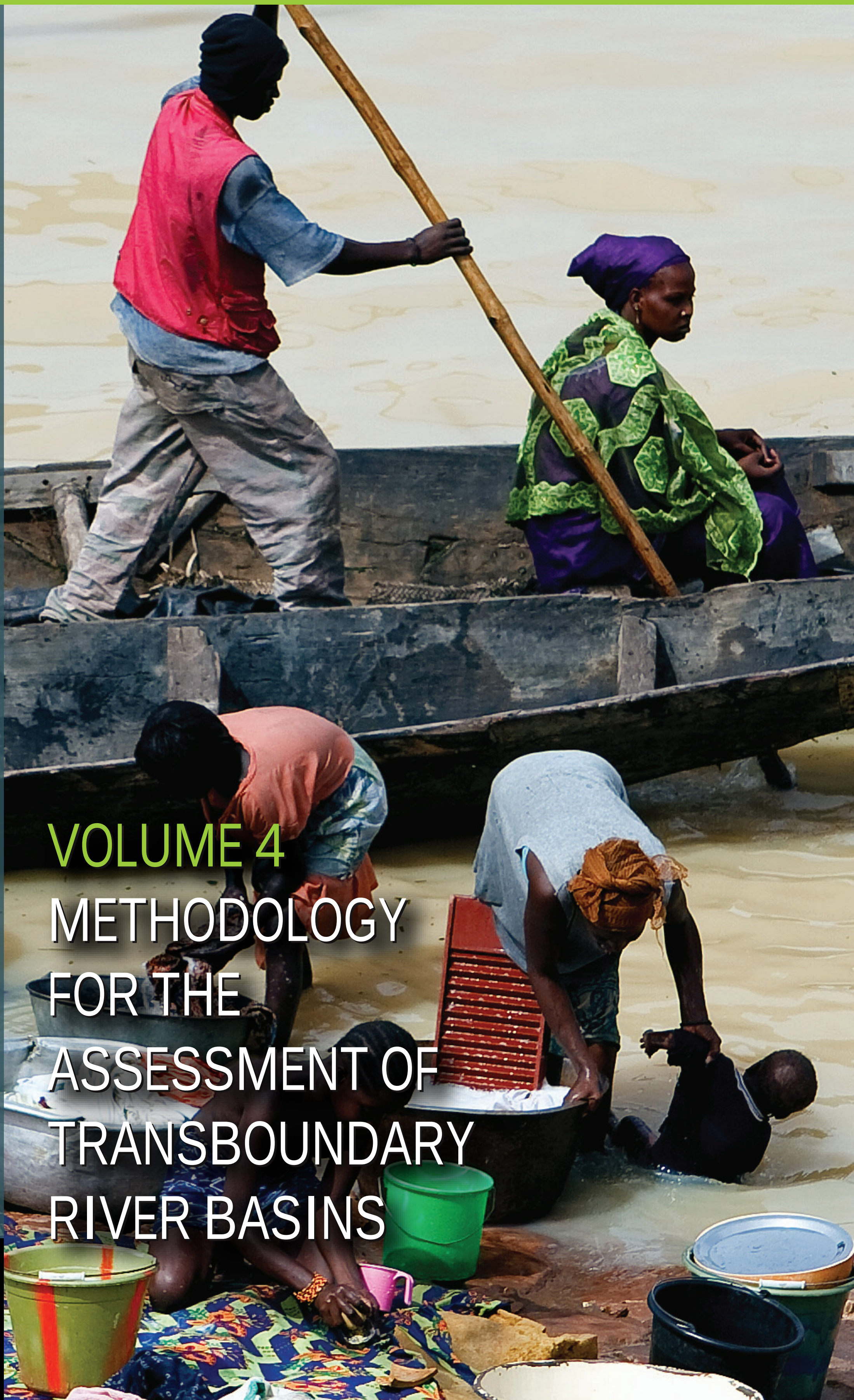

VOLUME 4
METHODOLOGY FOR THE ASSESSMENT OF TRANSBOUNDARY RIVER BASINS

METHODOLOGY FOR THE
GEF TRANSBOUNDARY WATERS
ASSESSMENT PROGRAMME

Published by the United Nations Environment Programme in September 2011.

ISBN: 978-92-807-3118-7
DEW/1323/NA

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CITATION

For bibliographic purposes, this document may be cited as:

UNEP-DHI, 2011. Methodology for the GEF Transboundary Waters Assessment Programme. Volume 4. Methodology for the Assessment of Transboundary River Basins, UNEP, viii + 147 pp.

Linguistic Editor: Peter Sanders
Technical Editor: Pinya Sarasas

Cover Design: Audrey Ringler (UNEP, Kenya)
Design and Layout: Pinya Sarasas (UNEP, Kenya)

Cover photo: © Hector Conesa / Shutterstock.com

METHODOLOGY FOR
THE GEF
TRANSBOUNDARY
WATERS
ASSESSMENT

VOLUME 4

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Acknowledgement

The authors would like to acknowledge Eric K. Mugurusi, Tanzania, and Peter Whalley, UK, for their peer review of this document.

PREFACE

The GEF Medium Size Project (MSP) *Development of the Methodology and Arrangements for the GEF Transboundary Waters Assessment Programme,* approved in January 2009, was envisioned as a partnership among existing programmes, which was considered to be more cost effective than the conduct of an independent data and information gathering exercise. The Project Objective was to develop the methodologies for conducting a global assessment of transboundary waters for GEF purposes and to catalyse a partnership and arrangements for conducting such a global assessment.

This Project has been implemented by UNEP as Implementing Agency, UNEP Division of Early Warning and Assessment (DEWA) as Executing Agency, and the following lead agencies for each of the water systems: the International Hydrological Programme (IHP) of the United Nations Educational, Scientific and Cultural Organization (UNESCO) for transboundary aquifers including aquifers in small island developing states (SIDS); the International Lake Environment Committee (ILEC) for lake basins; UNEP-DHI Centre for Water and Environment (UNEP-DHI) for river basins; and Intergovernmental Oceanographic Commission (IOC) of UNESCO for LMEs and the open ocean.

This Project resulted in developed methodologies for the following five transboundary water systems: (i) groundwater aquifers; (ii) lake/reservoir basins; (iii) river basins; (iv) large marine ecosystems; and (v) open oceans.

The results of this Project are presented in the TWAP MSP Publication, *Methodology for the GEF Transboundary Waters Assessment Programme*, which consists of the following six volumes:

- *Volume 1 – Methodology for the Assessment of Transboundary Aquifers, Lake Basins, River Basins, Large Marine Ecosystems, and the Open Ocean;*
- *Volume 2 – Methodology for the Assessment of Transboundary Aquifers;*
- *Volume 3 – Methodology for the Assessment of Transboundary Lake Basins;*
- *Volume 4 – Methodology for the Assessment of Transboundary River Basins;*
- *Volume 5 – Methodology for the Assessment of Large Marine Ecosystems; and*
- *Volume 6 – Methodology for the Assessment of the Open Ocean.*

The volume 1 is a summary of the detailed methodologies described in volumes 2 – 6. At the back cover of the volume 1 is attached a DVD that contains electronic version of all six volumes.

CONTENTS

FIGURES

TABLES

LIST OF ACRONYMS

AC	Assessment Consortium
AGU	American Geophysical Union
BOD	Biological Oxygen Demand
CBU	Country Basin Unit
CC	Consortium Coordinator
CCA	Causal Chain Analysis
CEH	Centre for Ecology & Hydrology
CERAT	Coastal Eutrophication Risk Assessment Tool
CGER	Center for Global Environmental Research
CIESIN	Center for International Earth Science Information Network
CIRES	Cooperative Institute for Research in Environmental Sciences
COD	Chemical Oxygen Demand
CP	Consortium Partner
CUNY	City University of New York
CVI	Climate Vulnerability Index
DGEF	Division of Global Environment Facility
DPSIR	Driver-Pressure-State-Impact-Response
EPI	Environmental Performance Index
EROS	Earth Resources Observation and Science
ESA	European Space Agency
EWR	Environmental Water Requirement
FAO	Food and Agriculture Organization
FSP	Full Size Project
GAUL	Global Administrative Unit Layers
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEMS	Global Environmental Monitoring System
GEO	Group on Earth Observations (or Global Environmental Outlook)
GEOSS	Group on Earth Observation System of Systems
GIS	Geographic information systems
GIWA	Global International Waters Assessment
GLCCD	Global Land Cover Characteristics Data Base
GLIMS	Global Land Ice Measurements from Space
GLIPHA	Global Livestock Production & Health Atlas
GMES	Global Monitoring for Environment & Security
GRUMP	Global Rural-Urban Mapping Project
GW	Ground Water (in the context of the TWAP ‘groundwater’ working group)
GWP	Global Water Partnership
GWW	Global Water Watch
HDI	Human Development Index
ICOLD	International Commission on Large Dams
IES	Institute for Environment and Sustainability
IIEP	International Institute for Educational Planning
IMAIG	Information Management and Indicators Working Group (TWAP)
IPE	Institute of Public and Environmental Affairs
IRI	International Research Institute for Climate and Society
IRWS	International Recommendations for Water Statistics
IUCN	International Union for Conservation of Nature
IW	International Waters
IW:LEARN	International Waters Learning Exchange and Resource Network (GEF)
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
JMP	Joint Monitoring Programme (on water supply & sanitation)
JRC	Joint Research Centre
LME	Large Marine Ecosystem
MAR	Mean Annual Runoff
MSP	Medium Size Project
NASA	National Aeronautics and Space Administration
NGO	Non-Governmental Organization
NIP	National Implementation Plan
NOAA	National Oceanic and Atmospheric Administration
NUTDB	National Nutrient Database
OO	Open Ocean
PAN	Pesticide Action Network
PIC	Prior Informed Consent
PIF	Project Identification Form
POP	Persistent Organic Pollutant
PWCMT	Program in Water Conflict Management and Transformation
RBO/RBP	River Basin Organization / River Basin Plan
SACMEQ	Southern and Eastern Africa Consortium for Monitoring Educational Quality
SAP	Strategic Action Programme

SEDAC	Socio-economic Data and Application Centre
SEEAW	System of Environmental-Economic Accounting for Water
SIWI	Stockholm International Water Institute
TBI	Transboundary Basin Index
TDA	Transboundary Diagnostic Analysis
TFDD	Transboundary Freshwater Disputes Database
TNC	The Nature Conservancy
TWAP	Transboundary Waters Assessment Programme
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNCSD	United Nations Commission for Sustainable Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USGS	United States Geological Survey
WB	World Bank
WBM	Water Balance (& Transport) Model
WG	Working Group (usually in the context of 5 TWAP WGs, one for each water system)
WHO	World Health Organization
WMO	World Meteorological Organization
WPI	Water Poverty Index
WRI	World Resources Institute
WSAG	Water Systems Analysis Group
WSS	Water Supply and Sanitation
WWAP	World Water Assessment Programme
WWF	World Wide Fund for Nature
YCELP	Yale Centre for Environmental Law & Policy

SUMMARY FOR DECISION-MAKERS

OBJECTIVES AND SCOPE OF TWAP

This report describes the methodology for the assessment of transboundary river basins prepared by the Transboundary River Basins Group (hereafter referred to as the River Basins Group). It is an output of the Medium-Sized Project (MSP) of the Transboundary Waters Assessment Programme (TWAP), with implementation of the assessment to be undertaken in the next phase (Full Size Project – FSP). The MSP is funded by the Global Environment Facility (GEF) and implemented by UNEP.

TWAP covers five transboundary water systems: aquifers, lake basins, river basins, large marine ecosystems (LMEs) and open oceans. The FSP will consist of two levels of assessment:

- Level 1 – a *global comparison of all transboundary river basins* (approximately 270), will enable the prioritization of funds for basins 'at risk' from a variety of sources. The assessment will be indicator based. It is not intended to be a global 'state-of-the-environment' assessment, but rather a relative analysis of basins based on risks to societies and ecosystems. Level 1 will be the focus of the FSP, and receive the majority of funding; and
- Level 2 – an assessment of a selection of basins with a geographical and socio-economic spread (four basins) to identify hotspots within basins, and undertake a causal-chain analysis and forecasting of issues of particular concern. Level 2 will provide input to the development of the GEF Transboundary Diagnostic Analysis (TDA) and subsequent Strategic Action Programme (SAP) processes, and will also act as a validation of results from Level 1. Level 2 is a relatively small but important component of the Full Size Project.

Experience gained from both levels may be used as input to the International Waters Learning Exchange and Resource Network (IW:LEARN 3) and support the development of the GEF's TDA/SAP process.

Although the main end-user will be the GEF, other stakeholders are encouraged to use the results to obtain an overview of global issues threatening human populations and ecosystems through the water system. The results may also be used by others to prioritize funding and as preliminary information for more location-specific projects. Potential users include donors, national governments, international agencies, and transboundary institutions of specific water systems (e.g. river basin organizations).

METHODOLOGY DESIGN

Few projects have attempted an assessment of this scale and nature before, so a new methodology has been developed. It is an ***issues-based approach*** rooted in the DPSIR (Driving forces-Pressures-State-Impacts-Responses) framework, and its further development in the Millennium Ecosystem Assessment. Five 'clusters' of issues were identified as being of relevance to both populations and ecosystems: water quantity, water quality, ecosystems, governance, and socio-economics. A sixth cluster of 'projected stresses' was also included, covering a cross-section of the five other clusters. A number of issues were identified within each cluster, and indicators were developed to assess each issue, as shown in the table below. Indicators were selected using the following criteria:

- Availability – data availability at the global scale, fit for the purposes of TWAP and which are cost-effective to acquire (either through direct data or modelling);
- Acceptability – perceived likelihood of stakeholder 'ownership' of indicators;
- Applicability – relevance to transboundary issues at the global scale in the context of TWAP, including being relevant to other International Water (IW) systems where possible; and
- Aggregation – much of the globally available data is either found at the national level, or modelled on a gridded surface of the earth (typically approximately 50 x 50 km). Therefore the potential to aggregate data from the national to the river basin level was an important consideration, and one that was often addressed through modelling.

Given the Level 1 objective of comparing basins and identifying those most at risk, it was important to devise a consistent scoring system. Once basins have been assessed for each indicator, they are ranked in order of risk for each indicator, then placed in the risk categories shown below. This system identifies the highest risk decile basins, as well as the lowest, to capture 'good practices'.

Level 1 Indicators

CLUSTER	INDICATOR
TRANSBOUNDARY STATUS	
Water Quantity	1. Environmental water stress 2. Human water stress 3. Agricultural water stress
Water Quality	4. Nutrient pollution 5. Urban water pollution
Ecosystems	6. Biodiversity and habitat loss 7. Ecosystem degradation 8. Fish threat
Governance	9. Governance architecture 10. River basin resilience 11. Water legislation
Socio-economic	12. Economic dependence 13. Societal well-being 14. Vulnerability
Projected Transboundary Stress (2030/2050)	
	1. Environmental water stress 2. Human water stress 3. Nutrient pollution 4. Population density 5. River basin resilience

Scoring system for each indicator

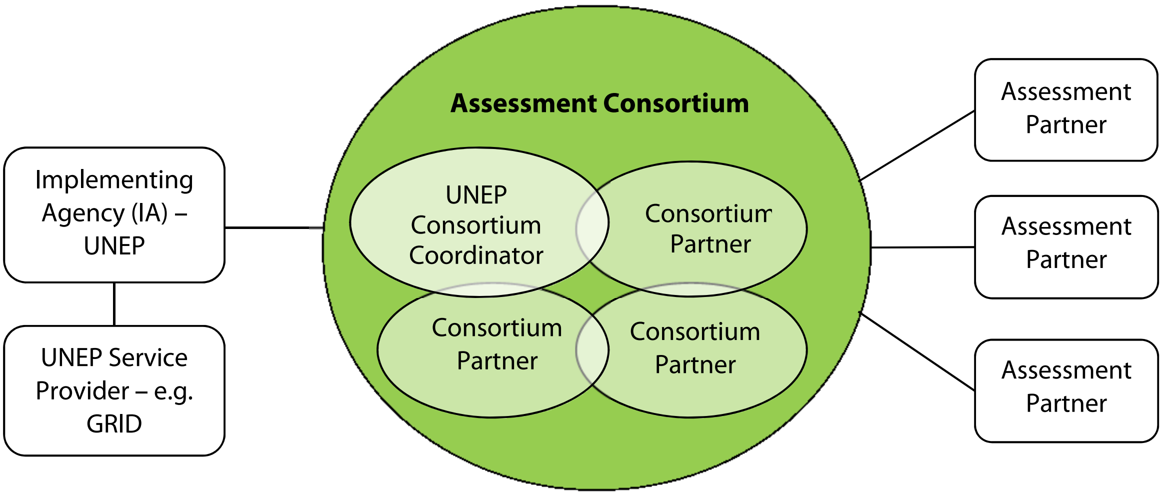
RISK CATEGORY	RANGE (%)	PROPORTION OF BASINS
1 High	0 – 10	10%
2	11 – 20	10%
3	21 – 50	30%
4	51 – 90	40%
5 Low	91 – 100	10%

Each group under TWAP has developed a separate methodology specific to the water system. However, many of the issues identified will be relevant to more than one water system, and information on these issues will be shared between the groups where possible. Two issues have been classified as 'cross-cutting', with particular relevance to all five categories: nutrient pollution (eutrophication and impaired water supplies), and mercury (a widespread pollutant with impacts on both populations and ecosystems).

The methodology was validated at a stakeholder workshop in the Mekong River basin, and within a peer-group setting at the World Water Week in Stockholm (2010), and has undergone an independent peer review. Emerging from the feedback, particularly from the stakeholder workshop, was that more focus should be placed on socio-economic issues and impacts on livelihoods, and that the weighting of indicators to form indices was a very sensitive issue and needed to be transparent and involve stakeholders where possible.

PROPOSED IMPLEMENTATION ARRANGEMENTS FOR THE FSP

The proposed institutional arrangement for the River Basins component is shown in the following schematic:



Consortium partners have the experience, capacity, and networks necessary to undertake the assessment. Assessment partners have data and/or expertise required by consortium partners. A provisional list of partners is:

Proposed Consortium Partners (CP)

- (1) Consortium Coordinator (CC) – UNEP-DHI Centre, with support from (2) IUCN and (3) SIWI, responsible for: Urban Water Pollution, Governance Architecture, Water Legislation, Economic Dependence, Societal Well-being, Biodiversity and Habitat Loss (species component).
- (4) CUNY Environmental Cross-Roads Initiative, City College of New York, responsible for: Human Water Stress (current status and projected stress), Ecosystem Degradation, Fish Threat.
- (5) Universities of Kassel (Centre for Environmental Systems Research) and (6) Frankfurt (Institute of Physical Geography), with WaterGAP (Water - Global Analysis and Prognosis) model, responsible for: Environmental Water Stress (current status and projected stress – runoff component), Agricultural Water Stress, Biodiversity and Habitat Loss (wetlands component).
- (7) Oregon State University (OSU), Program in Water Conflict Management and Transformation (PWCMT), responsible for: River Basin Resilience (current status and projected stress).

- (8) International Geosphere-Biosphere Programme (IGBP), with Global Nutrient Export from WaterSheds 2 (Global NEWS 2), responsible for: Nutrient Pollution (current status and projected stress).
- (9) Center for International Earth Science Information Network (CIESIN), Columbia University, responsible for Human Water Stress (population component), Urban Water Pollution (population component), Economic Dependence, Societal Well-being, Vulnerability, Population Density

Proposed Assessment Partners (APs)

- FAO Aquastat and FishStat Plus (water withdrawal data and fish catch).
- IWMI (global mapping of agriculture and environmental water requirements).
- UNICEF/WHO Joint Monitoring Programme (JMP) (water supply & sanitation).
- Secretariats of the Rotterdam Convention on Prior Informed Consent (PIC) for chemicals and of the Stockholm Convention on Persistent Organic Pollutants (POPs).
- World Bank (World Development Indicators).
- IMAGE group (scenario development for projected stress indicators).

Regarding data and information management, a decentralised system is proposed, with each Consortium Partner responsible for databases and information for their respective indicators. This contributes to the ownership, quality, and sustainability of the approach. However, partners must provide data and information to a UNEP Service Provider (e.g. GRID Europe or GRID Arendal) to enable dissemination of information to a wider audience.

The budget development requires further coordination between the TWAP working groups and the GEF secretariat, but an indicative budget outline is provided below, based on the following assumptions:

- The methodology utilises existing programmes and therefore all partners bring significant investments in data sets (co-financing) to TWAP. GEF will provide incremental funding that will add value to existing programmes and ensure results are suitable for TWAP objectives; and
- Total GEF contribution for TWAP in the region of US$ 10 million.

ITEM	TOTAL COST	CO-FINANCING (CASH AND IN-KIND)	REQUESTED GEF CONTRIBUTION (US$)
Indicators – Level 1: Acquiring data & calculating indicators	4,510,000	3,345,000	1,165,000
Level 2 (assuming 4 basins, US$ 50,000 per basin)	420,000	220,000	200,000
Cross-cutting issues & groups, analysis of results and reporting, contingency	870,000	435,000	435,000
Project Management	297,500	200,000	97,500
TOTAL	**6,097,500**	**4,200,000**	**1,897,500**

The time-scale of the FSP is expected to be 3 years (starting at the earliest at the end of 2011), with preliminary results being made available to inform the current GEF-5 planning process (2010 – 2014). Level 1 is expected to be completed within 1 – 2 years, with Level 2 assessments taking approximately six months per basin, and staggered to match the continuous disbursement schedule of GEF.

GENERAL INTRODUCTION

PROJECT BACKGROUND

This project, *Development of the Methodology and Arrangements for the GEF Transboundary Waters Assessment Programme (TWAP)*, is funded by the Global Environment Facility (GEF), and was approved by GEF in January 2009. It is designated as a Medium-Sized Project (MSP), and is being implemented by the United Nations Environment Programme - Division of Global Environment Facility (UNEP DGEF) and executed by the UNEP Division of Early Warning and Assessment (UNEP DEWA) together with partners. The inception meeting was held in June 2009.

Five water systems were defined, and a Working Group (WG) was established for each: (i) Groundwater, (ii) Lakes Basins, (iii) River Basins, (iv) Large Marine Ecosystems (LMEs), and (v) Open Ocean. This report describes the findings of the River Basins WG, and is the 4th Volume in the final TWAP MSP publication. The methodologies of each WG are described in volumes 2 – 6. Volume 1 is a summary document of the MSP.

WORKING APPROACH DURING MSP

The River Basins WG is led by the UNEP-DHI Centre for Water and Environment, and includes the Stockholm International Water Institute (SIWI) and the International Union for Conservation of Nature (IUCN) (See Annex 1 for WG members). The WG has collaborated closely together to develop the general approach, the development of indicators, and the identification of partners. The River Basins WG has also had close collaboration with the UNEP-DEWA Project Manager, as well as coordination with the other working groups, particularly Groundwater, Lakes, and LMEs. In order to validate the proposed methodology, consultation was held with stakeholders from a transboundary river basin in the form of a workshop, and with peers at a session at the Stockholm World Water Week 2010, as described in Part 6.

REPORT OUTLINE

The report outline was developed by the TWAP MSP Publication Correspondence Working Group (PUB CWG) in July 2010 and was agreed on by all groups in August 2010. The draft River Basins report at that time was reformatted to comply with the new outline. Consequently, the amount of internal cross-referencing within this report may be greater than normal, though this has been limited where possible. *It is therefore strongly recommended that the 'summary for decision-makers' in the previous section is read to provide a solid understanding of the logical flow of events during this project.*

The report is split into six 'Parts'. Part 1 describes the general approach to the project, links to ongoing global assessments, and the assessment framework. Part 2 describes the delineation of assessment units and lists key partners. Part 3 details the core indicators, presents the River Basin Fact Sheet Template, and includes a description of the scoring approach. Part 4 discusses the interlinkages and coordination with other water systems. Part 5 describes the data collection and management framework for collecting and processing data for the indicators listed in Part 3. Part 6 explains the validation of the approach, institutional arrangements and the resources required for the next phase of TWAP. The next phase will be a Full Size Project (FSP), and will involve the implementation of the assessment designed in this MSP phase. Annex 9 provides a cross-check of the locations of elements in the report as prescribed during the project.

PART 1. CONCEPTUAL FRAMEWORK

1.1 OBJECTIVE

The long-term goal of TWAP is to promote real investment in management and development of transboundary water systems through strong stakeholder engagement.

The expected impact of the next phase of TWAP, the Full Size Project (FSP), is to raise international awareness and political will to address strategic transboundary water system issues and their key causes.

The expected outcome is the establishment of a sustainable institutional framework for a baseline and ongoing periodic assessment of priority transboundary water systems. This will allow the tracking of results over time for GEF purposes in setting priorities for its resource allocation based on the understanding of baseline environmental and water resource conditions and tracking the longer term relative results of its interventions. In this manner, GEF can make more effective use of its resources for addressing higher priority transboundary systems and can report the impact of the use of its funding (TWAP 2007).

The main objectives of this Medium Size Project (MSP) are to develop:

(i) a methodology to undertake a global comparison of all transboundary water systems within the five categories of International Water (IW) systems, for the purposes of identifying areas 'at risk';

(ii) a methodology to undertake a more detailed analysis for selected IW systems;

(iii) a partnership among organizations; and

(iv) the arrangements needed to conduct a baseline transboundary waters assessment that may be conducted during the FSP following completion of the MSP (TWAP 2010).

The following outputs are expected from the MSP:

- Feasible, ecosystem-based methodologies for a global assessment of five IW systems. The methodologies will be used for assessing the changing conditions resulting from human and natural causes. The methodologies will also cover interlinkages between the five water systems. The development of methodologies will be based on indicators and existing data and information sources; and
- Recommendations for partnerships and institutional arrangements among agencies and organizations to conduct such a global assessment.

This report describes the methodology and general approach of the River Basins Working Group (WG). The terminology used in this report is consistent with the IHP Glossary (IHP 2010). The TWAP-specific glossary can be found in Annex 4.

Target audience

GEF is the main client for the assessment methodology and assessment results. Unless otherwise stated the term 'GEF' incorporates the entire GEF institution, including the Secretariat, Agencies, and recipient countries. The TWAP assessment is suggested to become an integrated part of the GEF IW focal area. It will assist GEF in setting priorities for its resource allocation base. UNEP and other UN and international organizations will also benefit from the assessment to better serve developing countries and countries in transition. For UNEP and other UN organizations the results will contribute to the global assessment efforts each organization is involved in (UNEP 2008). Countries with transboundary river basins and other stakeholders involved in or dependent on these basins will also benefit from the assessment. The assessment will identify transboundary hotspots and priority and emerging issues for the basins and the information coming out of the indicator analysis can be used by many stakeholders involved in the governance structures of transboundary basins. It may particularly benefit River Basin Organizations of transboundary rivers and the involved countries. NGOs, international organizations and the public will, through the TWAP process, receive access to a compilation of data for each of the world's transboundary basins that does not exist today that can benefit work on the ground.

The assessment can also be used by academic institutions for further research in the fields related to transboundary water, such as management and policy, data management, and ecosystem health.

1.2 SCOPE

The scope of the medium-sized project (MSP) is to develop an assessment framework based on existing data sets and techniques where appropriate, across five International Water (IW) systems (River basins, Lake basins, Groundwater, LMEs and Open Oceans). Each working group (WG) is to design a methodology that is suited to the respective IW category, whilst being compatible to the other methodologies as far as possible. The scope of this work package is to develop the River Basins methodology, including interlinkages with other IW systems where possible. The assessment itself will be carried out in the GEF-funded Full Size Project (FSP) which will be approved on the basis of the MSP.

The methodology involves two levels of assessment as described below, which is common for all five transboundary water systems under the MSP.

- **Level 1** is a baseline assessment where the results are used for a comparable analysis of all transboundary basins. It is not intended to be an in-depth 'state of the environment' type assessment. An approach to Level 1 has been designed so that it can be undertaken immediately after the current phase (MSP) in the framework of the FSP. The Level 1 framework can also be used for periodic assessments to monitor trends and impacts of management interventions as necessary. The key outputs of Level 1 are expected to be:
    - A database of indicator values with background data organized in a data structure;
    - Global maps and tables to compare basins and issues;
    - A Level 1 assessment report; and
    - Support prioritisation of transboundary river basins.
- **Level 2** involves a more detailed analysis of selected basins. These will be chosen to provide a wide geographic and socio-economic coverage. It will identify hotspots of transboundary concern within basins, as well as undertaking causal chain analysis and forecasting. Level 2 is also to be carried out under the framework of the FSP, and can be used as an initial verification of the results from Level 1, as well as including interlinkages between water systems. Level 2 will utilise existing basin and national studies (e.g. Transboundary Diagnostic Analyses (TDAs)).

Experience gained from both levels may be used as input to IW:LEARN 3 and to support the development of GEF's TDA/SAP process.

Results from both assessment levels will assist GEF in prioritising its resources. This approach is discussed in more detail in Parts 2 and 3. Both levels should both be compatible with existing GEF processes, particularly the GEF International Waters (IW) programme. In this way, TWAP can be seen as a 'service project' for the entire GEF-IW portfolio. This process provides a cost-effective approach, with a global assessment in Level 1 followed by a more detailed transboundary analysis of a selection of basins in Level 2, either building on, or providing input to the TDA/SAP process (which is outside the scope of TWAP) (IGA WG 2009).

Repeat assessments

The objective and scope of the TWAP FSP is to undertake a baseline assessment within the scope outlined above. Ideally this would be repeated at regular intervals to observe the change in status of basins. To this end the proposed partnerships that have been initiated during the MSP and are to be formalised for the FSP should be seen as sustainable and capable of undertaking ongoing assessments. Similarly, the methodology has been designed to enable repeat assessments. However, the feasibility of repeat assessments will depend on the success of the FSP and on the availability of funding.

1.3 FRAMEWORK

Level 1

The development of the Level 1 framework, a process involving discussions between the members of the River Basins working group (WG), the four other TWAP WGs, and TWAP and GEF secretariats, started at the TWAP inception meeting in July 2009. A full description of the process can be found in Annex 6.

A wide range of assessment frameworks exist, but few encompass the complexities of a global assessment of all IW systems (groundwater, lake basins, river basins, LMEs, and open oceans) with the objectives of TWAP. Consequently, each IW category has developed its own framework suited to its specific needs. The River Basins WG has developed an issues-based framework with roots in the DPSIR approach (GIWA, 2001), and its further development in the Millennium Ecosystem Assessment (MA, 2005). This grew out of the need to address both human and ecosystem vulnerability to stresses on their respective but closely linked systems. On the 'human' side, it is recognized that in many parts of the world the primary focus of river basin management is on socio-economic needs, and how livelihoods are affected by basin stresses and management responses. This was highlighted in the River Basins stakeholder workshop for the Mekong basin in August 2010, described in Part 6 and Annex 7. Ecosystem services have been considered either implicitly or explicitly within the indicators. However it is difficult to quantify ecosystem services, both direct and indirect, in practice. This is especially true for ecosystem services other than provisioning (e.g. food, water, fibre, fuel), which is still a challenge at the local, let alone the global level.

The framework shown in Figure 1 below shows the central function of governance (government, markets, civil society) in defining ways that humans access goods and services from water ecosystems to build livelihoods and enhance human well-being while conserving the integrity and health of the shared ecosystems (Talaue-McManus, 2010). Governance mediates within cultural contexts. Its strength and resilience derive from and result in a high level of human well-being, healthy ecosystems, and robust livelihoods. At the same time, it can be vulnerable to climate change, natural disasters, political instability and failed markets, depending on the overall health of its people, its economy and its natural resources. A failure to internalize environmental costs in valuing ecological goods and services has led to their misappropriation. In addition, inadequate policies for conserving environmental water requirements to maintain the functioning of aquatic ecosystems has put a number in peril. An integrated human-environment assessment therefore needs to encompass governance, human well-being, ecosystem health, and livelihood systems, and factors that may render these components vulnerable.

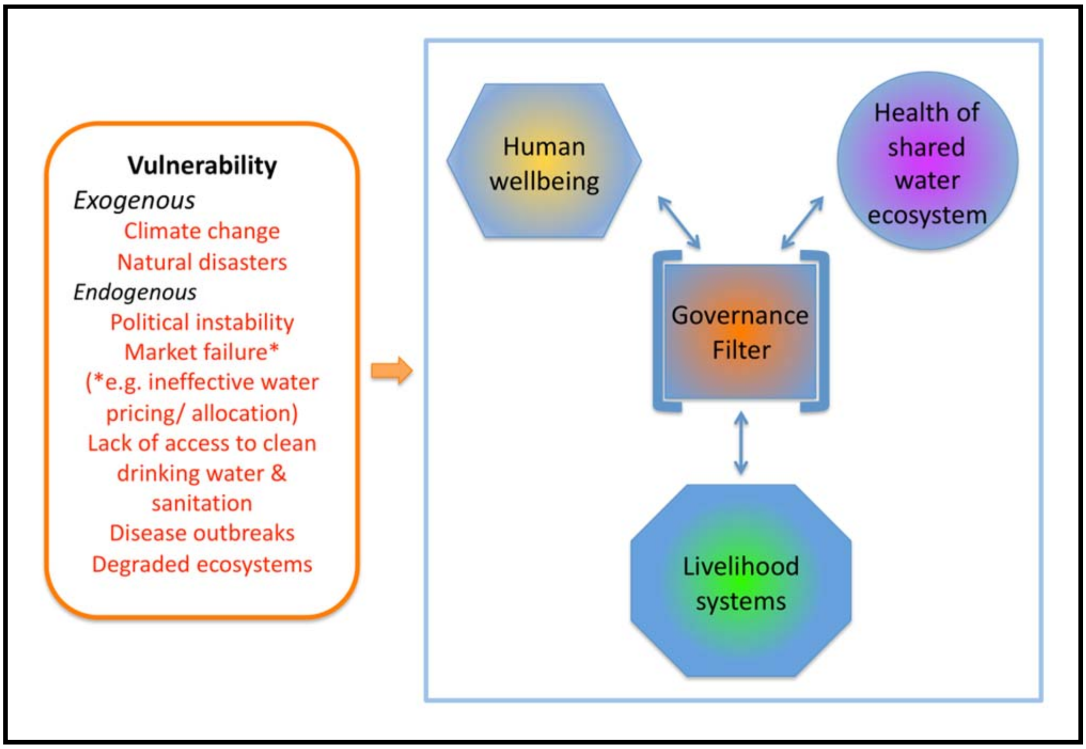


Figure 1. Framework for integrated human-environment assessment for shared water systems. (Source: Talaue-McManus (2010))

'Issues' that affect both human well-being and ecosystems have been identified:

1. Water quantity;
2. Water quality;
3. Ecosystem assets;
4. Water governance; and
5. Socio-economics.

In developing indicators to assess these, an attempt has been made to link them to human well-being, livelihoods and ecosystems where possible. The issues were also identified in the light of the interlinkages with the other IW systems. It was felt that these issues could be applied to the majority of the other IW systems, and this would facilitate the comparison of units between systems at a later stage.

It is noteworthy that the primary focus of the FSP is a global baseline assessment, though with potential for periodic repetitions to identify impacts of intervention, or changing situations without intervention. Consequently, the framework, and the indicators within this framework, has been designed to enable both a *baseline* assessment, and subsequent assessments measuring *change*.

In accordance with a request from the GEF Secretariat during the MSP, the assessment is divided into two main categories, *transboundary status* and *projected transboundary stress*. Approximately three quarters of the indicators address the current status, and one quarter projected stress. The projected stress indicators allow certain indicators to be assessed for 2030 and 2050.

From issues to indicators

Indicators addressing the above issues were chosen on the basis of the following criteria:

1. Supporting the DPSIR framework;
2. Capturing human and ecosystem vulnerability;
3. The four 'A's (IGA WG 2009):
    - 3.1. Availability – data availability at the global scale, fit for the purposes of TWAP and which are cost-effective to acquire (either through data or modelling);
    - 3.2. Acceptability – perceived likelihood of stakeholder 'ownership' of indicators;
    - 3.3. Applicability – relevance to transboundary issues at the global scale in the context of TWAP, including being relevant to other water IW systems where possible;
    - 3.4. Aggregation – the potential to aggregate data at the river basin level and comparability between basins;
4. Relevant to identify GEF priority issues, emerging issues and linkages to other water systems; and
5. Easy to understand and interpret, and without excess overlap between indicators.

Due to budget and timing considerations, the availability of data (or potential for generating modelled data) was assigned particular importance in selecting indicators. This was partly due to the expectation of the GEF Sec that the assessment should be undertaken as soon as the FSP was approved (IGA WG 2009). It was therefore important that as much data as possible was available in databases with global coverage for most transboundary river basins. For many of the world's transboundary river basins, measured and updated data are not available for all the core indicators. The methodology therefore also includes data retrieved from remote sensing as well as modelled data where needed. In this context, it is important to remember that the focus of TWAP is to undertake a *comparison* of basins, not to undertake a full global 'state of the environment' assessment. Thus in some cases proxy indicators could be used to identify the *relative* states of different basins for each issue.

The long lists of issues and indicators can be found in Annex 3. The core indicators chosen for Level 1 are described in Part 3. It is recognized that the core indicators will be affected in some way by each other due to the feedback loops inherent in freshwater systems.

Governance and Socioeconomics

Recognising that there is likely to be considerable overlap in governance and socio-economics between water systems, a Governance and Socioeconomics Correspondence Working Group (GS-CWG) was set up with representatives from each IW system working group. The River Basins methodology for governance and socioeconomics is based on the frameworks developed by the GS-CWG.

The governance framework developed focuses on the governance arrangements, or *architecture,* (government, markets, civil society), in place to address water issues at the transboundary scale. Due to the global scale of the assessment at Level 1 it does not attempt to assess the performance or effectiveness of these arrangements, but rather the extent to which they exist. This is achieved by analysing the full 'policy cycle' from preparation of advice, through implementation, to review. The data is expected to be collected by stakeholders or regional experts, and could be coordinated through a governance working group to be established under the FSP.

As experience in global governance assessments across water systems is limited, this methodology has been specifically developed for the assessment of transboundary river basins to be implemented under the TWAP FSP. So while the conceptual basis for this methodology is generally accepted, it has not previously been tested. Its application will therefore be exploratory and its development should be an integral part of its application.

In the River Basins methodology, this framework leads to the 'governance architecture' indicator. Two other indicators make up the governance group:

- Basin resilience – this assesses the regulatory and institutional capacity at the transboundary level; and
- Water legislation – this assess the extent to which 'modern', integrated water management is reflected in the national legislation of riparian countries.

The socioeconomics framework as developed by the GS-CWG contains a 'social' and an 'economic' cluster of indicators. The *social* cluster focuses on the human well-being of societies including access to water supply and sanitation, literacy, and life expectancy. The reason for these indicators is based on the principle that healthy, well-educated societies will have a greater capacity to manage water resources in a sustainable manner, and be more able to adapt to pressures on these resources. The *economic* cluster addresses the dependence of societies on water, including GDP per total water withdrawals, agriculture-related GDP, fisheries-related GDP, and reliance on water for electricity production.

Both the social and economics clusters had 'vulnerability to climate-related natural disasters' included. As the social and economic vulnerability to such disasters is so closely linked, this was extracted from both clusters to form a third cluster in the River Basins methodology. In summary, the River Basins socioeconomic framework comprises the following clusters:

- Social well-being;
- Economic dependence on the water resource; and
- Vulnerability to climate-related changes to the water resource.

Both the governance and the socioeconomic indicators are described in Part 3 and Annex 3.

Level 2

The Level 2 assessment was not included in the Project Document, but was introduced to all groups by the GEF Secretariat in December 2009 (IGA WG 2009), and further developed in July 2010 (IMAIG 2010), and February 2011 (2nd Steering Committee meeting). The original basis for the Level 2 assessment was that it would be a more detailed 'pilot study' in a selection of basins, and would undertake a causal-chain analysis (CCA) of key issues, forecasting, and identification of transboundary hotspots *within* basins. It should also serve as a validation of the Level 1 results.

However, partly due to limited funding for Level 2 for each basin (approximately US$50 000 proposed per basin), and partly due to a development of the approach by the working groups and the GEF Secretariat, the framework for Level 2 has been altered to address three main objectives:

1. To serve as a broad validation of the Level 1 results;
2. To undertake a broad-brush analysis of cross-cutting issues between different water systems where possible; and
3. To make recommendations for the Transboundary Diagnostic Analysis/Strategic Action Programme (TDA/SAP) process with regards to indicators and assessment processes.

Level 2 is expected to be mainly undertaken using existing analyses (e.g. TDAs). There is likely to be a range of data availability between basins. For the comparison purposes of Level 1, it is important that the indicator framework utilises data widely available for the majority of basins. However, in Level 2, it is less important that the indicator framework is identical for each basin. This allows the assessment to make the best use of the available data for any basin, or for new data to be obtained/derived as appropriate and within budget, allowing for a more in-depth analysis.

It is expected that a clear framework and objectives for Level 2 will be further developed during the project preparation phase, before the commencement of the FSP. It is recommended that as a minimum, Level 2 should be used to hold a stakeholder workshop to disseminate the findings of Level 1 and develop a 'roadmap' for future work. In basins where extra funding is available, a full Causal Chain Analysis (CCA), with forecasting of issues and hotspot analysis, should be undertaken (see sections 2.4 and 2.5). Furthermore, it may be feasible to undertake a more detailed assessment of ecosystem services, and hence develop the framework based on this approach. Another potential aspect to be included in Level 2 could be an assessment of the monitoring programmes in place in a particular basin.

There may also be scope for some 'informal' capacity building during Level 2, including within River Basin Organizations (RBOs), public authorities and government bodies, and regional and national research institutes. This is discussed in section 6.3.

As well as looking 'forward' to the TDA/SAP process, Level 2 in general should also look back to the GIWA (Global International Waters Assessment) methodology and findings.

1.4 VULNERABILITY

As described in the previous section, the framework considers the vulnerability (and resilience) of both human systems and ecosystems. This can be seen across all five 'issues' mentioned above. Following feedback from the joint River Basins and Lakes stakeholder workshop in the Mekong River basin, an attempt was made to strengthen the links between the issues and their impacts on livelihoods, and it is believed that this is reflected in the final choice of indicators. Almost every indicator is a reflection of either human or ecosystem vulnerability, or both. However, as described in the framework section above, governance and socioeconomics are particularly important in assessing the vulnerability of societies and ecosystems to pressures on the water resources as they indicate the capacity to adapt to and manage these pressures.

In a recent paper on the global threats to rivers (Vörösmarty, *et al.,* 2010), human vulnerability was addressed by including an 'investment benefits factor' in their analysis. This incorporated the level of supply stabilisation (e.g. reservoirs), and improved supply services and access to waterways. When this factor was applied to the indicator results, it significantly changed the global risk map. Such an approach could also be developed during the FSP, either using the same data, or socioeconomic and governance information obtained within the FSP.

Note that aspects of the vulnerability of human populations are also captured in the transboundary river basin fact sheet described in section 3.3.

1.5 CONTRIBUTION TO EXISTING GLOBAL ASSESSMENTS

The River Basins WG methodology builds on the lessons learnt from earlier and ongoing assessments of transboundary waters. Links to ongoing or completed assessments such as GIWA, WWAP, UNEP GEO and the GEF TDA/SAP process are described below.

Global International Water Assessment (GIWA)

The GIWA process started in 1999 with the final reports being published in 2006. GIWA assessed the ecological status and causes of environmental problems in 66 international water areas in the world.

GIWA studied the interactions between mankind and aquatic resources relating to four specific concerns: freshwater shortage, pollution, overfishing and habitat modification. A fifth overarching concern, global change, was also studied. The overall objective was *'to develop a comprehensive strategic assessment that may be used by GEF and its partners to identify priorities for remedial and mitigatory actions in international waters, designed to achieve significant environmental benefits, at national, regional and global levels.'* (GIWA 2006)

The issues of concern and the results from GIWA have all been considered when developing the indicators and methodology for the River Basins assessment. The main results of the five concerns in GIWA: pollution and eutrophication, water quantity issues, fish catch, effects of habitat modifications in the river basins and global change, are all issues that are part of the TWAP River methodology and prominent among the indicators.

A lesson learnt from the GIWA programme was that the methodology development and the implementation of the assessment should not be carried out in the same project phase. In TWAP, the MSP phase focuses on the development of methodology and the FSP is planned to carry out the actual assessment.

Another difference between GIWA and TWAP is that GIWA used the same methodology to assess the different water systems, whereas TWAP has separate methodologies for each of the five water systems.

UNESCO-World Water Assessment Programme

The UNESCO World Water Assessment Programme (WWAP) is a coordinating umbrella for existing UN initiatives on freshwater assessment. WWAP monitors freshwater issues and provides recommendations, develops case studies, enhances assessment capacity at a national level, and informs the decision-making process. The main objective of WWAP is '*to assess and report on the state, use and management of the world's freshwater resources and the demands on these resources, define critical problems and assess the ability of nations to cope with water-related stress and conflict*' (WWAP 2000). The periodic publication of the World Water Development Report provides a comprehensive picture of the state of the world's freshwater resources. The programme aims at informing stakeholders and the general public, as well as influencing governments, civil society and the private sector to promote sustainable social and economic development in their water policies and decision making.

The main client of TWAP is the GEF and its aim is to make a comparable baseline assessment of the world's transboundary waters. The TWAP River methodology caters foremost to the needs of the GEF to prioritize its resources. The results of the TWAP River Basins assessment will provide information that can be used and analysed in the context of WWAP and can contribute to the understanding of the world's freshwater resources. In Level 2 of the TWAP River Basins assessment the identified hotspots and priority issues identified in these basins can serve as case studies for WWAP.

UNEP Global Environment Outlook

The UNEP Global Environmental Outlook (UNEP GEO) is UNEP's global assessment process on the state of the environment. It aims at being a link between science and policy. UNEP GEO has a world-wide network of Collaborating Centres that provide input to the assessment. The TWAP River Basins assessment could benefit from the knowledge base as well as the data available in UNEP GEO for the Level 2 assessments. The outcome of the TWAP assessment can also be used in the UNEP GEO process when looking at aquatic environments and the ecosystem services they provide. The indicator maps, ranking basin status, could be of particular interest to UNEP GEO.

UNDP Human Development Report

TWAP closely considers the relationship between ecosystems and human vulnerability and governance aspects. Human development is strongly linked to available natural resources, including water resources, and how they are governed (UNDP 2010). To capture this, the TWAP River Basins methodology includes data from the UNDP Human Development Report (UNDP HDR), in particular the Human Development Index (HDI) and Gross Domestic Product (GDP).

UN Water Statistics

The *International Recommendations for Water Statistics* (IRWS) (UNSD 2010) was prepared by the United Nations Statistics division as part of its regular work programme to assist countries in the development of water statistics. The international recommendations reflect a multi-purpose framework, which can be applied flexibly by countries at different stages of development of environment statistics and environment-economic accounting. The drafting of IRWS was undertaken as part of the implementation strategy for the System of Environmental-Economic Accounting for Water (SEEAW).

GEF Transboundary Diagnostic Analysis/Strategic Programme of Action

Transboundary Diagnostic Analysis (TDA) is a scientific and technical analysis which is an objective assessment showing the relative importance of causes and impacts of transboundary water problems. In the GEF process the TDA is followed by a negotiated policy document which addresses the issues raised in the TDA. This is called a Strategic Programme of Action (SAP) and addresses policy, legal and institutional reforms, and investment needs (GEF 2005a). Within the GEF International Waters Focal Area the TDA/SAP is a requirement for financing for most projects.

Level 1 of the TWAP River Basins WG methodology assesses transboundary river basins globally, with a small selection of basins studied in Level 2. If a TDA has been undertaken for a selected basin, the Level 2 analysis can build on this TDA. If not, both levels could function as a pre-TDA/SAP phase, determining hotspots and priority issues for consideration during a TDA/SAP. Furthermore, experience gained from both levels may be used as input to IW:LEARN 3 and support the development of GEF's TDA/SAP process.

Rio+20 Earth Summit

UN-Water has decided to produce a status report for the UNCSD meeting in Rio 2012 (also called 'Rio+20') on the application of integrated approaches to the development, management and use of water resources. UN-Water has asked UNEP to lead a core team including UNDP and GWP and has established an ad-hoc Task Force led by UNEP to advise on the preparation of the report. The UNEP-DHI Centre on Water and Environment will coordinate the technical preparation of the report.

Water resources was a priority area at the UNCED in Rio 1992 (Chapter 18 of Agenda 21) and followed up by a Worldwide commitment to Integrated Water Resources Management (IWRM) in Johannesburg in 2002 (Article 25 of the JPOI). A previous survey carried out in 2006-7 and presented at CSD-16 in 2008 showed moderate progress in the development of national IWRM plans, and it is the intention that a new status report should help strengthen the global commitment to sustainable use of water resources. In addition, the status report is intended to provide a first step towards a regular global monitoring mechanism for the management of water resources.

PART 2. INVENTORY AND CHARACTERIZATION OF TRANSBOUNDARY RIVER BASINS

2.1 ASSESSMENT UNITS/BOUNDARIES

Transboundary river basins will be one of the assessment units for the FSP. 'Transboundary' refers to one or more nation states sharing a basin. The world's transboundary river basins are well defined in the Transboundary Freshwater Disputes Database (Oregon State University), which identifies approximately 270 such basins (See Annex 5). It is proposed that the FSP assesses all of these.[1]

River basin vs. country-based decision-support information systems

For transboundary waters, information such as water quality and hydrology is usually gathered from national monitoring systems, rather than from monitoring systems specifically established and operated by joint bodies. Establishing, upgrading and running basin-wide monitoring systems may thus require careful examination of national legislation as well as obligations under international agreements and other commitments. Likewise, socioeconomic statistics, measures and policies tend to be collected and analysed for administrative regions and then aggregated to larger spatial levels that may be other than the basin (Lorenz, *et al.,* 2001). While applying a framework at the river basin scale would be a useful contribution to integrated water resource management, disconnection in data sets between hydrological and socioeconomic data often hampers this (Sullivan*, et al.,* 2006).

For the purposes of TWAP, much of the raw data is available at the national level. It is thus necessary to re-aggregate national figures from riparian countries to the basin level. This poses a number of challenges and potential solutions. Simpler methods would use a proportion of average country data based on how much country area is encompassed in the basin. More complex methods would involve detailed GIS-based land-use zones to determine a more exact relationship to the national data. The tendency has been to adopt a mixture of approaches, depending on data availability and characteristics. For example, the Transboundary Freshwater Dispute Database by Oregon State University features population and land-use data for each basin that are also available as country shares. On the other hand, the FAO database on fisheries and aquaculture is strictly organized in country profiles and the basin splits thus have to be inferred from a river's productivity relative to all the country's inland waters. For basin features that can be geo-referenced such as dams or wetlands, locating and assigning country total units or areas to basins is a more straightforward task.

Fortunately, many of the indicators selected already have designated models set up which can undertake assessments on a gridded basis. Many of these models have tested methods for aggregating national data to the basin level.

As river basins usually stretch over different administrative and geographical units and State borders, cooperation between many actors is needed. These include environmental and water agencies, hydro-meteorological services, geological surveys, public health institutions and water laboratories. They also include research institutes and universities engaged in methodical work on monitoring, modelling,

[1] The latest figure, presented in De Stefano et al (2010), is 276 transboundary river basins. However, there may be a few basins where a single country covers the majority of the basin, and management institutions are likely to be intra-national instead of international. An example of this would be the Iranian portion of the BahuKalat/ Rudkhanehye, which has 99.8% of the population and area of the basin, with Pakistan sharing the small remainder. It may be decided with partners under the FSP to omit such basins from the assessment, though this should be done in consultation with the GEF.

forecasting and assessments. Such cooperative arrangements and institutional frameworks are believed to greatly influence the efficiency of transboundary monitoring and assessment (UNECE 2006). As decisions by river basin organizations (where they exist) have to be implemented by individual riparian States, it may be beneficial to maintain the ability to disaggregate river basin-relevant figures into national contributions. Furthermore, the institutional environment and polycentric or monocentric forms of water governance need to be recognized, including transboundary power asymmetry, as this may affect the source and reliability of data.

Sampling stations and monitoring networks

The level of detail that monitoring and assessment can provide depends on the density of the network, the frequency of measurements, the size of the basin and/or the issues under investigation. For example, when a measuring station at the outlet of a river basin reports water-quality changes, often a more detailed monitoring network is needed to reveal the source, the causal agent and the pathways of pollutants. The interaction between surface waters and groundwater may also be different in the upper and lower parts of the basin. In these cases, information would be needed for smaller sub-basins. Without going this far, the TWAP conceptual model of the river basin has been developed so that interactions such as between transboundary rivers and transboundary aquifers or between the state of water quantity and water quality can still be taken into account. This is reflected in the Indicator Description Sheets as presented in Annex 3. There, a short description can be found of how each river indicator is significant for other water systems in terms of input/output to groundwater, lakes or LMEs.

Ideally, monitoring networks, the frequency of measurements and determinants as well as assessment methodologies should be adapted to the particular conditions. As it is obvious that monitoring programmes are not available at a global scale with the consistency required for this study, other approaches have been used, including the development of proxy indicators based on stresses and covering agricultural, industrial and domestic pressures. This is the approach by which Level 1 of the FSP (Sections 1.2 and 2.5) will lead to the identification of priority basins, as well as transboundary water issues using interlinking indicators across water systems. Specifically, the assessment will be centred on existing transboundary stresses and the current status of governance arrangements as well as some estimates of projected future transboundary stress for the near-term and medium-term future. Level 2 will further assess selected basins and issues, identify hotspots within basins and undertake causal chain analysis (Sections 1.2 and 2.5). Level 2 could either build on existing TDAs, or be used as input information to future TDAs. As part of this process, project- or field-based measurements in the future may be secured though national monitoring systems, and/or through project-supported transboundary monitoring networks. Criteria for selecting sampling stations in a transboundary monitoring network may include considering locations: i) upstream or downstream of international borders, ii) upstream of the confluences of the main stem of the river and its main tributaries or main tributaries and their main sub-tributaries, iii) upstream of the confluences with major lakes and estuaries, iv) downstream of the major point sources of pollution including cities, and v) in the areas of water abstraction for drinking water supply (ICPDR, 2010).

Scalable approach

A weakness embodied in conventional water-resource assessments is dependence on available data, which may be of dubious quality or at the wrong scale. Although data can be scaled up or down, this can generate inaccuracies and decrease the reliability of the approach. This issue needs to be dealt with in models de-aggregating national data or filling in data gaps. Therefore, the challenge has been to develop a transboundary river assessment methodology that allows for greater or lesser detail as required and accommodates data when these become available.

Indicator methodologies can overcome the problems associated with incommensurability of data and also allow for the combination of both qualitative and quantitative data. It is important to note, however, that while indicators can simplify the characteristics of systems and situations, they must have adequate temporal and spatial coverage to ensure that they accurately represent reality and provide a dynamic tool for evaluation and comparison. Although there is no doubt that indicators are important policy tools, their construction and use must be approached with caution (Sullivan*, et al.,* 2006).

To address the question of multiple-level issues, a framework was developed that utilizes a core set of key indicators (e.g. human water stress, nutrient pollution, ecosystem fragmentation) to capture the essence of transboundary water issues (e.g. water quantity, water quality, ecosystem services) as discussed in section 1.3. The data required to monitor these variables with indicators is collected at different scales but is re-aggregated to represent the basin scale (Fig. 2). The draft indicators identified provide the basis for a fully integrated and comparable assessment tool on which water-management decisions can be based throughout the TWAP working process (See Scope of the FSP in Sections 1.3 and 2.5).

As an example, Issue 2 in Figure 2 represents Ecosystem Services as the transboundary area of concern and investigation. Information on provisioning services such as fish stocks or impaired services because of river fragmentation is available at the national or country scale, and in some cases this is available by basin depending on spatial data sets. Within the scope of ecosystem services, two indicators may be required based on two different variables. In this example, Variable 3 represents ecosystem fragmentation (based on impoundment density, etc.), and Variable 4 represents fish threat in transboundary basins within the riparian countries.

	ISSUE 1:		**ISSUE 2: ECOSYSTEM SERVICES**		**ISSUE 3:**		
	Variable 1	**Variable 2**	**Variable 3**	**Variable 4**	**Variable 5**	**Variable 6**	
Country				Data	Data	Data	
Basin (Level 1)	Data : Indicator	Data : Indicator	Data : Indicator	Indicator	Indicator	Indicator	**Possible Index**
Within-Basin intervention (Level 2)	Hotspot indicator	Hotspot indicator	Hotspot indicator	Hotspot indicator	Hotspot indicator	Hotspot indicator	**Map**

Figure 2. Combined approach to scale and issues (arrows depict steps in data requirements and indicator computation, rounded rectangles represent potential synthesis tools, i.e. indicators and maps)

Specific literature has confirmed that a tiered approach is particularly suited to define biological variables for a system. Noss (1990, 1995) and Dale and Beyeler (2001) suggest that an ideal set of indicators should consider the different ecological characteristics of structure and function in a hierarchy of ecosystem scales (i.e. species / population, community / ecosystem, landscape / region) (Adamus*, et al.,* 1990). Part 1 has introduced and Part 3 will describe in detail how these levels of biotic organization have been associated with the indicators for ecosystem assets. For example, wetland coverage and fish stocks are relevant for landscapes, habitat fragmentation has consequences for biological communities, and species abundances are informative of population dynamics. Disconnectivity of wetlands often leads to losses of habitat, nutrient processing and retention, and organic matter inputs. Fishing tends to alter community structures and can give rise to trophic cascades that change population, community, and ecosystem dynamics. Through the combined frameworks of scales issues, wetlands and fisheries can thus be utilised as proxy indicators that make up the analysis for ecosystem structure. At the same time, disconnected wetlands lead to loss of local flood protection, water storage, and natural water purification. Therefore, ecosystem services and functions are also echoed in issues of water quantity and quality (Vörösmarty, *et al.,* 2010).

While the primary focus of TWAP is to obtain results at the basin scale, there may be significant variations between sub-basins within the same basin. The majority of indicators described in Part 3 are modelled on a global grid (typically 0.5 x 0.5 degrees, which is approximately 50 x 50 km). This allows for the comparison between sub-basins if necessary, and if time and budget are available. This is further discussed in 'identification of hotspots' in section 2.4 and in section 5.3.

2.2 INVENTORY OF AGENCIES, PROGRAMMES, DATA SETS AND SOURCES

A list of potential data sources and partners can be found in Annex 2. The list in Section 2.3 shows the recommended partners, and the indicators that they will be involved in assessing. Partners have been selected based on the following criteria:

- Those already maintaining, or with access to, databases with global coverage for one or more indicators;
- Those with expertise, and/or strong networks, relevant to one or more indicators; and
- Those with expertise in transboundary waters, natural resource indicators and assessments.

Another important factor in the selection of partners has been the idea of trying to keep the total number of institutions involved in the FSP to a manageable level. Therefore, institutions have been selected that can provide data/expertise for more than one indicator where possible. This will make the FSP easier to coordinate, and represents a potential cost saving for TWAP.

It can be seen from the list in Section 2.3 that River Basin Organizations (RBOs) are not explicitly mentioned as partners. This is mainly due to the fact that partners have been selected that have global data sets available (particularly for Level 1 of the FSP). This will significantly simplify the institutional arrangements during the FSP by keeping the total number of partners to a reasonable level. This is not to say that RBOs will not be approached during the FSP, and that this important source of knowledge will not be utilised. It is recommended that all RBOs are contacted near the beginning of the FSP to explain the objectives of TWAP, and to indicate possible opportunities for involvement. During Level 1, they are likely to be approached to assist with providing information for the governance indicators (particularly governance architecture and water legislation). During Level 2, they are likely to be much more involved, with basins being investigated in more detail, including undertaking causal chain analyses and forecasting. At this stage RBOs can play an important role. There may also be scope for some 'informal' capacity building, potentially in the form of on-the-job training and networking, for RBOs during Level 2. This is discussed further in section 6.3.

For Level 2 there may be increased potential for private sector involvement for the provision of data. For example this may include water and sewage utilities data, and private industry water use and wastewater production data.

It may be beneficial to store institutional arrangement details in GEF IW:LEARN's Project Database or Geonetwork Metadata Catalogue, though this can be arranged during the FSP.

2.3 IDENTIFICATION OF MAJOR STAKEHOLDERS AND PARTNERS

Dissemination of Results

The main recipient of the assessment results is GEF. The project document also shows UNEP and other UN and international organizations as primary beneficiaries of the assessment results, in particular through contributing to the global assessments each organization is carrying out. The Implementing Agency could be responsible for disseminating the FSP assessment results to these organizations.

The GEF member countries are another group that will be able to use the assessment results to support national and international transboundary priorities. It is also important that dissemination of results is extensive in order for the assessment process and its uses to be transparent to countries and stakeholders. It is important to gain acceptance of the results of the assessment from GEF member countries if GEF is to consider the results in its allocation process.

The results will be of value to a wide group of stakeholders and could be made publicly available. There may be scope for other stakeholders to be given access to 'underlying' data in order to make the best use of the findings of the FSP for their particular purposes. International organizations, donors, RBOs and NGOs involved in transboundary river management, as well as academics could be interested in the assessment results and dissemination to, and use of the results by these groups could strengthen the validity of the assessment.

The Level 2 assessment would be of particular interest to the stakeholders involved in the selected basins and an effort to disseminate results to these groups in a useful format is important.

Partners

The TWAP MSP project document states that existing institutions and frameworks should be used as far as possible to gather data for the designed indicators. This has been a focus of the River Basins working group. In order to streamline the FSP, institutions that can provide data for multiple indicators have been chosen where possible. However, the need to identify partners with specific expertise has led to the selection of some partners that may have an overlap in general expertise (for example with global hydrological models).

Partner definitions and arrangements are discussed in section 6.1. In summary, the institutional arrangement for the FSP consists of a core Assessment Consortium (AC), made up of a Consortium Coordinator (CC), and Consortium Partners (CPs) who will be primarily responsible for undertaking the assessment. Assessment Partners (APs) are not included in the consortium but may provide data for the assessments. The list below indicates the proposed partnership arrangements for the FSP, as well as the broad area of expertise for each institution. It is important to secure in-principle interest from the Consortium Partners before the start of the FSP. Annex 2 provides a 'long-list' of further potential partners and data sources should it prove unfeasible to secure the recommended partners. Whilst considerable effort has been made to make the long-list as comprehensive as possible, it is acknowledged that there are a multitude of possible approaches to a global assessment such as TWAP, involving a range of techniques and project partners. Therefore it was recommended that the Information Management and Indicators Working Group (IMAIG), the five Working Groups, the TWAP Steering Committee and the TWAP Secretariat provided comments on the long-list during the MSP to try to ensure that all significant data sources and potential partners have been identified.

Consortium Coordinator (CC)

- (1) UNEP-DHI Centre for Water and Environment, with support from (2) IUCN and (3) SIWI – knowledge of TWAP, as well as UNEP and GEF processes, transboundary river basin management, environmental assessments.

Consortium Partners (CPs)

1. CUNY Environmental Cross-Roads Initiative, City College of New York: global modelling of river basins (WBM_{plus} model)
2. Universities of Kassel (Centre for Environmental Systems Research) & Frankfurt (Institute of Physical Geography): global modelling of river basins (WaterGAP model)
3. International Water Management Institute (IWMI): agricultural and environmental water requirements. Previous work with WaterGAP team.
4. Program in Water Conflict Management and Transformation (PWCMT), Institute for Water and Watersheds, Oregon State University (OSU): creators of the Transboundary Freshwater Dispute Database, and expert knowledge on transboundary water resources management.
5. International Geosphere-Biosphere Programme (IGBP), Global NEWS: global modelling of nutrients. Previous work with CUNY team.
6. Center for International Earth Science Information Network (CIESIN), (SocioEconomic Data and Application Center – SEDAC), of the Earth Institute, Columbia University – anthropogenic data, as well as risks to humans from climate-related natural disasters.
7. Netherlands Environmental Assessment Agency: IMAGE modelling group for scenarios for Projected Stress Indicators.

Assessment Partners (APs)

- FAO (Aquastat & FishStat Plus)
- UNICEF/WHO Joint Monitoring Programme (JMP) (water supply & sanitation)
- Secretariats of the Rotterdam Convention on Prior Informed Consent (PIC) for chemicals and of the Stockholm Convention on Persistent Organic Pollutants (POPs)
- World Bank (World Development Indicators)
- Global Water Systems Project (GWSP) (Global reservoir and dam database & river basin management)
- ICOLD (World register on dams)
- WorldFish Centre (GDP related fisheries)

2.4 PRIORITY ISSUES, EMERGING ISSUES AND HOTSPOTS

Priority issues

Priority issues are captured through the use of indicators in Level 1, and can be investigated further in Level 2. The indicator framework has been designed to enable the investigation of a range of issues (as described above) and highlight the key, or priority issues, for each basin. It will also be possible to identify whether some issues are particularly important at a regional or global scale.

It is appreciated that there are likely to be variations within each basin across the full range of issues and indicators. However, as previously discussed, the primary objective of Level 1 is a comparison between basins. Therefore most of the indicators for Level 1 use basin averages and totals, and do not account for variations within each basin. This step is to be undertaken in Level 2.

Emerging issues

The indicator framework has been designed in such a way that, as new issues emerge, indicators can either be modified, or new indicators can be incorporated into the existing structure or replace existing indicators without compromising its integrity.

Furthermore, the framework also allows for the tracking of issues (as they become more or less important) through repeated assessments. The role and frequency of repeated assessments is yet to be determined, and requires discussion between the secretariat, the steering committee, GEF, and other working groups.

Increasing water scarcity and depletion of natural resources, partly as a consequence of climate change, leads to a potential increase in water conflicts between countries that share transboundary waters (Yoffe*, et al.,* 2004). This water scarcity is however caused not only by natural processes but also by inadequate and inefficient water management and competition between water uses (Wester*, et al.,* 2002). But water scarcity is not the only problem confronting neighbours who share transboundary waters. Although only 10 per cent of all river floods are transboundary, they result in a considerable fraction of the total number of casualties, displaced/affected individuals and financial damage worldwide (Bakker 2006).

As an example of how this framework can cope with emerging issues, climate change has been incorporated into River Basin Resilience as both a present issue and a projected stress factor that mainly affects water quantity. This would be reflected in the overall flow metric through a change in precipitation and in the floods and drought metrics through more intense and frequent extreme events. Ecosystem indicators are also involved as climate change is expected to have substantial effects on energy flows and matter recycling through its impact on water temperature, resulting in algal blooms, increases in toxic cyanobacteria blooms and reductions in biodiversity (WWAP 2009).

Identification of hotspots

Hotspots are geographical areas where issues are of particular importance. These can be identified at different scales, as described below. Hotspots should indicate impacts that are transboundary in nature, not only those with national impacts (TWAP 2010).

To meet the objective of a comparison between basins, Level 1 will compute indicators based on basin averages. Thus, hotspots can be identified at the basin level. However, it is appreciated that this may mask the variations that are inevitably found within basins. Therefore, if it is necessary to identify hotspots within specific basins based on the Level 1 assessment, most of the Level 1 indicators are built on a grid (typically 30 minute grids, or approximately 50 x 50 km), so that extraction of information at this resolution will be possible. Some of the implications of applying indicators at different scales are discussed in Sullivan*, et al.* (2006). More discussion on the issues of scale is given in Section 2.1. The calculation of indicators on a gridded basis also allows for a 'contrast' indicator to be developed, showing the differences in scores within a basin on any particular issue or group of issues.

For Level 2, a much finer resolution can be used than for Level 1, and hotspots within basins will be identified. Examples of how indicators may be scaled down for Level 2 are provided in Section 3.4.

Causal Chain Analysis

This is to be undertaken in Level 2 only. In accordance with the TDA/SAP procedure, this involves the identification of immediate, underlying and root causes of each priority transboundary problem (GEF

2005b). In identifying issues for the TDA/SAP process, it is important to understand the root causes of transboundary problems, so that a judgement can be made on whether change can be achieved, and what resources and actions would be required to bring about this change. It is recommended that a causal chain analysis (CCA) is undertaken at least for those indicators for which the basin is performing poorly. The CCA should also build on the GIWA methodology (GIWA 2002) and findings of its CCA.

Forecasting

This is undertaken in both Level 1 and Level 2, and investigates the time-scale of the problem. Is the problem time-dependent – will the situation worsen significantly if action is not taken within a certain time-frame? This is part of the 'scaling' process within the 'identification and initial prioritisation of transboundary problems', which is part of the TDA/SAP process (GEF 2005c). For Level 2, it is recommended that this step is undertaken for all indicators for which a causal chain analysis is undertaken. The Assessment Consortium described in section 2.3 is to be responsible for both the causal chain analysis and forecasting, but may solicit external assistance if necessary.

The indicators that utilise modelling may provide the simplest opportunities for forecasting. For other indicators it may be possible to undertake a more qualitative approach to forecasting.

2.5 IDENTIFICATION OF DEMONSTRATION/PILOT PROJECTS (LEVEL 2)

This section refers to the Level 2 analysis, as described in section 1.3. In an earlier draft version of the River Basins report, it was suggested that Level 2 basins should be selected based on the outcomes of Level 1 – i.e. a selection of 'priority basins' for further investigation in Level 2. The process is outlined in figure 3 below.

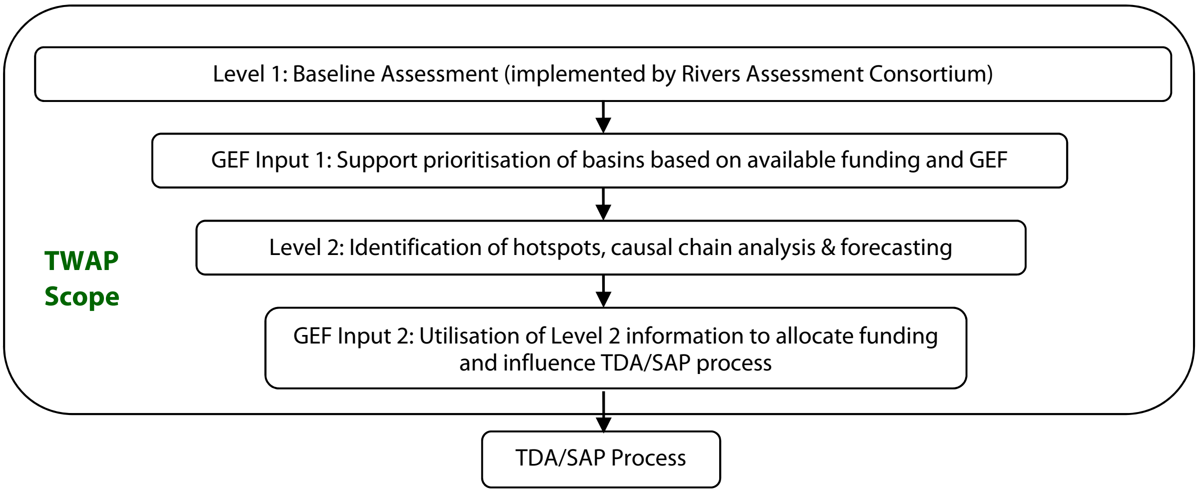


Figure 3. Previous draft schematic diagram of work process for FSP.

However, in a TWAP project meeting in July 2010 (IMAIG 2010), the GEF secretariat advised all groups that Level 2 basins could be selected independently of Level 1 results. The advice was that basins should be selected for Level 2 analysis according to the following criteria:

- A total of 6–8 basins, selecting 2 -3 from the 'global north' (e.g. North America and Europe), and 4–5 from the 'global south' (e.g. South America, Africa, the Middle East, and Asia). In December 2010 (and repeated at the Steering Committee meeting in February 2011) this advice was amended to 3–5 basins in total. **Indicative budgets have been based on 4 basins being assessed for Level 2**;

- The basins selected should cover a wide geographical spread and range of socioeconomic levels; and
- The basins selected should have a 'certain level' of previous transboundary projects or studies undertaken in them, so that there is existing data and information which can be built upon.

The selection process should be done with input from the GEF so that Level 2 can either build on, or contribute to, other GEF projects.

It is recommended that the selection of Level 2 basins is coordinated with other working groups as this may increase the impact of the Level 2 analysis within a region, allow for the development of an 'inputs-outputs' approach between water systems, and improve the cost-efficiency of the assessment.

PART 3. INDICATORS

The following definitions are important in the context of this report:

a) Measure – a quantity that measures a parameter which has limited value in and of itself in comparing basins. Examples include quantity of phosphorous produced, population and area;
b) Metric – calculated from two or more measures. Examples include quantity of phosphorous produced by unit area, and population density;
c) Indicator – made up of two or more metrics, to show the relative importance of certain issues within the basin. Examples include nutrient pollution, made of phosphorous and nitrogen loads; and
d) Index – made up of two or more indicators. The complexity involved in 'weighting' each indicator is considerable, and is based on a number of parameters, including scientific, environmental, social, economic, and political.

It is appreciated that there may be other definitions of the above terms, and that it may be necessary to harmonize the terminology used by the different transboundary water system groups at a later stage.

3.1 LEVEL 1 INDICATORS

The core indicators for the River Basins assessment are show in table 1 below. They have been selected under the framework described in Part 1, involving a lengthy process of identification of issues and indicators, as described in Annex 6. Several draft sets of indicators were created and revised over a period of more than one year with inputs from other working groups, the TWAP secretariat, the GEF secretariat, potential partners, stakeholders, and peers from independent institutions.

Considerable effort has been made to keep the number of indicators to a minimum. This is partly in response to the level of funding available, but more importantly to ensure that the results can be easily understood by end users and that prioritization decisions can be clearly based on the results. An attempt has therefore been made to remove redundancies in indicators that may cover similar issues and show similar patterns of global risk. Nonetheless, it must be acknowledged that there is no 'perfect' indicator, and sometimes a combination of indicators is necessary to achieve the required overall robustness for the assessment of a particular issue. It is therefore considered that the selected number of 14 current and 5 projected indicators covers an appropriate range of global issues, and that the end result will be simple enough to understand. However, this issue can be readdressed during the FSP by all partners to determine if the number of indicators can be further reduced. Furthermore, if upon analysing the results of the assessment it is believed that there is still some redundancy between indicators (or if gaps are identified), these may be addressed in potential repeats of the assessment.

The following sections briefly describe each indicator, addressing the rationale, how the indicator is computed, and the key partners involved. Both transboundary status indicators and projected transboundary stress indicators are described below. More detailed descriptions can be found in the Indicator Sheets in annex 3. Note that aspects of the vulnerability of human populations are also captured in the transboundary river basin fact sheet described in section 3.3 below.

Table 1. Core indicators.

CLUSTER	INDICATOR
TRANSBOUNDARY STATUS	
Water Quantity	1. Environmental water stress 2. Human water stress 3. Agricultural water stress
Water Quality	4. Nutrient pollution 5. Urban water pollution
Ecosystems	6. Biodiversity and habitat loss 7. Ecosystem degradation 8. Fish threat
Governance	9. Governance architecture 10. River basin resilience 11. Water legislation
Socio-economic	12. Economic dependence 13. Societal well-being 14. Vulnerability
Projected Transboundary Stress (2030/2050)	
	1. Environmental water stress 2. Human water stress 3. Nutrient pollution 4. Population density 5. River basin resilience

It is worth noting that the following are *proposed* methodologies for the calculation of each indicator. However, methodologies may be modified, for example as a result of changes to funding or the need for coordination with other TWAP working groups. Importantly, it is believed the right mix of partners has been identified, such that methodologies can be enhanced if necessary during the FSP.

Water Quantity Indicators

There are strong links between water quantity and quality which will be reflected in the analysis and presentation of results in the FSP.

Environmental Water Stress

Rationale: Over the past few decades the value of the environment has become better understood (MA, 2005). In some parts of the world environmental systems are being restored, but predominantly, environmental systems are coming under increasing threat from both demand for water from other sectors (water quantity), and pollution of available water (water quality). This indicator considers the Environmental Water Requirement (EWR), or the water quantity aspect, including both low-flow and high-flow components. The indicator can be compared to the human and agricultural water stress indicators to see which issue is likely to be of greatest importance to the basin in terms of quantity.

Computation: Mean Annual Runoff (MAR) minus Environmental Water Requirement (EWR), divided by total withdrawals.

Main partners & approach: Kassel/Frankfurt Universities with WaterGAP 2 model for global hydrological and water demand modelling. Level of updating (from approximately 2000) depends on funding available under FSP. IWMI may advise on EWR if funding is available.

Human water stress

Rationale: Water scarcity is a, if not the *key* limiting factor to development in many transboundary basins. Water stress can be caused by a combination of increasing demands from different sectors and decreasing supply due climate change-related variability. Human water stress has been defined in a number of different ways since Falkenmark (1989, Rijsbeman 2005). This indicator deals with the quantity of water available per person per year, on the premise that the less water available per person, the greater the impact on human development and well-being, and the less water there is available for other sectors.

Computation: Water availability per person per year

Main partners & approach: CUNY computed this indicator in 2010 using the WBM_{plus} hydrological model to determine water availability and CIESIN's Global Rural-Urban Mapping Project to determine population based on 2000 data.

Agricultural water stress

Rationale: Globally, agriculture accounts for approximately 70 per cent of all water abstraction. Agriculture is important for food security and livelihoods in many countries, and can be a key source of export income. This indicator covers both rain-fed (implicitly) and irrigated (explicitly) agriculture. The proportion of irrigation indicates the dependency of agriculture in the basin on irrigation. Higher levels of irrigation will generally indicate higher levels of water withdrawal, less available water for other sectors, and potential vulnerability to decreases in rainfall as a result of climate change. This indicator can be compared to the human and environmental water stress indicators to see which issue is likely to be of greatest importance to the basin.

Computation: Available water in the basin (accounting for water abstracted for domestic and industrial uses, and irrigation), divided by area of cropland.

Main partners & approach: Kassel/Frankfurt Universities with WaterGAP 2 model for global hydrological and water demand modelling, as well as land-use type. Level of updating (from approximately 2000) depends on funding available under FSP.

Water Quality Indicators

Nutrient pollution

Rationale: Nutrient pollution is caused mainly by agricultural activities (fertilizer use and wastes from livestock) and urban wastewater. Contamination by nutrients (particularly forms of nitrogen and phosphorous) increases the risk of eutrophication (e.g. algal blooms) in rivers, which can pose a threat to environmental and human health. Impacts include: reduction in levels of some flora and fauna due to reduction in light penetration and dissolved oxygen levels, increase in toxins making the water unsafe for humans and wildlife, and reduction in amenity value of water bodies. This indicator considers pollution from forms of dissolved inorganic, organic, and particulate nitrogen and phosphorous.

Computation: Six nutrient forms incorporated: Dissolved Inorganic and Organic Nitrogen & Phosphorus (DIN, DON, DIP, DOP), and Particulate Nitrogen and Phosphorus (PN, PP). The relative weighting of the nutrient forms is to be discussed with the main partner during the FSP. Total quantity divided by basin area (areal concentration).

Main partners & approach: Rutgers University, using Global NEWS 2 model. This data has been calculated for 2000, and may be updated for 2010 in coordination with the LME group.

Urban water pollution

Rationale: Urban water pollution can have adverse impacts on both environmental and human health. These include biological and chemical oxygen demand (BOD and COD), an increase in pathogens, turbidity, eutrophication, and an increase in 'persistent' pollutants such as metals and toxic chemicals (Persistent Organic Pollutants (POPs)). With rapidly expanding cities often without adequate sanitation services and regulatory frameworks to control pollution, this is a significant problem in many parts of the world. This indicator considers both municipal and industrial pollution, the two main pollution sources in the urban setting.

Computation: The computation of this indicator is complex and described in annex 3. Essentially it is a measure of the quantity of municipal and industrial effluents compared to available water resources, with a 'pollution control factor' which takes into account the likely level of treatment of the wastewater.

Main partners & approach: UNEP-DHI centre to collate data from FAO Aquastat, UNICEF/WHO Joint Monitoring Programme (JMP) for Water Supply and Sanitation, and the Stockholm and Rotterdam Secretariats.

Ecosystem Indicators

Biodiversity and habitat loss

Rationale: Protection of wetlands is an example of society's recognition of the importance of ecosystems for river basins and the willingness to take concrete steps to conserve these valuable resources. In contrast, biodiversity and habitat loss often results from direct draining or longitudinal impoundment that makes floodplain areas dysfunctional by levee construction and river channelization for urban areas and cropland protection. As the habitat lost/protected ratio may be the same for two areas with different climates and biomes irrespective of biodiversity status, basins are further prioritized based on the change occurred to species threat status.

Computation: The proportion of lost wetlands lost combined with the change in species threat status i.e. the number of species in each Red List Category moving between categories in different assessments.

Main partners & approach: Kassel/Frankfurt Universities with the Global Lakes and Wetland Database for the WaterGAP 2 model. Level of updating (from 2004) depends on funding available under FSP. IUCN with the spatial distribution data for the Red List species.

Ecosystem degradation

Rationale: The negative impact on ecosystems of altering waterways by dams, water transfers and canals must be considered for managing of water resources in a sustainable way. It is no longer acceptable to draw water from nature for use in agriculture, industry, and everyday life without taking into account the role that ecosystems play in sustaining a wide array of goods and services, including water supply.

Computation: A combination of the metrics: river fragmentation (proportion of basin accessible from each grid cell), flow disruption (proportion of upstream reservoir capacity over mean annual discharge), and dam density.

Main partners & approach: CUNY computed these metrics in 2010 using the WBM_{plus} hydrological model to determine river fragmentation and flow disruption, and ICOLD's database to determine dam density based on 2010 and 1998 data respectively.

Fish threat

Rationale: Fish are a major source of protein and micronutrients for a large part of the world's population. Inland fisheries in rivers, lakes, and wetlands are an important source of this protein because almost the entire catch gets consumed directly by people, i.e. there is practically no by-catch or 'trash' fish in inland fisheries. In addition to loss of fish habitat and environmental degradation, the principal factors threatening inland fisheries are fishing pressure and non-native species. Overfishing is a pervasive stress in rivers worldwide due to intensive, size-selective harvests for commerce, subsistence, and recreation.

Computation: The total estimated fish harvest relative to expected fish productivity and the proportion of non-native species.

Main partners & approach: CUNY computed these metrics in 2010 using FAO FishStat data set in combination with the WBM_{plus} hydrological model to determine fish catch, and existing literature to determine non-primary productivity and non-natives richness.

Governance Indicators

A governance correspondence working group was established in July 2010 during the MSP in an attempt to develop a common governance assessment framework. The output of this group is contained in indicator #9 on 'governance architecture'. However, other TWAP groups also developed alternative governance indicators. Should this indicator need simplification, an alternative for the River Basins group could involve an identification of the existence and relative development of RBOs, River Basin Plans (RBPs), and data sharing agreements. This approach was drafted by the River Basins group but subsequently replaced by the following indicators.

Governance architecture

Rationale: This indicator assesses the existence of transboundary governance 'architecture', or arrangements, in place to address selected issues relevant to transboundary river basins. It considers the completeness of the policy cycle, from the preparation of advice, through implementation and monitoring and evaluation of impacts. Given the global scale of the assessment in Level 1, it does not attempt to assess the performance or effectiveness of the governance arrangements, but only to assess the existence of such systems.

Computation: The assessment will identify the extent to which governance arrangements cover the following critical transboundary issues: water allocation, water quality, fisheries, biodiversity, and habitat destruction. Vulnerability to climate change is recognized as being a component of all of these issues. These issues have been chosen for their importance to transboundary basins at a global scale, but they may be amended during the FSP. The assessment is expected to reveal the extent to which the issues are covered, whether there are gaps or overlaps in coverage and the nature of the arrangements that are in place.

Main partners & approach: The assessment is to be carried out by stakeholders or experts within each basin or region, with groups or individuals selected from the networks of partners represented in the TWAP FSP.

River basin resilience

Rationale: Historically, events of conflict over transboundary waters have been more frequent in regions characterized by high inter-annual hydrological variability (De Stefano, *et al.,* 2010). Under climate change, this variability is likely to increase. The level of institutional and regulatory capacity of a basin is critical to define its resilience or vulnerability to climate change-induced water variability. This indicator assesses this capacity against the risk of variability. The results also indicate the potential for transboundary conflict within the basin, with low scores indicating greater potential for conflict.

Computation: Combination of type of treaty and membership of river basin organizations for each country basin unit. Aggregated to the basin level based on population, area, irrigation area, and discharge.

Main partners & approach: Oregon State University (OSU), who completed a study global study in 2010 which would only require re-calculation to derive the required indicator result.

Water legislation

Rationale: Both the above indicators (governance architecture and basin resilience) focus on governance at the transboundary scale. It is also important to look at governance at the national scale for countries within each transboundary basin. This indicator considers the development of water resources policy and legislation in each riparian country, and the extent to which these utilise an *integrated* approach to land and water resources management.

Computation: The development of water resources policy plus water resources legislation for each country-basin unit (CBU), combined using a weighted average 'importance' of each country to the basin based on population, area, irrigation area, and runoff.

Main partners & approach: The assessment is to be carried out by stakeholders or experts within each basin or region, with groups or individuals selected from the networks of partners represented in the TWAP FSP. This is to be coordinated with the 'water legislation' indicator.

Socioeconomic Indicators

The approach to socioeconomic indicators is strongly based on the outputs of the socioeconomics correspondence working group established in July 2010 during the MSP. The approach focuses on the quantifiable features of livelihood systems (economics), societal well-being (social), and vulnerability components. The three indicators are made up of a number of metrics and are therefore presented in table 2 to provide an overview, with a discussion of the indicators following the table.

Table 2. Socioeconomic indicators and metrics.

INDICATOR	METRIC
1. Economic dependence on water resources	GDP/total water withdrawal Agricultural GDP/total GDP Fish catch GDP/total GDP Energy-related GDP/total GDP
2. Societal well-being	Access to adequate water supply Access to adequate sanitation Adult literacy Life expectancy Income inequality
3. Vulnerability to climate-related natural disasters	Flood risk Drought risk

Economic dependence on water resources

Rationale: Several sectors that support national and basin economies depend on water resources. Increased pressures on these resources leave populations that are dependent on these sectors vulnerable. This indicator involves the metrics shown in table 2 above. The GDP per total water withdrawal gives an indication of the dependence of a society on water withdrawals across sectors. Globally, the agriculture, fisheries, and energy sectors are among the most important that rely heavily on water resources. Tourism and transport may also be dependent on water resources but insufficient data was available on a global scale.

Computation: A method for each metric is described in Annex 3

. By computing the contribution to GDP from each of the main three water-reliant sectors as a proportion of total GDP, it is relatively straightforward to combine these to obtain a proxy for economic dependence on water resources. The weighting of each metric to form the indicator will be discussed with partners during the FSP.

Main partners & approach: Kassel and Frankfurt Universities – responsible for water withdrawal data using the WaterGAP 2 model. CIESIN (Colombia University) – responsible for demographic and GDP data on a grid basis. The City University of New York (CUNY) – responsible for fish catch data on a grid basis (from FAO). UNEP-DHI centre – responsible for energy analysis and mapping.

Societal well-being

Rationale: The inclusion of the metrics for societal well-being is based on the premise that healthy, educated and well-serviced societies have a greater capacity to adapt to, and manage, pressures on water resources. The indicator is a measure of vulnerability or resilience that can be an additional way of assessing the likely impact of other 'pressure' indicators on societies. The social component is closely interlinked with the economic, vulnerability, and governance indicators.

Computation: A method for each metric is described in Annex 3. National data is generally aggregated to the basin level through a weighted average based on population in each country-basin unit (CBU).

Main partners & approach: CIESIN (Columbia University) – responsible for demographic data and re-aggregating national data to the basin level.

Vulnerability to climate-related natural disasters

Rationale: Floods and droughts cause more loss of life and economic losses than all other natural disasters each year, and the likelihood and severity of floods and droughts is likely to increase with climate change. Impacts of floods and droughts are felt both by humans and ecosystems, and include impacts on food security, damage to infrastructure, and displacement of people. A global analysis has already been undertaken by CIESIN in 2005 (Dilley, *et al.*, 2005).

Computation: Flood and drought risk calculated on a grid basis by combining the level of hazard with the mortality- and economic loss-related vulnerability coefficients.

Main partners & approach: CIESIN – previously completed a similar study in 2005, though some of the data used is now over 10 years old.

Projected Transboundary Stress Indicators

These use modelling tools to select four transboundary status indicators to predict future stresses in 2030 and 2050. The four indicators were chosen to cover a range of issues. A fifth indicator, 'population density', was added as a significant driver of stresses on water resources. The scenarios need to be carefully coordinated between the five working groups. One option is to take the scenarios from the IMAGE (Integrated Model to Assess the Global Environment) framework. This framework has been developed under the Netherlands Environmental Assessment Agency. The framework for IMAGE is shown in figure 4 below. The IMAGE model contains sub-models dealing with the different parts of the framework. The partners developing the current transboundary status indicators could collaborate with the IMAGE team to develop the projected transboundary stress indicators, but this would need to be done in conjunction with the other working groups.

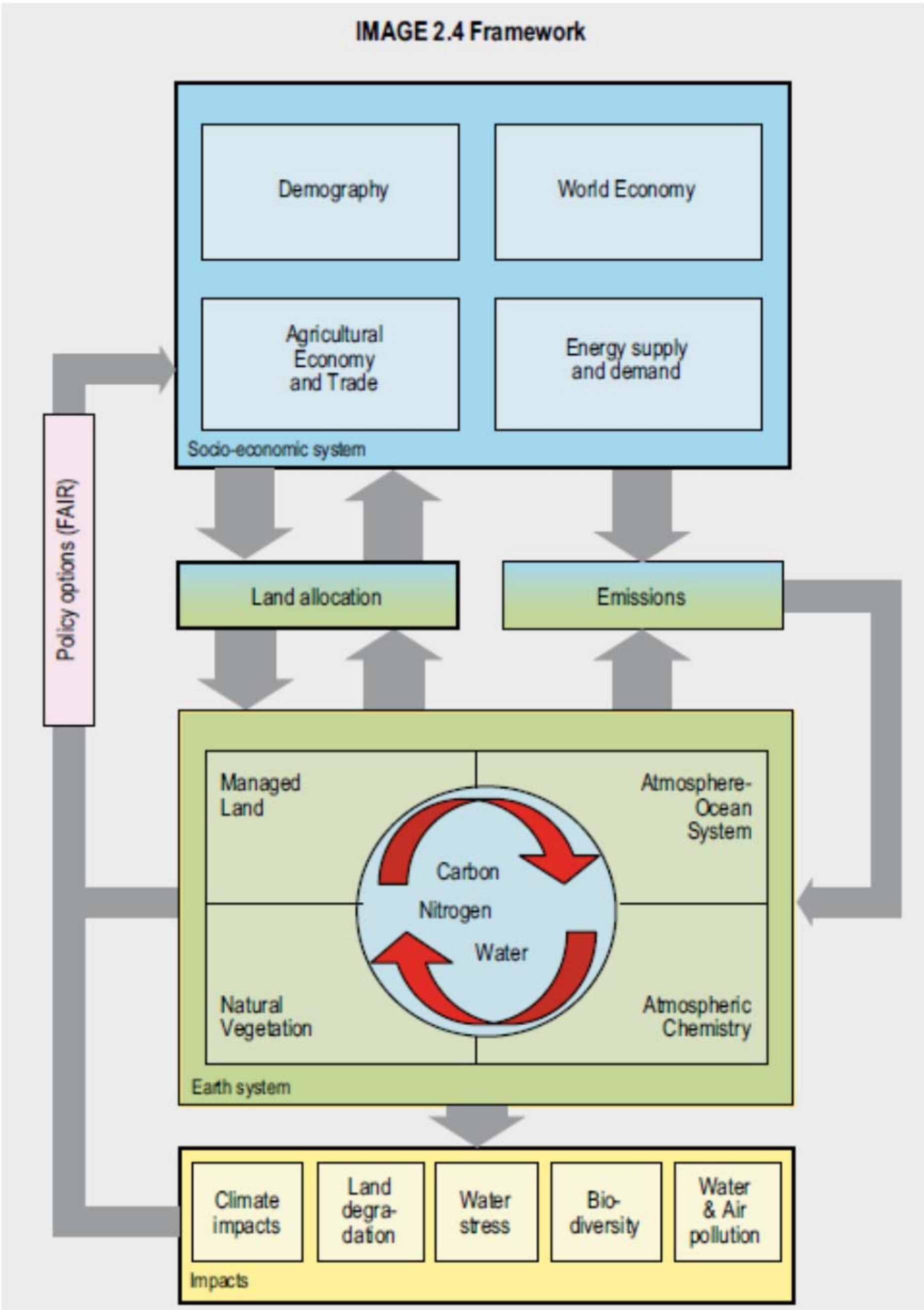


Figure 4. IMAGE modelling framework. (Source: Bouwman, Kram and Goldewijk (2006))

If comparisons are to be made between water systems, it is important that either the development and climate scenarios used are the same, or that any differences are well understood and can be addressed when interpreting results. The Open Ocean group could lead the projected climate modelling, and another option is to draw on data and experience of the 'Integrated Project Water and Global Change (WATCH), funded under the EU FP6, which the University of Kassel has been involved in http://www.eu-watch.org/.

1. **Environmental water stress**
   The tools used for the current status indicator will incorporate the IMAGE scenario input for hydrological change and threats to biodiversity (GLOBIO 3 framework).
2. **Human water stress**
   The tools used for the current status indicator will incorporate the IMAGE scenario input for hydrological change and demography (PHOENIX).
3. **Nutrient pollution**
   Global NEWS 2 has recently been used to predict nutrient pollution risk for 2030 and 2050 (based on inputs from IMAGE), and these results can be used for the TWAP FSP.
4. **Population density**
   The main partner for this will be CIESIN, and the indicator may be calculated using the PHOENIX model within the IMAGE framework.
5. **River basin resilience**
   Oregon State University (OSU) has calculated river basin resilience to climate-induced water variability in 2010 for 2000, 2030, and 2050. This information can be used for the TWAP FSP.

3.2 SCORING OF BASINS

There are three aspects to scoring:

1. How basins are scored for each indicator;
2. How scoring is standardized across indicators; and
3. How, and the extent to which, indicators can be combined into indices, or a single index.

Indicator scoring

Most indicators assign 'absolute' values or scores to each basin either with specific units relevant to the indicator, or as percentages. Basins can then be 'ranked' from the lowest to the highest scores. Low scores represent higher levels of threat or risk for each issue. The Indicator Sheets in annex 3 provide more detail on the scoring methodology for each indicator.

Standardizing scores

Standardizing scores are required for two purposes. The first is to be able to compare indicators to identify if basins are at 'high risk' for a number of issues. The second is to be able to compare different issues for an individual basin to identify which issues are more important in that basin.

Once basins have been ranked from lowest to highest, basins can be placed into risk categories for each indicator. With the primary aim of TWAP being to identify priority basins, the scoring system should have enough categories to identify basins 'at risk' for any particular indicator or issue. However, given the expected paucity of data for some indicators, and to keep the scoring system relatively simple for comparison purposes, it is also important not to have too many categories. Therefore, a scoring system of '1' to '5' is proposed, with '1' representing the highest and '5' the lowest risk for each indicator.[2] It should be noted that this method does not rank each basin consecutively, but rather places each basin into a scoring 'band', meaning that multiple basins may receive the same score. This may also highlight similarities in options between basins to resolve the cause(s) of the problems, and could provide an initial grouping of basins for possible twinning or basin partnerships under future GEF interventions. This is a 'relative' scoring system.

RISK CATEGORY	RANGE (%)	PROPORTION OF BASINS
Highest risk	0 – 10	10%
	11 – 20	10%
	21 – 50	30%
	51 – 90	40%
Lowest risk	91 – 100	10%

This system focuses on identifying the two most at-risk groups (scores of 1 and 2 – approximately 25 basins in each group), i.e. those requiring investment/intervention in different areas to reduce risk. This is in keeping with the objective of Level 1 of the FSP of identifying basins at risk. The ten per cent of basins with the lowest risk are also easily identified, which may provide some information on 'best practice' depending on their location and socioeconomic situation. With the aim of TWAP being to identify priority basins, the basins with scores of 3 and 4 are of limited interest in this instance, and therefore this skewed division of basins is deemed preferable to evenly distributing the basins to each score.

For the purposes of identifying change during subsequent assessments, it is important to maintain the 'absolute' scores assigned to each indicator in the first instance. These values will be maintained within the data structure of the FSP, although the 'relative' performance category scores will feature most prominently for the baseline assessment for TWAP. It will therefore be possible to go back and interrogate any data gathered during the FSP at a later stage. Figure 5 below shows the flow of information.

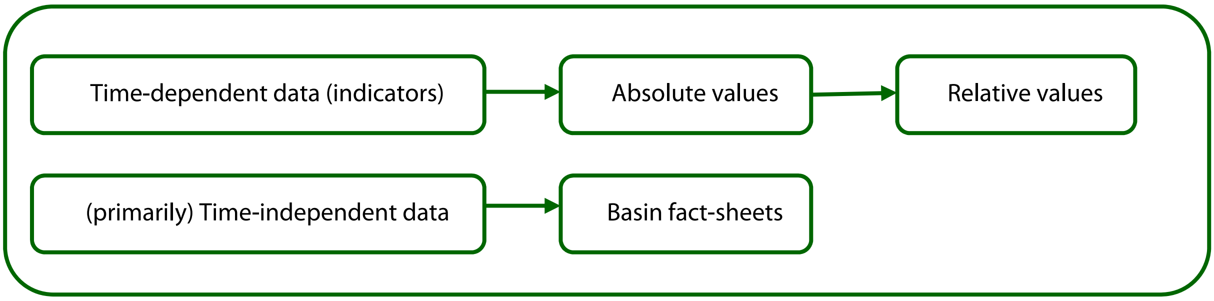


Figure 5. General data structure of FSP (Level 1)

By analysing how basins are improving or deteriorating in certain areas over subsequent assessments, it may also be possible to link 'improving' basins with those which may be deteriorating in the same areas. Presenting the opportunity for such basins to collaborate may prove to be a preferable outcome compared with more ad-hoc twinning practices which are sometimes based on resource availability rather than fundamental freshwater concerns.

[2] The scoring system can easily be inverted during the FSP to give '1' representing the lowest, and '5' representing the highest, risk for each indicator. This may be done in coordination with the other working groups to agree on a common final scoring approach.

Index creation

While there may be advantages in combining all indicators into a single index, the complexity involved in 'weighting' each indicator is considerable, and is based on a number of parameters, including scientific, environmental, social, economic, and political. Furthermore, the act of combining all indicators may result in certain important issues being overlooked – a single issue with a poor score may still be important even if other indicators receive a high score. Moreover, it is likely that future decision-making will require investigation of basins on the basis of individual indicators to determine key issues. The creation of a single index is therefore not recommended at this stage. However, the method described above, using a consistent scoring system, facilitates the creation of indices at a later stage, should this be required. This has been discussed in Part 1 above, highlighting that the process of 'weighting' indicators will likely require guidance from GEF.

One option for forming indices would be to combine the indicators in each 'cluster' into 6 indices, and then combining them into a single index if required during the FSP, as shown in table 3 below. The weightings would have to be determined with the GEF secretariat, a wide stakeholder group and partners in the FSP. If indices are combined, sensitivity analysis of weightings should be carried out in the FSP. Figure 6 in describes in more detail how the results of the scoring systems may be presented and potentially combined, without assigning a 'weight' to each indicator.

Table 3. Potential index creation schematic

OVERALL INDEX	WEIGHTING	CLUSTER INDICES	WEIGHTING	INDICATOR
TRANSBOUNDARY BASIN INDEX (TBI)		**Water Quantity**		1. Environmental water stress
				2. Human water stress
				3. Agricultural water stress
		Water Quality		4. Nutrient pollution
				5. Urban water pollution
		Ecosystems		6. Biodiversity & habitat loss
				7. Ecosystem degradation
				8. Fish threat
		Governance		9. Governance architecture
				10. River basin resilience
				11. Water legislation
		Socioeconomic		12. Economic dependence
				13. Societal well-being
				14. Vulnerability
		Projected Transboundary Stress		1. Environmental water stress
				2. Human water stress
				3. Nutrient pollution
				4. Population density
				5. River basin resilience

3.3 TRANSBOUNDARY RIVER BASIN FACT SHEETS

The following is a template of the River Basin Fact Sheets which are to be completed during the Full Size Project (FSP). There will be one fact sheet for each river basin. These fact sheets consist of (generally) time-*independent* data, in contrast to the indicators, which measure time-*dependent* data. The fact sheets complement the indicators in providing a useful summary of background information. This is a suggested template and may be updated with input from partners during the FSP.

TRANSBOUNDARY RIVER BASIN FACT SHEET

Insert Map of Transboundary River Basin

Geography[3]

- Number of Countries within Basin:
- Total Drainage Area (km^2):

Country	Area of Country in Basin (km^2)	Percentage area of Country in Basin (%)	Other Transboundary River Basins of which the Country is a Member	Geographical Overlap with other Transboundary Water Systems
XX				
XX*				
Total				

- Country at mouth

Water Resources

- Water Withdrawal
  - Total (km^3/year) :
  - Agricultural (km^3/ yr) :
  - Industrial (km^3/ yr) :
  - Domestic (km^3/yr) :
  - Per capita (m^3/yr) :
  - Total withdrawal as a % of Total Actual Renewable Water Resources (%):
- Total Actual Renewable Water Resources (km3/year) :
- Average Groundwater Recharge (km3/year) :
- Average Groundwater Discharge (km3/year) :
- Lake and Reservoir Surface Area (km2) :
- Percentage of Water Demand met by Surface Water (%):
- Hydropower Potential
- Distribution of water resources between countries (e.g. some form of water dependency ratio) (TBD)

Socioeconomics[4]

Country	Popn. in Basin	Average Popn. Density (n° of people per km^2)	Rural/ Urban Popn. Ratio	Number of Large Cities (>100,000 inhabitants)[5]	Annual Popn. Growth Rate (%)	GDP
XX						
XX						
Total						

Governance

Treaties & Agreements:
River Basin Organizations & Commissions:
River Basin Plans:
Joint Monitoring Programmes:

Climate[6]

- Latitude Stretch (°):
- Climate Zone Type:
- Climate Zone Sub-Type:
- Average Rainfall (mm) :
- Average Temperature (°):
- Average Evapotranspiration (mm):
- Percentage of Rainfall occurring in the Rainy Season (%):
- Coefficient of Variation for Climate Moisture Index (ratio) :

[3] OSU TFDD database to be cross-checked with data from other partners.
[4] OSU TFDD database to be cross-checked with data from other partners.
[5] ESRI 2000. data to be cross-checked with other partners.
[6] World Water Development Reports

3.4 LEVEL 2 INDICATORS

As described in sections 1.1, 1.2 and 1.3, the objectives, scope, and framework of Level 1 and Level 2 are significantly different, and the data and tools available for assessment will be significantly different at the national and basin scale compared to the global scale. Furthermore, the budget for the assessment of each basin may be relatively limited, as discussed in section 6.4. It is expected to be in the region of US$50 000 per basin.

Consequently, Level 2 should be undertaken within these constraints, and the following tasks are proposed:

1. Cross-check some of the results from Level 1, where possible, against results from existing studies (e.g. TDAs) for a particular basin (see below). This necessitates that the main issues covered by the framework of Level 1 are extracted from existing studies to allow for a comparison between the 'global' level results and basin level results. This serves as a rough validation of Level 1, whilst remembering that Level 1 is a global study and cannot go to the same level of detail as a basin study. As a minimum, there should be a check of whether the key issues identified in Level 1 are also identified as being important in the basin level studies;
2. Identify, and undertake preliminary investigation where possible, the interlinkages between water systems. For this purpose, it would be advantageous to identify basins where there is some geographical overlap with the transboundary lake basins, aquifers, and LMEs; and
3. Drawing on the experience of Level 1 and previous studies done in the basin (e.g. TDAs), make recommendations for the further improvement of the TDA process.

Whilst most of the assessment for level 2 will be based on previous studies, if there are gaps that need addressing *and* funding is available, some new assessment work may be undertaken. The issues covered within the indicator framework in Level 1 will form the basis of assessment for Level 2, though the indicator framework used in Level 2 will have two main differences:

1. The classification criteria for the scoring of indicators will be more refined due to the potentially increased level of data used; and
2. The focus will be less on a comparison *between* basins, and more on the identification of issues *within* each basin. This allows for the identification of hotspots as described in section 2.4.

In general, most of the issues covered in Level 1 will also be investigated in Level 2. In some cases, it may be possible to modify indicators from Level 1 for Level 2, but for some issues, new indicators may need to be developed, based on priority issues and the data available.

The specific issues to be further investigated will be agreed in consultation with GEF, following GEF input after Level 1. It is envisaged that the Assessment Consortium (section 6.1) will remain unchanged from Level 1 and will be able to undertake the work. If it proves necessary to obtain data outside the scope of the existing partners, it may be necessary to make arrangements with other partners.

The indicators used in Level 1 can be 'unpackaged', as well as supplemented by additional indicators. A 'long-list' of potential indicators is given in table 4 below, but the final choices will be dependent on data availability in each basin, and the funding available, both from within TWAP and co-financing. Supplementary indicators and issues can be taken from the tables in Annex 6.

Table 4. Level 2 indicator long-list.

CLUSTER	INDICATORS
CURRENT	
Water Quantity	1. Environmental water stress 2. Human water stress 3. Agricultural water stress 4. Consumptive water loss 5. Glacial melt
Water Quality	6. Nitrogen loading 7. Phosphorus loading 8. Industrial wastewater 9. Domestic wastewater 10. Total suspended solids (TSS) 11. Mercury risk 12. Soil salinization
Ecosystems	13. Wetland disconnectivity 14. Endangered species threat 15. Dam density 16. River fragmentation 17. Flow disruption 18. Fish catch 19. Fish productivity 20. Non-native fish
Governance	21. Governance arrangements & clustering 22. River basin resilience 23. Water legislation
Socioeconomic	24. Access to improved water supply 25. Access to improved sanitation 26. Adult literacy 27. Life expectancy 28. Deaths per 100 000 inhabitants caused by climate-related natural disasters 29. Freshwater dependency (GDP/freshwater withdrawal) 30. Per capita damages (in Purchasing Power Parity) caused by climate-related natural disasters (Climate Risk Index) 31. Average losses per unit total GDP (from climate related natural disasters) 32. Income inequality using wealth Gini index 33. Climate Vulnerability Index
PROJECTED (2030/2050)	
	1. Human Water Stress 2. Environmental water stress 3. Nutrients pollution 4. Population density 5. River basin resilience

PART 4. INTERLINKAGES WITH OTHER WATER SYSTEMS

As previously described, TWAP involves five transboundary water systems: groundwater, lake basins, river basins, LMEs, and open oceans. Thus five separate methodologies have been designed, though information developed for each may be relevant to other water systems. Whilst the strong links between the systems are recognized, the level of knowledge of each system is significantly different. For example there is a larger body of work on LMEs than on groundwater. Considering these different starting points, separating the assessment methodologies allows for suitable assessments to be conducted for each water system. However, with this split assessment there is a danger that the divide between different water programmes, for example surface and groundwater, is perpetuated. **It is therefore recommended that cross-cutting groups are established in the FSP to ensure that approaches are compatible to the greatest extent possible.** Furthermore **it is recommended that a global map of all transboundary water systems across all categories is created.** This will not only facilitate the interlinkages analysis, but also identify areas that are at particular risk of transboundary pressures, with multiple transboundary water systems in the same area.

This chapter is composed of three main sections: interlinkages, input-output approaches, and cross-cutting issues.

Interlinkages refer to issues that may be relevant to one or more water system, and may also be called *common issues*. These interlinkages should be identified where possible. The results of the assessments should be closely linked in order to show the effects of upstream systems on downstream systems. This will make it possible to determine where interventions would be most effective.

Input-output approach refers to the process by which information for these *interlinkages* is transferred between water systems.

Cross-cutting issues refer to two issues – nutrients and mercury – which are relevant to all five water systems. It should be possible to follow these through the water systems from mountain-top to ocean.

Further definition is provided in the glossary (see Annex 4).

There will also be interlinkages with other water systems in terms of partners and data sets used. This is discussed further in Part 5.

4.1 INTERLINKAGES AMONG WATER SYSTEMS

As discussed in Part 1, part of the selection criteria for issues and indicators was their relevance to other water systems. River Basins have clear links with groundwater, lakes, and LMEs, with fewer and less obvious links with the open ocean category. Consequently, almost all of the chosen indicators have relevance to these first three systems, as illustrated by table 5.

Table 5. Indicator relevance to other water systems.

CLUSTER	RIVER BASINS INDICATORS	GROUND-WATER	LAKES	LMES	OCEANS
Quantity	1. Environmental water stress	X	X	X	X
	2. Human water stress	X	X	X	X
	3. Agricultural water stress	X	X	X	X
Quality	4. Nutrient pollution	X	X	X	
	5. Urban water pollution	X	X	X	
Ecosystems	6. Biodiversity and habitat loss	X	X	X	
	7. Ecosystem degradation	X	X	X	
	8. Fish threat		X	X	
Governance	9. Governance architecture	X	X	X	
	10. River basin resilience	X	X	X	
	11. Water legislation	X	X	X	
Socioeconomics	12. Economic dependence	X	X	X	
	13. Societal well-being	X	X	X	
	14. Vulnerability	X	X	X	
Projected Transboundary Stress	1. Environmental water stress	X	X	X	X
	2. Human water stress	X	X	X	X
	3. Nutrient pollution	X	X	X	
	4. Population density	X	X	X	
	5. River basin resilience	X	X	X	

With the role that rivers play in linking groundwater, lakes, and LMEs, the River Basins WG may be able to provide information that is beneficial to these three other groups, and play a pivotal role in interlinkages. There are two main approaches to this, which may both be undertaken in the FSP:

1. An *issues-based* approach: this recognizes the fact that different methodologies and frameworks have been developed by each group. Nonetheless, many of the 'issues' will be common among the water systems, such as pressures from urban areas, and vulnerability of ecosystems and human societies to increases in development, population, and climate-change impacts. Thus if a risk is 'high' for one of these issues, it highlights the need to investigate the likelihood of this issue impacting downstream systems. Furthermore, comparing the status of issues between water systems can also act as a validation of approaches, and should be used for this purpose. For example, if the Aquifers assessment shows a high governance risk for a certain aquifer, but an overlapping lake basin shows a low governance risk from the Lakes assessment, this would require further analysis. In this way methodologies may be reviewed and improved; and

2. An *input-output* based approach: this builds on the fact that most of the River Basins Level 1 indicators are calculated on a global grid. If information on unit boundaries from the other groups is provided, the River Basins group can provide information on the relevance of each indicator to that particular unit. This is described further in section 4.2 below.

The general links between river basins and each group are described below. This may put the issues-based approach into context, and identify some potential issues to be considered. In discussions with the other working groups, it was found that the issues-based approach may give a useful indication of the transboundary nature of certain issues, even though the indicator results would not be a direct input to the downstream water system assessment. A draft set of indicators was shared with the Lakes and LME groups in June 2010, and responses to the potential for interlinkages with these groups can be found in Annex 8.

River Basins – Aquifers

Groundwater aquifers and river basins are closely related. Through groundwater discharge and river water infiltration, the two water systems affect each other's water quantity and quality. Where rivers and groundwater aquifers are linked through discharge or infiltration the systems also have a governance and socioeconomic link. The sustainable use of the basin resources will have an effect on how well the two water systems can provide the services needed by the basin population (and beyond).

River Basins – Lake Basins

Lake basins are often part of river basins or vice versa and the two systems are sometimes difficult to separate from a management perspective. River flow and river water quality are determinants for the ecosystem of the lake it flows into. Lakes often have a long retention time and measures taken to improve water quality through upstream interventions may take a long time to have an effect. Poor lake water quality also affects downstream rivers.

Rivers Basins – Large Marine Ecosystems

The unique environment of many marine ecosystems is dependent on the quantity, frequency and quality of river flows. The brackish water in estuaries is often a precondition for the ecosystems that develop in these locations. Changes in the flow regime or water quality due to activities upstream in the river or due to climate change will disturb the coastal ecosystems.

Both the River Basins and LME groups appreciate that estuaries/deltas will be dealt with mainly by the LME group, although close coordination will be required between the groups. However, the criteria for delineating the boundary between a river and its estuary still need defining. This may involve issues such as salinity and tidal range. Moreover, the definition of a 'transboundary delta' for the purposes of TWAP still needs to be developed.

River Basins – Open Oceans

Rivers are not directly connected to oceans and the links to oceans are less obvious. Through the links between LMEs and oceans the river systems are linked to oceans. Oceans, and in particular sea surface temperature, have a significant effect on river flows as they affect global and regional rainfall patterns.

4.2 COMMON ISSUES

Common issues include vulnerability to climate change, pressures on ecosystems, biological productivity, water quantity and quality, governance, socioeconomics, and projected stress. A selection of these are described below, to illustrate interlinkages.

Vulnerability to Climate Change

Climate change is expected to change rainfall patterns and temperatures globally. In river basins this will affect runoff from the basin area. The predicted change in rainfall patterns will disturb the volume of river discharge as well as the cycles of river flow. Frequency of floods and droughts are generally expected to increase. This will affect both quantity and quality of downstream water systems. It will affect water levels in lakes as well as the quality of the water. Groundwater recharge will also be affected by the change in runoff and river flow.

LMEs will be affected by the changes in the quantity, quality and pattern of river discharge that are predicted to be the result of climate change. Decrease in river flow or increase in flood size or frequency will affect the health of the estuaries and wetlands along the coast.

The predicted increase in global temperature will affect river water quantity in several ways. Rivers fed by melting glaciers will first experience an increased flow as long as the glacier still exists, and eventually a decrease in flow. Glacial melt is a major contributor of river flow in many of the worlds' transboundary river basins. The increase in global temperature is also predicted to increase the sea surface temperature, which is one of the main drivers of rainfall patterns.

River Basins issues/indicators: the socioeconomic vulnerability indicator addresses vulnerability to floods and droughts. The water quantity cluster and the governance cluster are also important, showing the vulnerability or resilience of communities and ecosystems to change.

Biological productivity

Rivers are transporters of nutrients that will affect biological productivity in downstream water systems. Rivers will increase the nutrient loads of downstream lakes and LMEs. For lakes situated upstream of rivers, rivers will receive nutrients that have accumulated in the lake. Biological productivity of the downstream water systems is related to the fertiliser use in the catchment area and general water quality and quantity from inflowing rivers.

River Basins issues/indicators: the ecosystem cluster (biodiversity and habitat loss, ecosystem degradation, and fish threat), and less directly, the water quality cluster (nutrient pollution), and the water quantity cluster (environmental water stress).

Water Quantity

The quantity of river flow links the river to all the other water systems. It will affect the health and function of the downstream ecosystems. Lakes situated downstream will be heavily affected by changes in the discharge. Likewise inflow from lakes to rivers affects the river ecosystems. Groundwater discharge to rivers can contribute to a substantial part of river flows and, if altered, can affect the rivers and the services they provide. Through groundwater infiltration through wetlands etc., river flow also affects the status of aquifers situated in the basin.

The delicate balance between freshwater and sea water that characterize the LMEs is disturbed by a change in river discharge patterns. Alterations in timing or quantity river discharge and increased inflow of sea water to estuaries and wetlands can have severe consequences for these ecosystems and the populations dependent on them.

There is a strong link between the sea surface temperature of the open oceans and global rainfall patterns. This will impact river discharge as increased or decreased runoff from the basin area.

River Basins Indicator: The water quantity cluster to show direct effects, and the governance and socioeconomic clusters to show resilience of systems to water stress.

4.3 INPUT-OUTPUT ANALYSIS

As described in section 4.1, the input-output approach enables the transfer of river basin data to other water systems, using indicator values for each grid cell. This approach relies on information on unit boundaries being available in GIS format and shared between working groups. For example it would be possible to determine the likely level of nitrates entering groundwater from a river basin with overlapping boundaries. However, the extent to which this data is useful is limited by the fact that inputs and outputs will only be relevant from part of one unit to part of another unit. For instance, a transboundary river basin could provide some useful input data to an LME, but there are likely to be national, or non-transboundary, rivers which are not assessed as part of the River Basins assessment, which would make up the remainder of the inputs to that LME. Consequently, each group cannot rely on inputs from other groups, but the data may still be useful to validate approaches, and identify issues of common concern.

4.4 CROSS-CUTTING ISSUES

Cross-cutting issues (CCIs) are issues that should be addressed by all groups where possible, as they are highly relevant to all groups, and impacts can be transferred between water systems. An initial list of five CCIs (water quantity, nutrients/eutrophication, vulnerability to climate change, biological productivity and mercury) where reduced to two (nutrients and mercury), as practical difficulties in transferring information between all five groups for the other CCIs was deemed inhibitive. This was agreed by all groups in July 2010 (IMAIG 2010). The three previous CCIs should now be seen as potential interlinkages between some groups, but not necessarily all five.

The objective for the CCIs is to identify indicators that will enable the assessment of specific components of the issues that can be traced between water systems. However, the same methodological issues identified in the sections above for interlinkages and the input-output approach are relevant here. In particular, techniques to 'measure' a certain issue may not be feasible across all groups. For example, remote sensing may be used to determine nutrient pollution risk for lakes, but this technology is not feasible for rivers.

Nutrients

Nutrients impact all five water systems in different ways, though some nutrients will be more relevant to each water system. The main causes are anthropogenic (fertilizer use, livestock waste, domestic & industrial wastewater), with natural deposition also contributing significant amounts in certain systems (e.g. LMEs). The main impacts are eutrophication (rivers, lakes, LMEs), and reduced water quality for water supply (groundwater, lakes, rivers). The main components of nutrients are generally dissolved inorganic and organic nitrogen and phosphorous, and particulate nitrogen and phosphorous.

It was agreed amongst all groups that nitrates and phosphates would be the indicators for nutrients, to be supplemented by total nitrogen and phosphorous where possible (IMAIG 2010). Rivers have an important role to play in distributing nutrients to other water systems. Nutrient pollution has been identified as a Level 1 indicator for the River Basins group as is discussed in Part 3 and in more detail in Annex 3. The approach uses the Global NEWS 2 model, which will also be used by the LME group. Currently Global NEWS models nutrient loads at the river mouth, which would give an average load for the river basin. The potential for using Global NEWS as a tool to assess nutrient loads for groundwater and lakes was investigated. Both the Lakes and Groundwater groups were potentially interested. It was suggested that producing load estimates on a grid of 30 minutes (approximately 50 x 50 km) would be achievable from a modelling perspective. However, the Lakes group were of the opinion that this was too coarse a resolution for their purposes. They suggested that land-use satellite data at a significantly finer resolution could be used to determine risks of nutrient pollution. The differences in approach have yet to be resolved, but both approaches would point to the *risk* of nutrient pollution, although they use different indicators and techniques.

There will be further opportunities to investigation nutrient risk at a finer resolution in Level 2.

Mercury

Mercury is transported by rivers to downstream water systems through sediment loads or dissolved in the river water. In many rivers the transport of mercury is characterized by an enormous variation over time because of the highly transient transport and re-suspension of sediment particles determined by river discharges. Mercury affects fish populations and aquatic wildlife and the populations living in affected areas.

It was agreed in July 2010 (IMAIG 2010) that it would be practically difficult to obtain specific measurements of mercury across different systems. It was therefore suggested that an important component of this CCI analysis would be a review of existing data and literature and an identification of knowledge and information gaps. UNEP completed a Global Mercury Assessment in 2002 (UNEP 2002) which serves as a useful source of information.

Sampling of water or sediment would probably lead to highly fluctuating and unreliable results due to the transient nature of the transport. A more temporally integrated measure is needed. The best option for monitoring of mercury (exposure, not transport) is therefore likely to be one where native and stationary aquatic species (e.g. molluscs or fish) are collected and analysed for mercury. By selecting species eaten by humans a measure of the danger to humans as well as the environmental pollution are obtained.

There are a number of issues to be dealt with in order to obtain reliable results, e.g.:

- Selecting comparable aquatic species (similar trophic status), because, for example, carnivorous fish accumulate more mercury than herbivorous fish;
- Selecting species that are stationary so that the results are representative of the location where they are caught;
- Methodologies for conservation, transport, storage and analysis need to be developed and described; and
- Few laboratories (maybe one per continent) have sufficient capacity and proven track record to be engaged in the analysis.

It should be possible to establish such a monitoring system within the framework of the FSP. However, it is assessed that it would not be possible to estimate fluxes of mercury through the rivers within the scope of the project given the budget limitations.

An alternative or complementary approach is the modelling work recently completed by Vörösmarty*, et al.,* (2010), in which risk of anthropogenic mercury deposition was calculated on a 30 minute grid, based on the work of Selin*, et al.* (2008). The analysis was undertaken for the year 2000 and included values for both wet and dry deposition, and considered the contribution of both divalent mercury, which is highly soluble, and particulate mercury.

PART 5. DATA AND INFORMATION MANAGEMENT

5.1 COORDINATED APPROACH

It is important that all five working groups coordinate data and information management to the greatest extent possible. This has a number of advantages:

- Using common data sets (e.g. population, climate data) allows for comparison between results from different water systems;
- Using common partners and datasets allows for a more cost-effective approach;
- Presenting the results in a coordinated fashion allows for comparison of results between systems, and improves understanding by end users; and
- Providing access to the indicators through a combined portal allows the TWAP results to be used by a wide variety of users.

At the TWAP IMAIG meeting in Geneva in July 2010, a Data Management, Modelling and GIS (DMMG) correspondence working group (CWG) was established to facilitate this process. The group achieved limited progress during the MSP, and efforts need to be increased during the preparation of the Project Identification Form (PIF), and maintained during the FSP, if significant coordination is to occur and produce the advantages outlined above.

Data management

The River Basins working group has adopted a mainly decentralised data management approach. This means that all Consortium Partners (section 6.1) are responsible for maintaining their own databases for their assigned indicators. This serves to provide partners with ownership over the indicators, as well as within the project. The aim of this is to contribute to achieving a high level of quality in assessment, as well as sustainability of the approach. Furthermore, as the FSP uses data and technology developed for other projects, so partners will be able to use data and technology developed for TWAP for other projects. In other words, partners and the GEF 'co-own' the data collected and technology developed in TWAP, and may use it for other purposes.

Data acquisition

There are a number of different methods for gathering data for indicators, each with varying levels of complexity, cost, and reliability. They can be split into three categories:

1. Primary collection and monitoring of raw data: includes field data collection, remote sensing, expert committees, and questionnaires;
2. Modelling; and
3. Accessing data through secondary, or existing, data holders.

The objectives of TWAP state that data should be collected in a cost-effective manner, using existing institutions and networks where possible. Consequently, there has been a focus on categories 2 and 3 above in selecting the data acquisition methodology. However, when using secondary sources, the data produced by the primary sources must be of a suitable standard for the purposes of TWAP, namely the data produced must be of a sufficient quality, and produced with a sufficient frequency and geographical coverage. If the primary sources are not reasonably expected to continue to produce data of a sufficient quality, frequency and coverage, it may be necessary to coordinate directly with the primary sources to ensure that their data can continue to be used in TWAP. It should be noted that the issue of frequency is dependent on how often (if at all) periodic assessments will be undertaken as part of TWAP. This issue is yet to be resolved by the GEF.

Modelling is an important way of assessing indicators, and allows for the development of future scenarios. Several global models have been identified, as described in Part 3. However, many of these are based on data more than 10 years old, and would require updating for TWAP.

For some indicators, particularly governance indicators, there is a lack of available data, and this gap will have to be filled by primary data collection. It is likely that questionnaires will be used as the method of data collection in this instance. In other instances, the lack of data can reasonably be expected to be addressed by the data partners, whose mandate it is to collect the relevant data for public dissemination. For example, there may be data gaps in some of FAOSTATs databases, which can reasonably be expected to be updated to coincide with the TWAP FSP.

Remote sensing has been investigated as a possible method of obtaining water quality data in rivers. Although remote sensing has been used successfully to monitor water quality of lakes, reservoirs and coastal zones, defining robust algorithms and techniques to translate remote sensing data into water quality information for river ecosystems is not well tested (Cherkauer*, et al.,* 2010). It is therefore not deemed to be a suitable method for obtaining water quality data for the TWAP FSP at this stage. However, remote sensing could still be very relevant for other indicators. For example, land-use types and extents and changes, as well as water extents (rivers, lakes, small water bodies) and water-extent change, can be determined by remote sensing. The technique has proved particularly useful in identifying potential groundwater boring sites. Whilst it has not been directly recommended for use at this stage since other data forms and indicators have been chosen, recommendations for the use of remote sensing may increase with coordination with the other Water Systems, particularly in determining land-use data. In this light, or if remote sensing becomes an option for determining water quality in rivers during the project lifetime of TWAP, the following two options are worth exploring:

- DevCoCast, which is part of GEONETCast, and shares Earth Observation products, produced by and for developing countries, with (incomplete) global coverage (www.vgt4africa.org); and
- European Space Agency's (ESA) TIGER II initiative, which has selected 20 project proposals across Africa to receive support from Earth-observation technology to learn more about the water cycle and to improve water-monitoring resources. This initiative only covers Africa (http://www.tiger.esa.int/home.asp).

Both of the above have been used in water resource planning and vulnerability assessment, in conjunction with more traditional, land-based methods of data capture. Furthermore, both of the above programmes have significant capacity-building components. However, they may not be sufficiently 'tried and tested' to be used in the immediate future in a global study as part of TWAP.

5.2 INFORMATION MANAGEMENT AND DISSEMINATION

The Consortium Partners are also responsible for transforming data into information (indicators). However, to ensure harmonization across groups, this process may be coordinated by a Service Provider (section 6.1) such as GRID Europe or GRID Arendal. Furthermore, to encourage a wider dissemination of information, partners must provide the data and information to the Service Provider. It is recommended that all TWAP results are presented through a common portal, even if underlying data sets and analyses are held in databases by respective partners.

The main recipient of the results from the FSP is GEF. The presentation of results is therefore directed to GEF and its intended use of the results. However, the assessment results will benefit a much wider group of interested parties and the method for presentation should therefore be flexible to accommodate varying needs (section 2.3).

As discussed in Part 6, the Assessment Consortium (AC) is expected to have the internal capability to present results in an appropriate format, which could be guided by a UNEP Service Provider (e.g. GRID Arendal or GRID Europe).

Presentation of results

The assessment should be presented through maps and other graphics to clearly illustrate the results to GEF and other potential target audiences. National boundaries and river basin boundaries should be based on UN standards. Accompanying reports would provide further information and analysis.

Indicators

The indicators will form the main part of the results and may be presented as global maps and in tabular format.

Global maps

Global maps of the world's transboundary river basins could be produced to provide an overview of the indicator results. A possible application for this is the open-source StatPlanet (2010), developed by the SACMEQ research programme at the UNESCO International Institute for Educational Planning (IIEP).

Each indicator could be presented on a separate global map to allow comparison of basins for each indicator. This may also highlight potential geographical 'grouping' of issues. Each basin will receive one value per indicator. Should a single index be produced (see Part 3), this may be represented on a single global map.

The development of the result maps could be a joint activity between the STATPLANET developers and the Assessment Consortium (AC), possibly in collaboration with the UN-WATER Decade Programme on Capacity Building, who has expressed interest in such collaboration.

Tables - Priority Basins and Priority Issues

In addition to the global maps, the indicator scores for each basin may be presented in a table similar to the schematic representation shown below in figure 6. This will enable the prioritisation of both basins and issues.

	Indicator 1	Indicator 2	Indicator3	Indicator 4	Indicator 5	Indicator 6	Indicator 7	…	Indicator 14	Combined *Unweighte d* Score (%)* if required
Basin 1	3	1	4	2	1	1	3		2	**53**
Basin 2	3	3	2	4	2	3	2		2	**66**
Basin 3	1	1	4	2	1	2	4		1	**50**
Basin 4	2	4	3	4	1	3	2		3	**69**
…										
Basin 260	1	3	2	4	1	3	3		2	**59**
Key overall indicator Issues	**10**	**12**	**15**	**16**	**6**	**12**	**14**		**10**	

* This may be a percentage based on the total possible scores, but has not been weighted. This column could also be colour-coded based on categories which may be decided in the FSP.

Figure 6. Potential schematic representation of results summary

A few issues are illustrated in figure 6:

- It is possible that priority basins can be identified relatively quickly – those which have a greater number of issues that could have significant adverse impacts (e.g. basins 1 and 3 have a lower score than basins 2 and 4). However, it should be noted that no 'weighting' has been applied to the indicators at this stage, so some indicators may be deemed more important than others;
- The key issues within a priority basin can be determined (e.g. for basin 1, indicators 2, 5 and 6 are key issues);
- Although a basin may not be identified as a priority basin, there may be a critical indicator for which it receives a low score (e.g. basin 4 may have a critical issue with indicator 5); and
- It is possible to get a relatively quick oversight of which indicators in general may be priority issues by looking at the bottom row (e.g. indicator 5, which has the lowest score).

In the table above there is a possibility for combining the indicator scores for each basin. A discussion of scoring and possible weighting of results can be found in Part 3.

As the majority of indicators are calculated on a gridded basis, this allows for the comparison of sub-basins, or Country-Basin Units within each basin. This may be developed into a 'contrast' indicator for each basin, showing the geographic difference in scores for a particular issue (or group of issues). This may be used as an additional prioritization tool. There is scope for this approach in Level 1, and the grids may be further refined to identify hotspots in the Level 2 assessment.

Interlinkages between water systems

Presentation of the cross-cutting issues described in Part 4 could be the responsibility of the proposed Implementing Agency, or of an interlinking working group, in order to create continuity in reporting between the water systems on these specific issues.

Indicators linking the TWAP River Basins assessment with particular water systems as described in Part 4 could be highlighted in the presentation in order to be easily identified. If needed, combined maps showing indicator results from several of the water system assessments could be produced to facilitate input/output analyses. The more that results can be combined and overlaps between water systems identified, the more chance there is for better integration of programmes between systems. In conjunction with the combined map of transboundary water systems recommended at the beginning of Part 4, this work will also assist in the prioritization process.

PART 6. TOWARDS IMPLEMENTATION OF THE RIVER BASINS ASSESSMENT

6.1 PARTNERSHIP AND INSTITUTIONAL ARRANGEMENTS

The proposed institutional arrangement for the River Basins component of the Full Size Project (FSP) is shown in figure 7. It should be noted that this is a recommendation for the River Basins component only, and how each of the five water systems are coordinated will require further inputs from the other working groups and the secretariat.

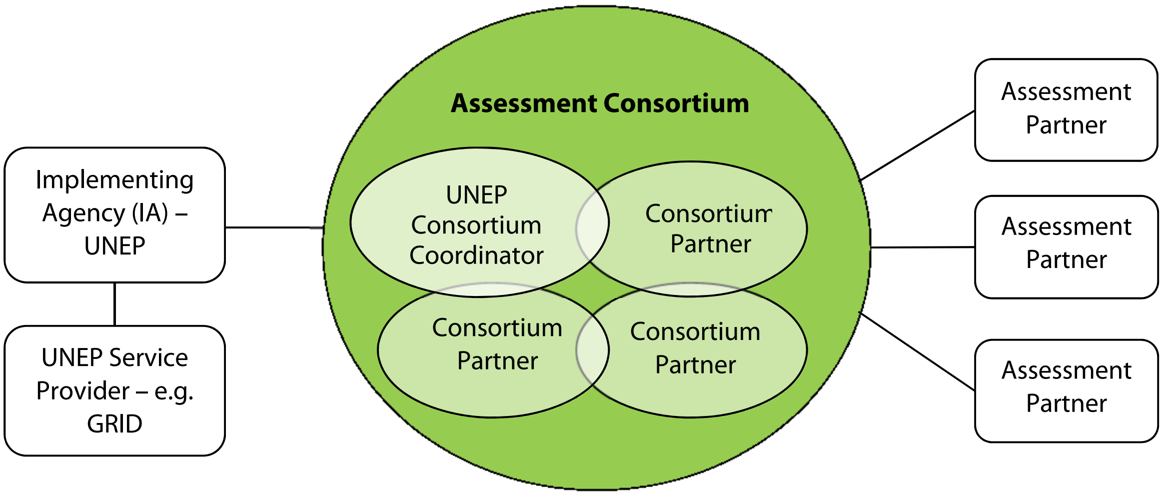


Figure 7. Proposed institutional arrangement for the FSP for the River Basins Working Group

Figure 7 is described in more detail below:

- **Assessment Consortium:** The organizational core of the TWAP FSP for the River Basins group is the Assessment Consortium (AC). This consists of Consortium Partners (CPs) and a UNEP Consortium Coordinator (CC). The AC is collectively responsible for producing the final report for the River Basins component, as well as scoring basins for all indicators. Furthermore, it is expected to have the expertise to produce global maps and graphical representation of results. It is envisaged that there will be approximately eleven Consortium Partners (CPs) in the AC. To ensure consistency in the presentation of results (maps, tables, etc.) between the five water systems, it is recommended that a **Service Provider** (e.g. GRID Arendal, GRID Europe) specifies the formats to the AC and coordinates this process.
  - **UNEP Consortium Coordinator (CC):** This has three primary functions:
    1. To provide specialist input and advice into the assessment process;
    2. To act as a coordinator for the CPs; and
    3. To act as a liaison between the CPs and Implementing Agency (UNEP).
  - **Consortium Partners**: The CPs must have the experience and capacity to undertake such an assessment, as well as an established network to access data (or hold the data

themselves). The CPs are each responsible for a sub-set of indicators and collate data from their respective Assessment Partners (APs) and score basins for each indicator (as described in Parts 3 and 5). They are also collectively engaged in the cross-cutting assessment. A formal agreement will be made between GEF and the CPs for TWAP, which will include an agreement on fees for services provided. It is proposed that CPs are responsible for sub-contracting to, or making similar arrangements with, APs as necessary.

- **Assessment Partners:** The APs hold either data or expertise that can be used by the Assessment Consortium in the computation of indicators. The data may be ready to use and publicly available, or may need updating. TWAP promotes open access to data and information, and transparency in their management and interpretation. Consequently, APs will have the benefit of access to all data managed under TWAP. This means APs in turn must commit to sharing, within the terms of the agreement, relevant data to which they have access for the benefit of TWAP.

All partners will be expected to provide some co-financing, which is discussed in section 6.4.

Advantages of the Institutional Arrangement

This is a relatively decentralised data management approach, with a handful of existing institutions (the Assessment Consortium) with leading expertise being responsible for gathering data for indicators and ranking basins accordingly. This approach has two main advantages:

- It utilizes the strength of institutions with expertise in specific areas to undertake work in which they are world leaders. This enables TWAP to gain access to a high quality of data collection and analysis in a cost-effective manner.
- It provides Assessment Partners with ownership over the indicators, as well as within the project, which contributes to achieving a high level of quality, as well as sustainability of the approach.

How this arrangement ties in with other water systems, and the broader institutional arrangements, (such as an interlinking working group, a steering committee, an implementing agency (secretariat), and the GEF), needs to be discussed with all relevant parties as part of the MSP.

The partners were described in section 2.3, and a summary is provided below:

Consortium Coordinator (CC)

- (1) UNEP-DHI Centre, with support from (2) IUCN and (3) SIWI, to ensure continuity from the MSP to the FSP. The UNEP-DHI Centre has the following relevant expertise for this role.
    - Coordinator of the River Basins group in the TWAP MSP phase
    - Transboundary water resources management expertise
    - IWRM River Basin Management expertise
    - Experience in indicator development and application in assessments
    - Familiarity with GEF processes and implementation of GEF projects
    - Familiarity with UN process and implementation of UN projects
    - Experience in modelling and mapping
    - Large-scale project management experience
    - Project experience across continents
    - Global track record

Specific indicators

- Urban Water Pollution
- Governance Architecture
- Water Legislation
- Biodiversity and Habitat Loss – species component (IUCN)
- Economic dependence
- Societal well-being

Consortium Partners (CPs)

- (4) CUNY Environmental Cross-Roads Initiative, City College of New York (WBMplus model)
  a. Human Water Stress (current status & projected stress)
  b. Ecosystem Degradation
  c. Fish Threat
- (5) University of Kassel (Centre for Environmental Systems Research) and
- (6) University of Frankfurt (Institute of Physical Geography), with WaterGAP model
  a. Environmental Water Stress (current status & projected stress) – runoff component
  b. Agricultural Water Stress – runoff component
  c. Biodiversity and Habitat Loss – wetlands component
- (7) Oregon State University (OSU), Program in Water Conflict Management and Transformation (PWCMT)
  a. River Basin Resilience (current status & projected stress)
- (8) International Geosphere-Biosphere Programme (IGBP), with Global Nutrient Export from Watersheds (Global NEWS) model
  a. Nutrient Pollution (current status & projected stress)
- (9) Centre for International Earth Science Information Network (CIESIN), Columbia University. Responsible for demographic data for:
  a. Human Water Stress;
  b. Urban Water Pollution;
  c. Economic Dependence; and
  d. Societal Well-being.

  Lead responsibility for:
  e. Vulnerability; and
  f. Projected population density.

The above institutions have all been contacted and have provided 'in principle' agreement to being members of the Assessment Consortium during the FSP. These partnerships can begin to be formalised in the FSP preparation phase and finalised on approval of the FSP. However, institutional arrangements and responsibilities may change on the basis of the need to coordinate with other TWAP groups. This will be addressed during the TWAP FSP preparation phase.

Partners that could also become part of the assessment consortium, depending on collaboration with other groups and funds available, include: IWMI (with expertise in global mapping of irrigated areas and agricultural water use, as well as environmental water requirements; FAO (with expertise through the Aquastat database on global water resources use and availability); and the IMAGE modelling group (currently within the Netherlands Environmental Assessment Agency, with expertise in scenario development for the projected stress indicators). Whilst the methodology is not dependent on the inclusion of these partners, it is believed that their inclusion could add value to the assessment, as well as broadening the 'reach' of TWAP.

Assessment Partners (APs)

- FAO (Aquastat & FishStat Plus)
- UNICEF/WHO Joint Monitoring Programme (JMP) (water supply & sanitation)
- Secretariats of the Rotterdam Convention on Prior Informed Consent (PIC) for chemicals and of the Stockholm Convention on Persistent Organic Pollutants (POPs)
- World Bank (World Development Indicators)
- Global Water Systems Project (GWSP) (Global reservoir and dam database)
- ICOLD (World register on dams)
- WorldFish Centre (GDP related fisheries)

Note that this is a provisional list and may be altered depending on unexpected data requirements encountered during the FSP.

6.2 VALIDATION

Through a validation process the TWAP River Basins assessment methodology was presented to stakeholders knowledgeable and involved with IWRM / TWRM at the basin level. The draft methodology was presented during a joint River and Lake Basins workshop organized with stakeholders from the Mekong River Basin. Representatives from the Mekong River Commission, governmental representatives, NGOs, and the private sector were invited. The workshop provided the opportunity to present TWAP and to explain the indicators, draft scoring approaches, and the thinking behind developing the global approach.

Workshop participants were given the opportunity to scrutinise and comment on the suggested methodological framework and indicators. The objective of the workshop was to share the TWAP methodology for the river basins and lake basins workgroups and seek stakeholder input for validation of the approach. Further information can be found in Annex 7.

Stakeholder consultation

The conclusion and recommendations from the workshop were as follows.

1. TWAP needs to consider the wider drivers within transboundary river basins, especially surrounding issues such as governance changes, and the impacts this has on socioeconomics within basins, and future demands and needs for economic growth.
2. TWAP needs to make clearer the links to ecosystem services within transboundary basins. Ecosystem services are the main link between water systems, and the information used to determine this is not always presented in technical scientific approaches, which is the approach dominating TWAP at present.
3. Strong links and use of socioeconomic and ecosystem services would be more politically relevant to decision makers in the Asia region, in order to gain regional support for TWAP, co-investment, and data sharing in the future.
4. There was a general feeling amongst participants that the weighting of indicators, and the priority given to indicators in any future indices should be transparent and should not be technologically- and science-driven. Some participants highlighted that they would need to see more livelihood and socioeconomic issues included in TWAP, and questioned the reliability of

the weighting process if this was to be done from Washington, or even through offices based in the regions but from external agency perspectives. Weighting, if this is to be done, should be transparent and regionally-determined to provide a global assessment with global data-sets, but with regional grounding to improve the reliability of the approach and the results.

5. It is also worth noting that some participants considered that GEF was not very active in the area of freshwater. Further co-investment opportunities for TWAP, use of the final methodology, and engagement would be enhanced by more awareness-raising by the TWAP Secretariat and GEF Sec in order to make TWAP more relevant to regions and GEF's membership.
6. Some concerns were raised over who would use and have access to the data held by TWAP in the future, if agencies and transboundary water management institutions and governments do share information.
7. Whether TWAP should be used to determine where the problems are the worst, or where the greatest impact could be had, are two separate decisions and GEF needs to think about this and be transparent in its decisions. As GEF is a donor, is the decision for funding priorities identified by the TWAP methodology the best return on investment? Cost-benefit analyses need to be developed to guide TWAP. It may be more appropriate for TWAP to be used to guide decision-making and 'returns' from transboundary river systems to preserve and expand ecosystem services for livelihoods and economic growth.
8. The hydrologic links between rivers and lakes, and their environmental and management implications justify substantial and significant collaboration between the River Basins and Lake Basins Working Group in carrying out their assessments under the Full Size TWAP Project.
9. GEF should stress the hydrological links, and their relevant assessment and management implications, in making decisions about international waters funding allocations. Continuing to consider these water systems in an isolated manner is both inconsistent with the realities of nature, and will continue to dissipate the limited GEF funds in a manner that does not provide their most cost-effective use.

Based on these recommendations from stakeholders present at the workshop, the River Basins methodology has been reviewed to better include indicators of socioeconomic relevance, and recognition of these elements within the entire indicator framework. Points raised by participants relating to socioeconomics and governance and the technocratic dominance of the approach are very relevant. These will be shared with the governance and socioeconomics working groups of TWAP. The River Basins workgroup has a member on these two workgroups. Many of the other points are relevant for the TWAP Secretariat and the GEF Sec. It was noted that the River Basins and the Lake Basins working groups should work closer together during the FSP.

The main findings of the stakeholder workshop for the River Basins component are presented in Annex 7.

Peer consultation

The River Basins WG presented its draft methodology at a seminar during the World Water Week in Stockholm on 7 September 2010. The presentation was part of the session on 'Water quality assessment: Indicators and optimal decisions in IWRM'. This session was attended by about 80 persons covering a wide range of researchers, NGOs, government institutions, and other water professionals – from both developed and developing nations. The TWAP project in general was described and explained and the Rivers Basins methodology in particular was outlined, with emphasis on explaining our approach: issue-centred and based on a modified DPSIR (Drivers-Pressure-State-Impact-Response) framework. The process and criteria for developing the key indicators were explained and the draft indicators were presented.

The audience was encouraged to comment on the work of the River Basins WG and respond to the WG within two weeks of the presentation. A few questions were raised at the session, mainly on who would be the users of the methodology and to what extent end-users would be involved in the assessment. The response offered on the first issue was that the GEF-SEC would be the main user of the methodology but that it was envisaged that all river basin stakeholders would be interested in comparing basins and learning from each other's experience. On the second issue the response was that level 1 of the assessment methodology was designed (for economic reasons) to be independent of actual involvement of basin stakeholders and rely on already available data – but that close stakeholder involvement was envisaged at Level 2. No comments or questions have been received since the seminar.

The final draft version of this report was also peer-reviewed by two independent reviewers, organised by the UNEP TWAP secretariat. Comments included the need to enhance the ability to make an analysis at the sub-basin scale, which is addressed by the grid-based indicators, to build on lessons learned from comparable studies, and advice on streamlining TWAP with GEF processes. Responses to all comments were provided by the River Basins group to the TWAP secretariat and are also reflected in this version of the report.

6.3 IDENTIFICATION OF CAPACITY-BUILDING NEEDS

Given the likely time and budget constraints, the FSP has been designed to minimise the *need* for full scale, formal capacity building in its implementation. During Level 1, it is not envisaged that there will be any need for formal capacity building. However there is expected to be some form of training of basin stakeholders or regional experts to collect data for the governance assessment. Level 2 will present the opportunity for some 'informal' capacity building, particularly within RBOs, and potentially within some public authorities/government agencies. This may be in the form of on-the-job training on the implications of TWAP, transboundary IWRM and the benefits of the TDA/SAP process.

6.4 FINANCIAL RESOURCES REQUIRED

Based on guidance from the GEF Secretariat, it is critical that the methodology builds on existing programmes so that a consortium of partners is assembled that are committed to the success of TWAP. The proposed partners all bring baseline programmes and associated investment to TWAP, without which TWAP would not be feasible. Incremental GEF funding will add value to the baseline programmes and ensure that outputs are suitable for the objectives of TWAP.

Attempts have been made to keep the required incremental GEF contributions to a minimum, for example by using or building on existing data sets and tested methods from previous assessments. Significant investment and research has already gone into developing these tools and approaches. However, most of the previous assessments used a baseline year of 2000, which will be more than 10 years old by the time of the FSP. While this may not be significant for some data sets (e.g. hydrological), it may be more significant for others (e.g. socioeconomic). It is therefore recommended that data sets are updated where relevant (e.g. to a 2010 baseline).

Table 6 shows the budget based on initial inputs from all proposed partners. The table includes a breakdown by co-financing in 'cash' and 'in-kind', as well as the requested GEF contribution, which can be defined as:

- 'Cash' co-financing: includes funding raised by groups from outside GEF, as well as staff time paid by the partner organizations which has been specifically allocated to the FSP;

- 'In-kind' co-financing: includes staff time not specifically allocated to the FSP, but nonetheless spent on the FSP, as well as baseline projects/programmes which will be directly used in the FSP (e.g. the cost of updated data sets and model improvements); and
- Requested GEF contribution: the incremental funding required to ensure that the baseline programmes of partners lead to outputs appropriate for the objectives of TWAP.

Table 6 shows the breakdown of costs by indicator and additional line items. However, the costs per indicator may be misleading, as costs are actually split between indicators. The incremental cost of Level 2 is based on US$ 50 000 for four basins. This is a relatively low budget for a detailed basin-wide study undertaking a causal chain analysis etc., and this should be taken into account in both the allocation of resources and in the methodology chosen for Level 2.

It is expected that some cost savings will be made through increased coordination between TWAP groups to use common data sets. This is an important step that needs to be taken during the FSP project preparation phase, probably led by the TWAP Secretariat.

Table 6. Indicative budget.

		CORE ACTIVITIES			
item	**Indicator**	**Total Cost**	**Partner co-financing**		**Requested GEF contribution**
			Cash	**In-kind**	
1	Environmental water stress	390,000	-*	250,000	140,000
2	Human water stress	600,000	-	500,000	100,000
3	Agricultural water stress	30,000	-	-	30,000
4	Nutrient pollution *	243,000	-	133,000	110,000
5	Urban water pollution*	180,000	-	150,000	30,000
6	Biodiversity & habitat loss*	725,000	-	615,000	110,000
7	Ecosystem degradation	585,000	-	550,000	35,000
8	Fish threat	75,000	-	45,000	30,000
9	Governance architecture	755,000	25,000	600,000	130,000
10	River basin resilience	30,000	-	-	30,000
11	Water legislation	40,000	-	-	40,000
12	Economic dependence	60,000	-	-	60,000
13	Societal well-being	100,000	50,000	-	50,000
14	Vulnerability	250,000	-	200,000	50,000
15	Projected Environmental water stress	40,000	-	-	40,000
16	Projected Human water stress	40,000	-	-	40,000
17	Projected Nutrient pollution*	20,000	-	-	20,000
18	Projected Population density*	20,000	-	-	20,000
19	Projected River basin resilience	327,000	-	227,000	100,000
	Level 1 subtotal	*4,510,000*	*75,000*	*3,270,000*	*1,165,000*
20	Level 2	420,000	20,000	200,000	200,000
21	Cross-cutting groups & issues	300,000	75,000	75,000	150,000
22	Analysis & reporting	300,000	75,000	75,000	150,000
23	Sustainability & Outreach	70,000	-	35,000	35,000
24	Project Management	297,500	200,000	-	97,500
25	Contingency	200,000	-	100 000	100,000
	TOTAL	**6,097,500**	**445,000**	**3,755,000**	**1,897,500**

* Note that cells marked with a '-' do not necessarily indicate no co-financing for that item, as co-financing is likely to be distributed between the line items.

Table 6 shows the 'core activities' necessary for undertaking the FSP, largely relying on existing data sets and methodologies. 'Optional activities' that would add value to the assessment, including updating data sets and refining methodologies and models, are shown in annex 10. The optional activities may only be possible if extra funding is identified during the project preparation phase. Annex 10 also includes a more detailed breakdown of the budget.

Public sector co-financing opportunities

The identification of significant co-financing other than from consortium partners could be led by the TWAP secretariat, with more authority than an individual group. Co-financing TWAP may not be immediately appealing to donors as it is a prioritization exercise and the objective does not include immediate improvements to livelihoods or ecosystems. Nonetheless, the project could be of significant benefit to donors prioritizing and coordinating funding, and it would be worthwhile explaining the benefits of the project to donors.

There may be greater public or private co-financing opportunities in Level 2 as it has a more narrow geographic focus.

Private sector co-financing opportunities

There is increasing recognition, both within public and private sectors, that private sector development is required both for product and services development due to increasing demand, especially in growing cities and deltas, and to help reduce poverty through the creation of income, employment, and opportunities. Within river basins, private sector activities are reliant on a range of ecosystem services, like all public and community-level enterprises and livelihoods. Regulation is required to monitor both public and private activities in basins, in order to maintain ecosystem integrity as well as compliance with other laws.

With the complexities of climate change, demographic shifts and population growth within river basins, the private sector faces both significant risks and opportunities to their operations due to their reliance on water systems and the ecosystem services they provide. These risks manifest themselves as physical, regulatory, and reputational risks, and there are many case study examples of these. These three types of risk often appear in combination, and risk can often be traced back to feedstock, raw product, and other value- and supply-chain services – risks that have not been considered before such as the risks to power industries from water scarcity and competing uses, and the impact this could have on finance lending. A number of global initiatives exist to support the private sector in identifying and mitigating these risks, such as work by the World Business Council on Sustainable Development, the World Resources Institute and the Corporate Ecosystem Services Review, and ongoing work supported by Goldman Sachs. A number of global reporting initiatives are also underway to capture and report on company performance, and water is just recently required in Dow Jones sustainability reporting as a cross-cutting issue.

This presents an opportunity for TWAP to look towards private sector co-finance as an additional tool to support the review of risks to business operations in transboundary basins. Entire sectors such as energy, mining, and others hold a vast amount of data at their operational levels to identify new opportunities, and to aid with ongoing practices. This is useful information for TWAP, but also vital for improved Transboundary Diagnostic Analysis (TDA) processes in the future. Bringing the private sector to the table at both global and basin level can bring additional expertise and finance to transboundary projects.

UNEP-Finance Initiative is a partnership between UNEP and global financial industries to understand the impacts of environmental and social considerations on financial performance. It is recommended, given the interest in private sector involvement in the project by GEF (presented at the Inception

Meeting) that UNEP looks at innovative approaches and options to engage global business in supporting the development of TWAP. At present, UNEP-FI is involved with a number of relevant programmes, such as The Economics of Ecosystems and Biodiversity (TEEB), the Regional Seas Initiative, and UNEP-GPA. There may be opportunities for TWAP support which are worth exploring.

6.5 FSP TIMEFRAME

The FSP should inform the current phase of the GEF planning process, GEF-5, which runs for four years from mid-2010 to mid-2014. The total time-span for the FSP is expected to be 3 years, starting at the end of 2011 at the earliest. It is therefore recommended that a milestone be set at the end of year one (late 2012) to deliver preliminary results for as many of the Level 1 indicators as possible. It may be possible to deliver final draft results for some indicators at this point. Other indicators that would take longer to compute should be completed as soon as possible in year two, but no later than the end of year two (late 2013). Interlinkages between basins and cross-cutting issues would be addressed throughout the project.

Depending on the specifics of the selected basins for Level 2 in terms of priority issues, information availability and existing capacity, each Level 2 basin assessment is expected to take approximately 6 months. It is proposed to undertake these Level 2 Assessments in a sequential or staggered mode. Upon completion, each assessment could naturally feed into a TDA. This proposed sequential mode would match the continuous disbursement schedule of the GEF, and would also contribute towards a more even distribution of the work load throughout the FSP.

Year three should involve coordinating results with other IW systems, collating all results from the FSP, and reporting. Consequently, *if* the FSP starts at the end of 2011, it can be expected to be completed by the end of 2014.

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ANNEX 1
TWAP RIVER BASINS WORKING GROUP MEMBERS

ORGANIZATION	TEAM MEMBERS
UNEP-DHI Centre for Water and Environment	▪ Dr. Peter Koefoed Bjørnsen, Group Coordinator, Director, UNEP-DHI Centre Email: pkb@dhigroup.com ▪ Henrik Larsen, Head of Department, DHI Water Policy Email: hel@dhigroup.com ▪ Paul Glennie, Group Coordinator, Water Resources Management Specialist (River Basins representative on 1) Governance and Socioeconomics (GS), 2) Publications (PUB), and 3) Data Management / Modelling / GIS (DMMG) Correspondence Working Groups (CWGs)) Email: pgl@dhigroup.com
IUCN - International Union for Conservation of Nature	▪ Dr. James Dalton, Water Management Adviser, Water Programme Email: james.dalton@iucn.org ▪ Stefano Barchiesi, Water Programme Email: stefano.barchiesi@iucn.org
SIWI - Stockholm International Water Institute	▪ Rebecca Löfgren, Project Officer ▪ Andreas Lindström, Project Officer Email: andreas.lindstrom@siwi.org

ANNEX 2
DATA SOURCES AND PARTNERS

2.1 Assessment Consortium

Consortium Coordinator (CC)

1. UNEP-DHI Centre for Water and Environment, with support from (2) IUCN and (3) SIWI – knowledge of TWAP, as well as UNEP and GEF processes, transboundary river basin management, environmental assessments.

Consortium Partners (CPs)

4. CUNY Environmental Cross-Roads Initiative, City College of New York: global modelling of river systems (WBM_{plus} model).
5. University of Kassel (Center for Environmental Systems Research) and
6. University of Frankfurt (Institute of Physical Geography): global modelling of river systems (WaterGAP model)
7. Oregon State University (OSU), Program in Water Conflict Management and Transformation (PWCMT): Creators of Transboundary Freshwater Dispute Database, and expert knowledge on transboundary water resources management.
8. International Geosphere-Biosphere Programme (IGBP), Global NEWS – global modelling of nutrients. Previous work with CUNY team.
9. Center for International Earth Science Information Network (CIESIN), (SocioEconomic Data and Application Center – SEDAC), of the Earth Institute, Columbia University – anthropogenic data, as well as risks to humans from climate related natural disasters.

2.2 Long list of data holders

Note: This long-list is made up of a mixture of different sources and is not comprehensive. Furthermore, some of the information was gathered at a fairly early stage in the project (early 2010), was primarily focussed on water quality, and may not have been updated. It should be seen as work in progress and may contain errors. Nonetheless it provides an overview of many potential partners.

Data Holders

a) State Data

ORG. (INCL. LINKS)	DATABASE	COVERAGE	DESCRIPTION	METHOD OF DATA REPRESENTATION
UNEP: Global Environmental Outlook (GEO), UNEP DEWA (Division of Early Warning and Assessment) http://geodata.grid.unep.ch/ http://www.unep.org/dewa/index.asp	GEO Data Portal	Global (with gaps)	Several Environmental & Social Assessments, including water. Some data gaps filled with model results. More of a portal than a data provider. **Method of Data Collation:** Website states, 'Global GEO Collaborating Centres: consultative, participatory, capacity building process.' But limited info on water quality (WQ) is from GEMSTAT, whilst 'Popn. Affected by Water Related Disease' is from FAO.	**Advantage:** Free online database, with maps, graphs & tables available. Possible to observe (some) trends on maps/graphs. **Disadvantage:** Major temporal and spatial data gaps. E.g. 'Water quality for major watersheds' is 1976 only. Some broken links.

ORG. (INCL. LINKS)	DATABASE	COVERAGE	DESCRIPTION	METHOD OF DATA REPRESENTATION
UNEP: Global Environmental Monitoring System (GEMS) www.gemstat.org	Gemstat	Global (with gaps)	Multi-faceted water science centre to build knowledge on inland quality issues worldwide. Twin goals: (1) improve WQ Monitoring and Evaluation (M&E) capacity in participating countries, and (2) determine the state and trends of regional and global WQ. **Method of Data collection:** National Focal Points of governmental agencies, and Collaborating Focal Points of NGOs. Advantage is that they have contact orgs. in most (though by no means all – 70%?) countries, though major gaps in Africa & Eastern Europe.	**Advantage:** Free online database. Maps show monitoring locations, and one can zoom in on a specific location and get the data on various parameters in the form of graphs. Can also view country data. Indicators vary by country and measuring station. **Disadvantage:** Major temporal and spatial data gaps, so much so that this database is unlikely to have sufficient current data to undertake an initial global assessment. E.g. Much of the relevant data for PRC ends in '97, Pakistan '03, Sudan '92, S.Af '08, Congo '84, Chile '88. Not easy to see trends within basins – can only view results from 1 monitoring station at a time or by country.

b) Proxy / Stress data

See also 'Potential Research Organizations / Models / Partnerships'

ORG. (INCL. LINKS)	DATABASE	COVERAGE	DESCRIPTION
FAO	AQUASTAT http://www.fao.org/nr/water/aquastat/data/query/index.html	Global (with gaps)	'Comprehensive' statistics on the state of agricultural water management globally, focussing on Developing Countries (DC's). **Method of Data Collation:** Not sure. Possibly by FAO country offices? **Advantage:** Some info on Salinity & river sediment yields. May be useful for proxy information (in terms of agricultural activity) **Disadvantage:** Limited information on WQ. Only shows records for completed 5 year periods (last one 2003-2007)Significant temporal & spatial data gaps.
	FAOSTAT http://faostat.fao.org/	Global	Contains over 1 million time-series records from over 210 countries and territories covering statistics on agriculture, nutrition, fisheries, forestry, food aid, land use and population. **Method of Data collection:** Not sure. Possibly by FAO country offices? **Advantage:** On-line, currently with fee, but making it free as of June 2010. May be useful for proxy information Very good user interface. Scalable overview of spatial and temporal variation of quantitative information through the combination of maps, tables and charts. May be useful proxy. **Disadvantage:** No direct WQ data.
	GLIPHA (Global Livestock Production & Health Atlas) http://kids.fao.org/glipha/	Global	highly interactive electronic atlas using the Key Indicator Display System (KIDS) developed by FAO, related to animal production and health **Method of Data collection:** FAOSTAT, IUCN, Global Administrative Unit Layers (GAUL), Center for International Earth Science Information Network (CIESIN) (for population).

ORG. (INCL. LINKS)	DATABASE	COVERAGE	DESCRIPTION
UNICEF/WHO	Joint Monitoring Programme (JMP) for WSS. http://www.wssinfo.org/home/introduction.html	Global	Accessible database with good coverage for both water supply and sanitation, divided by rural and urban populations. **Method of Data collection:** Assume through country partners. **Advantage:** Good user interface. Choice of maps, graphs, or tables. Downloadable in .csv format.
WSAG (Water Systems Analysis Group - Uni New Hampshire) (key staff from WSAG moved to CUNY)	Global-RIMS (Rapid Indicator Mapping System) http://rbis.sr.unh.edu/	Global with gaps	Interactive database with numerous parameters, incl.: Land characteristics (elev, soils, crop area, irrig. Area, landcover - Afr), Climate & Water cycle (Air temp, Evapotransp., Precip, runoff, discharge), Human Dimension (Popn., popn. Dens., water demand, infant mortality, underweight child.), Ecohydrology Indicators (Discharge, Fragmentation, Floodplain, land use), WWDR Indicators (CMI, Water Stress Index, N load, WRI etc), Geographic Extents ('masks', cult. Land, dryland, coastal, inland water etc). **Method of Data collection:** Data from various sources, including ICOLD, SAGE, CIESIN. **Advantage:** Usable maps **Disadvantage:** No tabular/downloadable data. Only about 25 transboundary basins?? Unclear as to when last updated.
	DSS http://www.wwap-dss.sr.unh.edu/index.html		Data Synthesis System for World Water Resources, focus on Africa. Has about 55 transboundary basins?
Australia, National Land & Water Resources Audit.	Assessment Framework http://www.nlwra.gov.au/national-land-and-water-resources-audit/water-quality	Proxy Indicators	Has developed 10 indicators for resource condition under the National M&E Framework (land salinity, soil condition, native vegetation communities' integrity, inland aquatic ecosystems integrity, estuarine, coastal and marine habitat integrity, nutrients in aquatic environments, surface water salinity in freshwater aquatic environments, significant native species and ecological communities, ecologically significant invasive species), as well as 3 socioeconomic indicators, and 4 integrated themes (biodiversity, intensive land use zone, rangelands, & signposts for Australian agriculture). **Method of Data collection**:

The following are potential partners using Remote Sensing. May be useful for proxy data, e.g. land use. Likely to be relatively quick, cheap, mode of gathering recent data. Problem exists in linking proxy data to water quality, but considerable research done into this area.

ORG. (INCL. LINKS)	DATABASE	COVERAGE	DESCRIPTION	
Group on Earth Observation System of Systems (GEOSS), partners: National Oceanic and Atmospheric Administration (NOAA), the World Meteorological Organization (WMO) and EUMETSAT	GEONETCast (umbrella project) http://www.earthobservations.org/geonetcast.shtml	Global	Multiple data sets from: EUMETCast (Europe, Africa, Americas); GEONETCast Americas (NOAA), FengYunCast (Asia, Chinese Met. Agency). DevCoCast (GeonetCast for & by developing countries). Other GEOSS achievements /partners include the Global Runoff Data Centre (GRDC), & the WISE (Water Information System for Europe) viewer. **Method of Data Collation:** Remote Sensing	**Advantages** :Global coverage, state-of-the-art, possibility of near real-time (every 10 days – but probably only for climate related data). DevCoCast particularly interesting partner, includes capacity building component. **Disadvantage:** Mostly concerned with climate. Difficult to determine accessibility to useable data for TWAP. Many & varied products (e.g. vegetation parameters). Cannot find 'land-use' type data set, but may be able to create one
International Steering Committee for Global Mapping. JICA funded. Increasing collaboration with UN, unclear which body. http://www.iscgm.org/cgi-bin/fswiki/wiki.cgi	Global Map	Global (186 partner countries, 75 countries data released to date. 10 further countries under consideration)	Geographic data sets at 1km, with the following 8 layers: elevation, vegetation, land-cover, land-use, transportation drainage systems, boundaries and population centres. Recently increased cooperation with UN. Based out of Japan. **Method of Data Collation:** Mixture of remote sensing & surveyed data. International corporation, data are produced mainly by National Mapping Organizations participating in Global Mapping project (e.g. USGS).	**Advantage:** Need to register to download, but it is free, state commercial or non-commercial. Period ranges from 2002 (Kenya) to 2009 (Bulgaria). Could be useful partner, particularly for proxy indicator data (e.g. land use). Land use includes: forest (multiple types), shrub, crops, paddy, mangrove, wetland, bare area, urban, snow/ice, water bodies. **Disadvantage:** Some country data from 2002. Believe priority is to cover more countries, Data to be updated approx. every 5 years. How soon will other countries come online?
Global Land Cover Facility (with USGS, NASA, http://www.landcover.org/data/, http://glovis.usgs.gov/	Various, incl. Global Land Survey, & Land Cover Classification	Global	Land cover data, e.g. forests, urban, croplands, sand dunes. Latest from around 2005? **Method of Data Collation:** Remote Sensing, from numerous satellites.	**Advantage:** Free to download data. **Disadvantage:** Not sure if latest data was from 2005?
OzCoast: Cooperative Research Centre for Coastal Zone, Estuary, & Waterway Management.	Model/Research http://www.ozcoasts.org.au/pdf/CRC/74_fitzroy_PC_remote_sensing_screen.pdf		Chlorophyll & suspended sediment: spatial & temporal assessment using remote sensing. **Method of Data Collation:** Remote Sensing	Check

c) Governance Information

ORG. (INCL. LINKS)	DATABASE	COVERAGE	DESCRIPTION	
ECOLEX (IUCN, FAO, UNEP) http://www.ecolex.org	ECOLEX	Global (with gaps?)	Database on treaties & legislation. Search for 'water resource management' yields 115 results (157 treaties & 1457 legislation). Many bilateral treaties. **Method of Data Collation:** Through partners	**Advantages** : Central database with major partners. **Disadvantage:** Unclear as to spatial & temporal data coverage. Can be difficult to navigate through information. May be 'double-up' with TFDD.

Potential Research Organizations / Models / Partnerships

RESEARCH GROUP	ORG. LINKS	DESCRIPTION/PRODUCTS	RELEVANCE
WSAG (Water Systems Analysis Group – University of New Hampshire) (key staff moved to CUNY)	UNESCO/IHP http://wsag.unh.edu/inlandwaters.html	Has multiple projects & Products on water resources, some global but primarily within US. Several projects to monitor the WQ in individual basins (US). WSAG used by NEWS models (see below). Includes global nutrient (Nitrogen) model (2003). **Products:** Global-RIMS (Rapid Indicator Mapping System GHAAS, GRDC, RivDIS1.1, DSS (Data Synthesis System) for World Water Resources - database on Africa, WWDRII	
Global NEWS (Nutrient Export from Wtrsheds) http://marine.rutgers.edu/globalnews/	IGBP, UNESCO – Intergov. Oceanographic Commission), WSAG, CUNY	Developing understanding of global nutrient export from catchments to oceans (5761 watersheds), as a function of land use, nutrient inputs, hydrology and other factors. Particular relevance with respect to Climate Change given the importance of the oceans as Carbon Storage. **Products:** NEWS models (using TSS as a surrogate for nutrients & other pollutants).	Certainly useful to River Basins group, with obvious benefits to LME & Open Ocean WGs.
Group on Earth Observation (GEO) http://www.earthobservations.org/wa_igwco_th_wq.shtml	NASA Energy- and Water-Cycle Sponsored Research (NEWS), GEMS	An empirical approach to measuring water clarity from space-borne sensors, but maybe only for lakes at this stage.	May be of more significance to Lakes WG
Chaoyang University of Technology, Taiwan http://www.colorado.edu/Research/cires/banff/pubpapers/154/index.html		Application of Remote Sensing and GIS in Water Quality Simulation and Calibration. 2000. **Products:** water quality model QUAL2E and an image processing and GIS package ERDAS Imagine	Have not found follow-up of this research. Centre may not have the capacity for this research.
Cooperative Institute for Research in Environmental Sciences (CIRES) http://www.colorado.edu/research/cires/banff/pubpapers/89/	University of Boulder	A method for rapid water quality assessment in developing countries (research 2000). Uses GIS compatible data on socioeconomic activity in the catchment, combined with a Digital Terrain Model (DTM) and hydrological models, to estimate point source and distributed pollution loadings into rivers. Uses BOD as a key surrogate. Case study of Yellow River only. **Products:** Research only?	Highly relevant, but perhaps unlikely that this Institute has the capacity or properly tested methods for TWAP.

RESEARCH GROUP	ORG. LINKS	DESCRIPTION/PRODUCTS	RELEVANCE
Utrecht University, Netherlands		Large scale nutrient modelling using globally available data sets: A test for the Rhine basin. Development of model RiNUX, to adequately simulate present and future river nutrient loads in large river basins. Particularly interested in nutrient modelling from rivers to oceans. 2009. **Products:** RiNUX	Highly relevant, but relatively recent research, and perhaps not fully tested.
NSW Department of Environment, Climate Change and Water, Australia http://www.ozcoasts.org.au/nrm_rpt/index.jsp		CERAT integrates the latest natural resource management into data catchment export and estuarine response models for every major estuary in NSW. **Products:** Coastal eutrophication risk assessment tool (CERAT),	Check

Others:

- HydroSHEDS is a new hydrographic mapping product that provides river and watershed information for regional and global-scale applications in a consistent format (http://hydrosheds.cr.usgs.gov/).
- WaterGAP 2 model is an integrated global water model, i.e. it combines both a physically based hydrological model with a socioeconomically driven water use model, including industrial, household and agricultural water use scenarios. See http://www.usf.uni-kassel.de/cesr/index.php?option=com_content&task=view&id=134&Itemid=72.
- DDM30 – Global Drainage Direction Map at 30 minute resolution. See http://www.geo.uni-frankfurt.de/ipg/ag/dl/forschung/Global_Water_Modeling/DDM30/index.html.

ORG. (INCL. LINKS)	DATABASE	COVERAGE	DESCRIPTION
Transboundary waters, Oregon State University, http://www.transboundarywaters.orst.edu/index.html	TFDD Transboundary Freshwater Dispute Database	Global	Definitive database of transboundary catchments. Mainly focuses on surface water, admitting that groundwater management in the international arena is in its infancy. **Method of Data Collation:** Research **Advantage:** Interactive online map, with pressures such as population, irrigation, land cover. This centre is the forerunner in transboundary cooperation & conflict. **Disadvantage:** No info on WQ.
Center for International Earth Science Information Network (CIESIN), Columbia Uni., UNEP/GEMS, EU-WISE	EPI http://epi.yale.edu	Global	Environmental Performance Index (EPI), contains WQ index. In reality uses other sources, so best to go to the original source for this project. **Method of Data Collation:** Mainly collected from other databases and networks. **Advantage:** Data shown by country via clickable map. **Disadvantage:** Not possible to separate WQ index.
UNESCO http://www.unesco.org/water/wwap/	World Water Assessment Programme		Potentially useful partner/reference, though gathers data from other primary sources (e.g. GEMS)

ORG. (INCL. LINKS)	DATABASE	COVERAGE	DESCRIPTION
World Resources Institute (WRI) http://earthtrends.wri.org/index.php	Earth Trends Environmental Information	Global	Environmental Information Portal **Method of Data Collation:** Data from other primary sources **Advantage:** Some pollution (BOD) data available by country & year. **Disadvantage:** No WQ data
European Environment Agency (EEA)	WISE http://water.europa.eu/en/welcome	Europe	Detailed database on WQ & pressures **Method of Data Collation:** Member countries obliged to report to EEA **Advantage:** Easy to view interactive maps. Also Free to download in tabular format. The Waterbase-Rivers Quality table contains data on nutrients and organic matter in water measured at WISE-SoE river monitoring stations.
Global Monitoring for Environment & Security (GMES), also part of GEO	geoland2 http://www.gmes.info/pages-principales/projects/land-projects/	Europe	Project, development of Core Mapping Services (CMS) and Core Information Services (CIS) (including water quality). **Method of Data Collation:** Under development.
GRID-Arendal, UNEP http://www.grida.no/	Various, including 'Globalis'	Global & local	This collaborating centre of UNEP communicates environmental information to policy-makers and facilitates environmental decision-making for change. Another potentially useful portal. **Method of Data Collation:** Mainly derives data from other primary sources & partners. Some 'in-house' projects & programmes. **Advantage:** Multitude of reports, figures, databases. May have expertise for data management & representation for TWAP. **Disadvantage:** Probably don't hold direct data for indicators.
US EPA http://www.epa.gov/storet/index.html	STORET	US	National WQ database, with multiple parameters. **Method of Data Collation:** Groups submit data through the Water Quality Exchange Network (WQX), through the National Environmental Information Exchange Network. **Advantage:** Free to download data (multiple parameters) in Excel format. **Disadvantage:** Have to focus in on individual sites, and Maps/Graphs not available online, not so user-friendly to determine trends
USGS	National Water Information System (NWIS)	US	National WQ database, with multiple parameters. Claims to be continuous & near real-time. (Temp, EC, pH, DO, Turbidity, Discharge)
Institute of Public and Env. Affairs (IPE) China http://en.ipe.org.cn/		China	Has national water pollution map, including yearly summaries of WQ, Pollutant Discharge, & Pollution Sources information **Method of Data Collation:** Various Chinese government agencies. **Advantage:** (in Chinese). Potentially a useful partner that knows the Chinese systems and can gather information. **Disadvantage:** Main focus on industry (kind of 'watchdog'). Much of the site is in Chinese.

ORG. (INCL. LINKS)	DATABASE	COVERAGE	DESCRIPTION
World Bank http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTWAT/0,,menuPK:4602384~pagePK:149018~piPK:149093~theSitePK:4602123,00.html		Global (with gaps)	Database on Water Resources, but only parameter for WQ is BOD. **Advantage:** Clickable map or tables. **Disadvantage:** Significant spatial and temporal data gaps.
American Geophysical Union (AGU)	COSCAT http://www.agu.org/pubs/crossref/2006/2005GB002540.shtml	Global (with gaps)	global database of 151 catchments, concerns water quality and nitrogen loads, linking rivers and oceans **Method of Data Collation:** Cannot find info. **Advantage:** Cannot find online database, nor mention of it on the AGU website. Many research papers have used the database though. **Disadvantage:** Unsure of accessibility/usability?

There is also overlap with other groups in potential partners highlighted in tables above.

ORG. (INCL. LINKS)	DATABASE	COVERAGE	DESCRIPTION
IWMI, The Nature Conservancy (TNC), UNEP/GEMS http://dw.iwmi.org/ehdb/efr/wetlandvisitor/information.aspx	Global Environmental Flows Database	Global	Global Environmental Flows Database **Method of Data Collation:** Individual Studies **Advantage:** Simple table. May be a useful cross-reference when prioritising catchments.
WWF, The Nature Conservancy (TNC) http://www.feow.org/index.php	FEOW (Freshwater Ecoregions of the World)	Global	Global biogeographic regionalization of the Earth's freshwater biodiversity. **Method of Data Collation:** Individual Studies In-country partners, including UNESCO. Maps for different indicators. Could be useful partner for prioritising, and for proxy indicator data.
World Meteorological Organization (WMO) & German Govt.	GRDC http://www.bafg.de/cln_005/nn_298696/GRDC/EN/Home/homepage__node.html?__nnn=true	Global	Historical data set of discharges, but a specialised network is planned to capture near Real Time Discharge Data (Global Terrestrial Network for River Discharge (GTN-R)). **Advantage:** Believe necessary to make data request. **Disadvantage:** Flows only, no WQ data. Currently only historical data.
Center for Sustainability and the Global Environment (SAGE) (Uni. Wisconsin-Madison)	Global River Discharge Database http://www.sage.wisc.edu/riverdata	Global	Monthly mean river discharge data for over 3500 sites worldwide **Method of Data Collation:** RivDis2.0, the United States Geological Survey, Brazilian National Department of Water and Electrical Energy, and HYDAT-Environment Canada **Advantage:** Free online database, can zoom in on map to select individual sites. **Disadvantage:** Run-off only, no WQ.

- Global Lakes and Wetlands Database (GWLD), available through WWF (http://www.worldwildlife.org/science/data/item1877.html) or Center for Environmental Systems Research, University of Kassel, Germany (http://www.usf.uni-kassel.de/cesr/)

- Global Reservoir and Dam Database (http://atlas.gwsp.org/index.php?option=com_content&task=view&id=99&Itemid=63)
- International Groundwater Resources Assessment Centre http://www.igrac.nl/
- The Black Sea Global Ocean Observing System (GOOS), provides a data portal to improve public access to high-quality information and time series data.
- OzCoast: Cooperative Research Centre for Coastal Zone, Estuary, & Waterway Management. Chlorophyll & suspended sediment: spatial & temporal assessment using remote sensing. http://www.ozcoasts.org.au/pdf/CRC/74_fitzroy_PC_remote_sensing_screen.pdf

DATABASE/ ORGANIZATION	ORGANIZATIONAL LINKS	COVERAGE	DESCRIPTION
The Global Water System Project http://www.gwsp.org/about_us.html	Multiple	Global	International Coordination for Integrated Research **Method of Data Collation:** Research projects **Advantage:** Publications **Disadvantage:** No data, rather researching network.
River and Catchments Database for Europe	E.C. Joint Research Centre (JRC), Institute for Environment and Sustainability (IES) http://ies.jrc.ec.europa.eu/index.php?page=data-portals	Europe	Database on catchments. Currently security problems accessing database. **Method of Data Collation:** Project Dependent **Disadvantage:** Likely that WISE provides a more comprehensive data set on WQ.
Center for Global Environmental Research (CGER)	http://db.cger.nies.go.jp/gem/moni-e/index-e.html	Project based	Conducts 'Global Environmental Monitoring'. Based out of Japan. **Disadvantage:** Not much focus on freshwater, although 1 joint GEMS collaboration project on Lake Kasumigaura database
Centre for Ecology & Hydrology (CEH) http://www.ceh.ac.uk/	Natural Environment Research Council, Environmental Information Data Centre (UK)		Although useful global research, database on UK Only. Already has significant EU data.

Community / Education Networks

DATABASE/ ORGANIZATION	ORGANIZATIONAL LINKS	COVERAGE	DESCRIPTION
Global Water Watch (GWW) http://www.globalwaterwatch.org/	Auburn Uni., Alabama, USA.	Global (partial)	Voluntary network of community based water monitoring (CBWM) groups. **Advantage**: Could be useful network to build on if education/community action is to be a part of this project framework.
The Global Water Sampling Project http://www.ciese.org/curriculum/waterproj/index.shtml		US	This is for high school students, and appears to only be in the USA, although the project is current (Sep/09-June/10) **Method of Data Collation:** Community based water monitoring (CBWM) groups: Thailand, Brazil, Ecuador, US, Philippines, China, Mexico **Advantage**: Could be useful network/model to build on if education/community action is to be a part of this project framework. **Disadvantage:** US only at this stage

- List of global hydrology data holders: http://www.fao.org/gtos/tems/mod_hyd.jsp?hyd_PAGE=hyddata.htm. Worth visiting this webpage for networks. Not much on nutrients and WQ, though some on Sedimentation.

- Australia: National Water Commission: Framework for the Assessment of river and Wetland Health (FARWH) http://www.nwc.gov.au/www/html/222-framework-for-the-assessment-of-river--wetland-health.asp?intSiteID=1
  - a national framework that can form the basis of national river and wetland health assessments, and has the capacity to bring together results of existing broad-scale assessments conducted at state, territory and basin scales.
  - The FARWH does not generate data itself or replace existing monitoring and assessment programs. Rather, it provides a methodology to integrate and aggregate the data collected by the states and territories to be reported at a water management area scale. This provides an important link between aquatic ecosystem health and water management planning.
  - The FARWH uses a conceptual model of river and wetland function, based on six ecologically significant components that should be represented in all future river and wetland health assessments. These key ecological components are:
    - catchment disturbance; hydrological change; water quality and soils; physical form; fringing zone; aquatic biota.

- U.S. Geological Survey's (USGS) National Water Information System (NWIS) http://water.usgs.gov/data/ 'is a comprehensive and distributed application that supports the acquisition, processing, and long-term storage of water data.' It has WQ data including nutrients.

- US, EPA, Water Quality Criteria for Nitrogen and Phosphorous Pollution, National Nutrient Database (NUTDB): http://www.epa.gov/waterscience/criteria/nutrient/database/. Has data about Lakes/ Ponds, Reservoirs, and Rivers/Streams. Downloadable as Excel.ZIP.

ANNEX 3
DESCRIPTION OF INDICATORS

This annex contains Indicator Sheets, which provide the rationale and functional details of each indicator.

Indicator sheet template

Indicator No. and Name

Rationale:	Sets the indicator in the context of: ▪ why the issue is important globally; ▪ what are some of the impacts of the issue (these two may overlap); ▪ what the results of the indicator will show; and ▪ how they can be interpreted.
Interlinkages:	Gives a brief overview of how the indicator is important to the four other IW systems, if relevant. The abbreviations are: GW – Groundwater; Lakes (no abbreviation); LMEs – Large Marine Ecosystems; OO – Open Ocean.
Definition:	Describes which underlying metrics are used in the indicator, and how they are combined.
Units:	If applicable, provides the final units of the index
Metrics:	Contains information on the metrics used, and the data required, including the following: ▪ Name of metric – year of baseline data, data source (including hierarchy of sources if secondary sources are used) and year of completion of study (including references), whether data is national or grid based, and a short rationale for the metric.
Computation:	Provides a step-by-step description of how the indicator is calculated. Includes the weighting of each metric if applicable, and how national level data is aggregated to the basin level. In general, grid-based data is computed to provide an average basin score for each index.
Scoring system:	Generally basins will be ranked according to final scores for each indicator, with low scores indicating a higher level of risk for the indicator. The scores can easily be inverted during the FSP to give high scores for high risk. Though it will not be described here, in order to be able to compare indicators using the same scoring system, the basins will then be assigned a risk category of 1 to 5 based on the following criteria:

Risk category	Range (%)	Proportion of basins
1	0 – 10	10%
2	10 – 20	10%
3	20 – 50	30%
4	50 – 90	40%
5	90 – 100	10%

The scoring approach is elaborated on in section 3.2. The scores can easily be inverted during the FSP to give high scores for high risk, and this may be coordinated with other working groups.

Limitations

- These describe issues which may not be included in the indicator, as well as any cautionary notes in interpreting the results.
- They may also be seen as 'challenges' which could be addressed during the Full Size Project (FSP), and if successfully addressed, would add value to the approach.

Alternative approaches:

- This section should identify main alternative data sources and approaches to calculating the indicator, as well as giving the reasoning for selecting the preferred approach/data source.
- These approaches/data sets may be used as some form of verification of results in certain cases, as they may use different methods to arrive at similar information.
- They may also provide practical alternative approaches should unforeseen problems occur with the proposed approach.

It is worth noting that the following are proposed methodologies for the calculation of each indicator. However, methodologies may be modified, for example as a result of changes to funding or the need for coordination with other TWAP working groups. Importantly, it is believed the right mix of partners has been identified, such that methodologies can be enhanced if necessary during the FSP.

Water Quantity

1. *Environmental water stress*

Rationale: Over the past few decades the value of the environment has become better understood (MA, 2005). In some parts of the world environmental systems are being restored, but predominantly, environmental systems are coming under increasing threat from both demand for water from other sectors (water quantity) and available water being polluted (water quality). This indicator considers the Environmental Water Requirement (EWR), or the water quantity aspect, including both low-flow and high-flow components. The indicator can be compared to the human and agricultural water stress indicators to see which issue is likely to be of greatest importance to the basin in terms of quantity.

Interlinkages: GW (some ecosystems are dependent on healthy GW supplies, linked to recharge from rivers), Lake Basins (lakes and rivers ecosystems are strongly interrelated, and environmental water stress in rivers is also likely to impact on lakes), LMEs (quantity of water output to LMEs, particularly affecting estuarine areas where freshwater/saltwater interactions are important).

Definition: Mean Annual Runoff (MAR) minus Environmental Water Requirement (EWR), divided by total withdrawals.

Units: Unitless (proportion)

Metrics:

- Mean Annual Runoff (MAR) – 2000 data computed by Uni Kassel in 2003 at 30 min. grid using the Global Hydrology sub-model of the WaterGAP 2 model (Alcamo, et al., 2003).
- Environmental Water Requirement (EWR) – Calculated by IWMI as a percent of MAR, ranging from 20 to 50%. (Smakhtin, et al., 2004). Already calculated for 128 major river basins and drainage regions of the world.
- Total withdrawals, calculated by the Global Water Use sub-model of the WaterGAP 2 model (Alcamo, et al., 2003), made up of:
  - Domestic demand: 2000, based on relationship between water use intensity and income using 'sigmoid curves'.
  - Electricity production demand: 2000, based on Utility Data Institute.
  - Manufacturing industry demand: 2000, based on six manufacturing sectors,
  - Agricultural demand: based on irrigation (1995) and livestock (1995) demand. Considers 'irrigation water use efficiency', crop type and growing seasons.

Computation:

1. (MAR – EWR)/Total withdrawals for each grid cell.
2. Average the values for each grid cell to give an average value per basin.

Scoring system: Basins with a lower score have a higher environmental water stress.

Limitations

- Data likely to need updating
- Difficulties in estimating the EWR in each basin
- Does not consider water quality
- Original EWR approach received criticism for not adequately addressing temporal variability. This needs to be considered in the final methodology.

Alternative approaches:

- Work by Döll, et al. (2009) 'Global-scale analysis of river flow alterations due to water withdrawals and reservoirs', which has a number of indicators that could be modified for the purposes of TWAP.
- Some data (MAR & total withdrawals) could be compared with, or supplied by, CUNY data from the work by Vorosmarty, et al. (2010).

2. *Human water stress*

Rationale:	Water scarcity is a, if not the *key* limiting factor to development in many transboundary basins. Water stress can be caused by a combination of increasing demands from different sectors and decreasing supply due climate change-related variability. Human water stress has been defined in a number of different ways since Falkenmark (1989, Rijsbeman 2005). This indicator deals with the quantity of water available per person per year, on the premise that the less water available per person, the greater the impact on human development and well-being, and the less water there is available for other sectors.
Interlinkages:	GW (some of the water available is from aquifers), Lakes (this is also a reflection of the pressure on lake water), LMEs (indication of the quantity of water likely to reach the coast).
Definition:	Water availability per person per year
Units:	m^3 discharge / person / year

Metrics

- Discharge – 2000 baseline, computed by CUNY in 2010 at 30 min. grid (Vörösmarty, et al., 2010). Accounts for irrigation demand and operation of reservoirs (Fekete, et al., 2010; Wisser, et al., 2008).
- Population – 2000 baseline (update may be available), computed by CUNY in 2010 at 30 min. grid based on CIESIN Global Rural-Urban Mapping Project (GRUMP) (CIESIN 2004).

Computation:

1. Divide average discharge by population for the basin to derive a single value for each basin.

Scoring system: Basins with a lower score have a higher human water stress.

Limitations

- Does not consider water quality. The level of water stress may also be impacted by the water quality, as the available water needs to be of a certain standard fit for the required use. This indicator can be compared with the water quality indicators.
- Does not explicitly consider water demands from the domestic and industrial sectors

Alternative approaches:

- Oak Ridge National Laboratory (2008). LANDSCAN 2007 Global Population Data set could be an alternative to GRUMP. This applies to all indicators where population is required. However, CUNY already have links with CIESIN and have imported their data sets into the model.

3. *Agricultural water stress*

Rationale:	Globally, agriculture accounts for approximately 70 per cent of all water abstraction. Agriculture is important for food security and livelihoods in many countries, and can be a key source of export income. Indeed, agriculture is the most important economic sector in many developing countries. This indicator covers both rain-fed (implicitly) and irrigated (explicitly) agriculture. The proportion of irrigation indicates the dependency of agriculture in the basin on irrigation. Higher levels of irrigation will generally indicate higher levels of water withdrawal, less available water for other sectors, and potential vulnerability to decreases in rainfall as a result of climate change. This indicator builds on work published by CUNY in 2010 (Vörösmarty, *et al.,* 2010). The indicator can be compared to the human and environmental water stress indicators to see which issue is likely to be of greatest importance to the basin.
Interlinkages:	GW (potential abstraction & recharge), Lakes (potential abstraction & inflow), LMEs (quantity of water output to LMEs)
Definition:	Available water in the basin (accounting for water abstracted for irrigation) divided by cropland.
Units:	million m^3 discharge per km^2 cropland area per year
Metrics: ▪ Total cropland area in basin - 2000 data computed by IWMI as part of the Global Map of Rainfed Cropland Areas (GMRCA) (Version 2.0, 2007), based on satellite remote sensing at 5 minute (10km) resolution. Map is seasonal (Thenkabail, et al., 2008). ▪ Mean Annual Runoff (MAR) – 2000 data computed by Uni Kassel in 2003 at 30 min. grid using the Global Hydrology sub-model of the WaterGAP 2 model (Alcamo, *et al*., 2003). ▪ Total withdrawals, calculated by the Global Water Use sub-model of the WaterGAP 2 model (Alcamo, *et al*., 2003), made up of domestic, industrial, and agricultural demand.	
Computation:	Values of the following have been calculated on a grid basis, so data is available at the basin level, but requires updating. 1. MAR minus total withdrawals 2. Divide '1' by cropland area per year.
Scoring system: Basins with the lowest scores have the highest agricultural stress.	
Limitations	
Alternative approaches: ▪ CUNY have developed an indicator on which this was based, published in 2010, also with a 2000 baseline (Vörösmarty, et al., 2010). However it was felt that Kassel & IWMI have a strong background in agriculture and should be included. ▪ University of Frankfurt, global map of irrigated areas (Siebert, *et al*., 2005) (baseline 2000), in collaboration with FAO. Based on University Kassel work for World Water Development Report . 5 minute (10km) resolution. Partly based on Aquastat statistics & modelling. ▪ IWMI also has Global Irrigated Area Map (GIAM), should this be required.	

Water Quality

1. Nutrient pollution

Rationale:	Nutrient pollution is caused mainly by agricultural activities (fertiliser use and wastes from livestock) and urban wastewater. Contamination by nutrients (particularly forms of nitrogen and phosphorous) increases the risk of eutrophication (e.g. algal blooms) in rivers, which can pose a threat to environmental and human health. Impacts include: reduction in levels of some flora and fauna due to reduction in light penetration and dissolved oxygen levels, increase in toxins making the water unsafe for humans and wildlife, and reduction in amenity value of water bodies. This indicator considers pollution from forms of dissolved inorganic, organic, and particulate nitrogen and phosphorous.
Interlinkages:	GW (nitrates contamination, making sources potentially unfit for drinking water supply), Lakes (contamination, eutrophication), LMEs (coastal eutrophication, degradation of water quality and coastal habitats, and increases in hypoxic waters).
Definition:	Six nutrient forms incorporated: Dissolved Inorganic and Organic Nitrogen & Phosphorus (DIN, DON, DIP, DOP), and Particulate Nitrogen and Phosphorus (PN, PP). *(Actual number and weighting to be determined)*. Total quantity divided by basin area (areal concentration).
Units:	kg/km^2/ yr (areal concentration)

Metrics

- Average annual loads of DIN, DON, DIP, DOP, PN, and PP – 2000 (though 2010 update expected), calculated using Global Nutrient Export from WaterSheds 2 (NEWS 2) model. Measured in kg. Results output is average for the basin, but most input data sets (for sources of pollutants) calculated at 30 min. grids.
- Basin area – part of NEWS inputs, measured in km^2

Computation:

1. Calculate total annual average loads of nitrogen and phosphorous forms, all equally weighted at this stage.
2. Divide by basin area to give average value for each basin.

Scoring system: Basins with the lowest scores have the highest risk of urban pollution.

Limitations

- Considers agricultural and urban sources of nutrients, but does not contain this information in the results. This may be relevant in addressing main sources of nutrient pollution in Level 2.
- Difficult to accurately describe how and at what speed the pollution is transferred from the land to water. One could have rather low concentrations of pollutants on land and high ones in water because of fast and efficient transfer and vice versa.
- Only provides basin averages, so not possible to identify hotspots within basins.

Alternative approaches:

- If costs can be shared among groups, the Global NEWS model grid can be refined to produce outputs at 30 minutes (approximately 50 x 50 km at the equator). In this case the inputs would have to be at a much finer scale. This would be of significant benefit to the River Basins, Groundwater, and Lake Basins assessments, as well as adding value to the NEWS models. The technique has already been tested for DIN and DIP at sub-basin spatial scales.
- CUNY have also recently published work on global nitrogen and phosphorous loading at a 30 min. grid, but it is understood that Global NEWS 2 will be doing a 2010 update of input data as part of the LME approach.

2. *Urban water pollution*

Rationale:	Urban water pollution can have adverse impacts on both environmental and human health. These include biological and chemical oxygen demand (BOD and COD), an increase in pathogens, turbidity, eutrophication, and an increase in 'persistent' pollutants such as metals and toxic chemicals (Persistent Organic Pollutants (POPs)). With rapidly expanding cities often without adequate sanitation services and regulatory frameworks to control pollution, this is a significant problem in many parts of the world. This indicator considers both municipal and industrial pollution, the two main pollution sources in the urban setting.
Interlinkages:	GW (contaminated recharge), Lakes (contamination, eutrophication), LMEs (quality of water), OO (persistent pollutants)
Definition:	The 'concentration' of municipal and industrial effluent compared to available water resources, with a 'pollution control factor' accounting for municipal and industrial wastewater quality.
Units:	Unitless

Metrics

- Municipal and industrial water withdrawal – 2000 average data from Aquastat (FAO). National data only. This is a proxy for urban wastewater discharge (for which no global reliable sources had been found at the time of writing), and assumes that much of water withdrawn is returned to the system. For comparison purposes the proportion of consumption vs withdrawal becomes less critical.
- Population within the country basin unit (CBU) compared with total population of that country – 2000 data from Global Rural-Urban Mapping Project (CIESIN 2005). This is necessary to convert the national data above into basin level data.
- Total available water in basin - 2000 data computed by CUNY in 2010 at 30 min. grid from Fekete, et al. (2010) (water availability) and Wisser, et al. (2008) (irrigation demand). This indicates the dilution effect of receiving waters.
- Access to improved sanitation – 2000 data from the UNICEF/WHO Joint Monitoring Programme (JMP), 'total improved sanitation', expressed as a percentage (already calculated as aggregate of the population-weighted urban and rural numbers, divided by the total population). National data only. This is a proxy for the level of municipal wastewater quality.
- Status of ratification of Stockholm and Rotterdam Conventions – use most up-to-date data available at time of assessment, available from the respective convention secretariats. Six possible scores. National data only. This is a proxy for the quality of industrial wastewater quality, focussing on hazardous chemicals. The Stockholm Convention deals with Persistent Organic Pollutants (POPs), and the Rotterdam Convention deals with hazardous chemicals. They are considered the two most comprehensive and widely adopted conventions on POPs and hazardous chemicals.

The last two metrics are grouped to form the 'pollution control factor' for urban water pollution.

Computation: Much of the data used for this indicator is available at the national scale, and will therefore have to be aggregated to the basin level.

1. Calculate average municipal and industrial water withdrawal for each country in the basin from 2000 from Aquastat. If year 2000 data is available, use this figure (this is the case for the majority of countries). If not, use available information to calculate average.
2. Calculate the proportion of population in the country basin unit (CBU) compared to the country.
3. Multiply '1' by '2' to arrive at the approximated municipal and industrial water withdrawal in each CBU.
4. Divide the available water in the CBU (total minus agricultural withdrawals) by '3' to obtain a ratio that may be termed the 'concentration' of wastewater in each CBU.
5. Determine the proportion of access to improved sanitation in each country (combined rural plus urban).

6. Calculate the status of ratification of the Stockholm and Rotterdam Conventions (SC & RC respectively) for each country and award the following scores: Under the RC, countries receive 2 points if they are a party and have designated a national authority for its implementation, 1 point if they are a party but have no national authority, and 0 points if they are not a party. Under the SC, countries receive 2 points if they are a party and have created a national implementation plan (NIP), 1 point if they are a party but have no NIP, and 0 points if they are not a party. Add the total number of points to obtain scores ranging from 0 to 6. Assign each score from with the following weights (100 divided by 7 categories):
   - 6 - 0.93; 5 – 0.79; 4 – 0.64; 3 – 0.50; 2 – 0.36; 1 – 0.21; 0 – 0.07
7. Combine '5' and '6' from each CBU, weighting scores from '5' and '6' by the ratio of municipal vs. industrial water withdrawal.
8. Multiply '4' by '7' to obtain a score taking into account quantity and likely level of treatment for each CBU.
9. Combine the results of '8' for each CBU based on the proportion of population within each CBU compared to the whole basin.

Scoring system: Basins with the lowest scores have the highest risk of urban pollution.

Limitations

- Assumes a uniform access to improved sanitation within each country.
- Does not consider varying levels and types of industry and related pollution.
- Does not explicitly consider thermal pollution (e.g. wastewater from cooling processes).

Alternative approaches:

- If status of ratification of the Stockholm and Rotterdam Conventions does not provide a wide enough distribution of results, one can add specific actions on specific pollutants (see EPI 2010, Pesticide Regulation Index) for more information) (Yale 2010).
- ECOLEX (2010) is a potential source of data for environmental legislation at the national level. However, the Stockholm and Rotterdam Conventions have been chosen due to their global coverage and ease of access of data.
- FAOSTAT has information on pesticide use. However, quoting directly from FAOSTAT: *'A strict inter-country comparison on the basis of the database is not feasible because:*
   - *The country coverage and time series are incomplete due to a high rate of non-response; and*
   - *Although countries have been requested to report data in terms of active ingredients, some countries may have reported in formulation weight ... without specific indication.'* (FAOSTAT 2010)

Furthermore, significant spatial & temporal data gaps exist. For 2003-2007, there are only 58 countries with at least one record of insecticide and herbicide use, whilst there are approximately 150 countries within transboundary basins.

Ecosystems

1. *Biodiversity and habitat loss*

Rationale:

In most of the world's terrestrial biomes and ecoregions, habitat conversion exceeds habitat protection (Hoekstra*, et al.,* 2005). Yet areas such as wetlands and riparian habitats in particular play a critical role in maintaining the integrity and proper functioning of freshwater and coastal ecosystems. Protection of wetlands is illustrative of society's recognition of the importance of ecosystems for river basins and the willingness to take concrete steps to conserve these valuable resources (IUCN*, et al.,* 2003). By contrast, conversion is in many cases the result of direct draining or longitudinal impoundment that make floodplain areas dysfunctional by levee construction and river channelization for urban areas and cropland protection (Vörösmarty*, et al.,* 2010). As the habitat lost/protected ratio may be the same for two areas with different climates and biomes irrespective of biodiversity status, basins are further prioritized based on the change occurring to species threat status. Such a metric has the potential to illustrate the effectiveness of national, regional and global measures designed to conserve biological diversity and ensure that its use is sustainable, including the measures implemented in fulfilment of obligations accepted under the Convention on Biological Diversity and under the Millennium Development Goals (UNDESA 2007). In addition, the IUCN's Red List Index is currently 'in process' for adoption by the UN Statistics Division for the new BD indicator under MDG7, Target 9bis.

Interlinkages with other water systems:

Wetlands are an essential part of catchment hydrology. The definition of wetlands includes rivers, lakes and near-shore marine areas, and boundaries cannot be clear-cut. Hence the obvious linkages with the other water systems. Depending on the gradient of the groundwater table and topography of the land surface, wetlands also perform the important function of aquifer recharge or discharge.

Definition:

The indicator is based on knowledge of a) the different types of freshwater habitats, biomes and ecosystems and their geographic delineation and area; b) species composition and abundances. Wetlands are broadly defined by the Ramsar Convention as lakes and rivers, swamps and marshes, wet grasslands and peatlands, oases, estuaries, deltas and tidal flats, near-shore marine areas, mangroves and coral reefs, and human-made sites such as fish ponds, rice paddies, reservoirs, and salt pans.

A threatened species is one that is listed under the IUCN Red List Categories as Vulnerable, Endangered or Critically Endangered (i.e., species that are facing a high, very high or extremely high risk of extinction in the wild). Increasing numbers of threatened species represent actual or potential declines in biodiversity. The IUCN Red List of Threatened Species™ is widely recognized as the most authoritative and objective system for classifying species by their risk of extinction. Species are included in the following categories according to a range of data regarding their abundance, populations, ecology, and the threats they face: Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered, Extind in the Wild, Extinct, or Data Deficient. This indicator uses an adaptation of the IUCN's Red List Index (RLI) methodology to show biodiversity loss through the overall changes in threat status (i.e. relative projected extinction risk) of representative sets of species at the global level.

Units: unitless (proportion of lost wetlands relative to the rate of change in species threat status)

Metrics

- Total wetland area in basin – update of the Class 3-10 of the Global Lakes and Wetlands Database (GLWD) (Lehner*, et al.,* 2004) as generated by WWF/University of Kassel in the course of developing WaterGAP, based on different wetland types in the form of a global raster map at a 30 sec. resolution and excluding lakes and reservoirs (Classes 1 and 2)
- Red List Index – the 2009 IUCN Red List of Threatened Species contains assessments for 49 000 species of which spatial data exists for about 25 000 species, including all amphibians, mammals and threatened birds data.

Computation:

1. Wetland loss area calculated by overlay and re-sampling at 30 min. grid of the 2004 and potential 2010 update Class 3 maps from the Global Lakes and Wetlands Database (University of Kassel, WWF), or the 2000 and potential 2010 update from the SRTM Water Body Data (SWBD) (NASA).
2. Red List Index calculated for those species whose status change and distribution are both available. The Index is based on the number of species in each Red List Category, and the number moving between categories in different assessments owing to genuine improvements and deterioration in status only (i.e. category changes owing to revised taxonomy or improved knowledge are excluded). A near zero value or downward trend means that the expected rate of biodiversity loss is increasing.
3. Values for each grid cell are averaged to generate a single value per basin.
4. The two values per basin are combined, all equally weighted at this stage.

Scoring system: Units with the lowest scores experience the highest biodiversity and habitat loss.

Limitations

- The lack of detailed descriptive attributes in Class 3-10 items of the GLWD such as names or volumes may hamper analysis at level-2 scale; however GIS information could be derived from data sources other than remote sensing, including Ramsar site data in Ramsar Information Sheets (RIS) format.
- The RLI shows relatively low temporal resolution, because the Red List Categories are a relatively broad measures of status, and the RLI can be practically updated only every four years at most. As such, it does not capture particularly well the deteriorating status of common species that are declining slowly as a result of general environmental degradation.
- The RLI captures trends in one particular aspect of biodiversity: the rate that species are moving towards extinction and becoming extinct. It does not encompass the wider spectrum of biodiversity, including genes and ecosystems, although the Sampled Red List Index will be representative of a wide diversity of taxa. However, losing species through extinction is a particularly tangible and readily understandable component of biodiversity loss and has clear relevance to ecosystem function.

Alternative methods/data sources:

By assuming that human occupancy results in severing the natural physical and biological interconnections between river channels and their floodplains, habitat loss can also be captured as a measure of wetland disconnectivity, which is the proportion of wetlands occupied by dense cropland or urban areas. Croplands are defined as land designated as arable and devoted to growing permanent crops whereas constructed impervious surface areas reflect buildings, roads, parking lots, and other man-made surfaces. Wetland area occupied by cropland or urban use has already been calculated by River Threat in 2010 on a grid basis by overlay of the respective maps. Cases where cropland plus impervious surface area exceeded 100 per cent of wetland area in a grid cell area were set at 100 per cent. An alternative, or complementary, metric to the RLI could be one that uses estimates of population trends in selected species to represent changes in biodiversity and the relative effectiveness of measures to maintain biodiversity.

2. *Ecosystem degradation*

Rationale:
The negative impacts on ecosystems of altering waterways by dams, water transfers and canals must be considered for managing water resources in a sustainable way. It is no longer acceptable to draw water from nature for use in agriculture, industry, and everyday life without taking into account the role that ecosystems play in sustaining a wide array of goods and services, including water supply (WWAP 2006). Very large dams accounts for 85 per cent of registered water storage worldwide. In order to compensate for considering only the impacts of very large dams on river fragmentation and flow disruption, dam density is also factored in.

Interlinkages with other water systems:
GW (reduction in mean annual discharge due to impoundments may affect the amount of groundwater recharge), Lakes (reduction in the rate of sedimentation in lakes and reservoirs), LMEs (reduction in the amount of nutrients that reaches marine ecosystems).

Definition:
The degree of environmental impact at the river basin level results from flow disruption, channel fragmentation and other stresses associated with dams, withdrawals and diversions. The fragmentation and flow indicator was developed by Umeå University in Sweden, in collaboration with the World Resources Institute (WRI), for assessing the state of large river systems. According to Nilsson*, et al*. (2005), flow disruption is the degree to which the Virgin Natural Annual Discharge (VMAD) is regulated by dams or other diversions. This is also described as the sum of reservoir capacity within a river system, irrespective of a reservoir's location within the catchment, expressed as the percentage of river system VMAD which can be contained by the reservoirs. River fragmentation is the degree to which the river system is spatially fragmented by dams. Dynesius & Nilsson (1994) classified fragmentation according to the longest segment of the main river channel without dams and whether dams exist in the major tributary, minor tributaries, or both. Building of global databases on reservoirs and dams has lately enabled a better description of their geographical distribution which is here referred to as dam density.

Units: unitless (proportion of accessible basin relative to years of increased residence time)

Metrics

- Estimated total river fragmentation in basin – 2010 data computed by River Threat in 2010 at 30 min. grid from the GWSP-GRAND (Global Reservoir and Dam Database) (ICOLD 1998) data set of 6 879 very large dams.
- Estimated total flow disruption in basin – 2010 data computed by River Threat in 2010 at 30 min. grid from the GWSP-GRAND data set, based on Vörösmarty, *et al*. (2000a, b) and Fekete*, et al*. (2010) flow network and modelled river discharge.
- Estimated total density of dams in basin – 1998 data computed by River Threat at 30 min. grid with probabilistic approach from the World Register on Dams by ICOLD (International Commission of Large Dams) database of 28 096 smaller dams, summed with 2010 data from the GWSP-GRAND data set.

Computation:
1. River fragmentation has already been calculated as the proportion of each drainage basin that is accessible from a given grid cell.
2. Flow disruption has already been calculated as the changes in residence time computed by dividing upstream reservoir capacity by the mean annual discharge at a given point in a river network.
3. Dam density has already been calculated on a grid basis as the sum of the actual number of GWSP-GRAND dams and the estimated number of additional ICOLD dams.
4. Values for each grid cell are averaged to generate a single value per basin.
5. The three values per basin are combined, all equally weighted at this stage.

Scoring system: Units with the lowest scores experience the highest ecosystem degradation.

Limitations

- The dam density map used should not be construed as the spatial distribution of dams, because it reflects a probabilistic estimation of spatial patterns within each country, and excludes a very large number of small dams and other structural barriers for which global data are unavailable.
- The rate of dam construction in some regions is so high that the indicator may change faster than the ability to update the reference base.
- The inclusion of additional dams for which no data are available may alter the impact classification for a given river basin. Therefore, the indicator represents the minimum level of impact.

Alternative methods/data sources:
For VMAD data: the Global Hydrology Research Group, University of New Hampshire, USA; The Global Runoff Data Centre in Koblenz, Germany; J.D. Milliman, C.M. Rutkowski and M. Meybeck 'River Discharge to the Sea, A Global River Index (GLORI)' (LOICZ Reports & Studies No. 2., 1995); F. van der Leeden, Water resources of the world (Geraghty & Miller, Inc., New York, 1975); State Hydrological Institute, Russia and UNESCO, World Water Resources and Their Use, St. Petersburg, Russia, 1999. For dam data: World Atlas (International Journal on Hydropower and Dams); International Rivers Network (IRN). WRI's Rivers at Risk from dams planned and under construction database – compiled from multiple sources.

3. *Fish Threat*

Rationale:

Fish are a major source of protein and micronutrients for a large part of the world's population. Inland fisheries in rivers, lakes, and wetlands are an important source of this protein because almost the entire catch gets consumed directly by people, i.e. there is practically no by-catch or 'trash' fish in inland fisheries (Revenga, *et al.*, 2000). In addition to loss of fish habitat and environmental degradation, the principal factors threatening inland fisheries are fishing pressure and non-native species. Overfishing is a pervasive stress in rivers worldwide due to intensive, size-selective harvesting for commerce, subsistence, and recreation (Vörösmarty, *et al.*, 2010). More commonly, non-native species introductions may result from species being released for hunting or biological control as well as to form part of fish catches. Invasive alien species threaten native species as direct predators or competitors, as vectors of disease, by modifying the habitat, or altering native species dynamics (UNDESA 2007).

Interlinkages with other water systems:

Lakes (as fish are free to move along rivers, fishing or introductions in one river basin area can have consequences for species diversity and composition of lakes in other basin areas).

Definition:

Fishing pressure is deemed more important than absolute catches because the impact on river ecosystems depends upon the catch relative to the production of fish. Any non-native species introduced outside its normal distribution whose establishment and spread modifies ecosystems, habitats, or species is defined as invasive alien species. Although humans have been responsible for species introductions to new areas for thousands of years, the number of such introductions has increased greatly with improvements in transport and the globalisation of trade. Most introductions fail, but those that do establish themselves as invasive alien species can have a major impact on native biodiversity.

Units: unitless (estimated fish harvest relative to expected fish productivity and non-native richness)

Metrics

- Average annual catches of inland and diadromous fishes – 1997-2006 data computed by River Threat in 2010 at 30 min. grid from FAO FishStat Plus data set by means of empirical relationship between fish catch and discharge
- Estimated potential fish production – terrestrial net primary production (NPP) data computed by River Threat in 2010 at 30 min. grid from Foley, *et al.* (1996) and Kucharik, *et al.* (2000)
- Proportion of non-native fishes – data computed by River Threat in 2010 at 30 min. grid from LePrieur, *et al.* (2008), based on extensive literature survey of native and non-native freshwater fish species check lists, presented on a 0.5° unit grid.

Computation:

1. Fishing pressure in basin has already been calculated as the spatial distribution of estimated fish harvest relative to expected fish productivity; documented fish catches from very large lakes (Baikal, Michigan, Erie, Superior, Ontario, Huron, Tanganyika, Malawi and Victoria) have been subtracted to focus on riverine fisheries.
2. The percentage of non-native fishes in basins has already been calculated as the ratio of non-native species richness over total species richness.
3. Values for each grid cell are averaged to generate a single value per basin.
4. The two values per basin are combined, all equally weighted at this stage.

Scoring system: Units with the lowest scores experience the highest fish threat.

Limitations

- The indicator assumes that terrestrial primary productivity either directly supports fish production or serves as an adequate proxy for the aquatic primary production that supports fish.
- Annual catch for each grid cell has been based on estimated fish catches from rivers. However, historical trends in fisheries statistics are normally available only for a few well-studied rivers, and because of the multispecies composition of the catch in most inland water bodies, particularly in developing countries, assessments on the condition of the resources are hard to carry out.
- The negative impacts of non-native species on aquatic ecosystems are a function of both the absolute number of non-native species and the proportion of fauna represented by non-native species. Here, only number is considered. Moreover, these data cover 1 055 basins which amount to 80 per cent of global land area.

Alternative methods/data sources:

Other GIS data of inland fisheries by country has been made available by the Pilot Analysis of Global Ecosystems (PAGE) freshwater maps by the World Resources Institute (WRI). Data from various sources exist for transboundary river basins such as the Danube, Rhine, Missouri, Great Lakes, Illinois, Pearl/Xi Jiang, Lake Victoria, Colorado, and Aral Sea. However, all studies looked at either changes in species composition or changes in commercial landings of important inland fisheries.

Governance

1. Governance Architecture

Several steps are required to determine the governance architecture in place for a particular water system (Table 1). The whole architecture is greater than the sum of its parts, especially for integration of governance at the transboundary level. This process summarised in Table 1 will provide a picture of: the extent to which governance issues are covered (and allow identification of gaps); the match between governance arrangements and issues; the extent to which arrangements extend outside the system; the extent to which issues are covered by multiple arrangements that could result in conflict; and how well arrangements are clustered to make best use of existing institutions and organizations.

Table 1. Steps required to assess governance architecture in a system to be governed

STEP	KEY POINTS
1. Identify system to be governed	Basin boundaries should be consistent with the rest of the River Basins TWAP assessment.
2. Identify issues to be governed	IW systems are likely to involve a variety of governance issues. For the purpose of this assessment, five major categories have been identified which are likely to be global in nature and cut across several of the IW systems. It is expected that all arrangement-level issues will fit into these categories to facilitate comparison within and among IW systems. The categories are: 1) water withdrawals, 2) water allocation, 2) water quality, 3) fisheries, 4) biodiversity, and 5) habitat. In some IW systems the issues will have been identified through a TDA and may have been further explored through CCA.
3. Identify arrangements for each issue	Determine the extent to which each issue is covered by an identifiable arrangement, whether formal or informal. The completeness of each arrangement will be assessed in three modes: (1) The meta-mode (articulation of principles, visions and goals; (2) the institutional mode (agreed ways of doing things reflected in plans and organizations; and, (3) the operational mode if it is to be adaptive and effective. These modes may operate at different scales within the same arrangement, hence the need for linkages within arrangements.
4. Identify clustering of arrangements within institutions	Examine the way that arrangements are clustered for operational purposes and/or share common institutions/organizations at different levels. Similar issues may be covered by similar arrangements. There may be efficiency in clustering these arrangements. Alternatively, clustering may occur at higher levels for policy setting or institutional efficiency, but be separated at lower levels.
5. Identify linkages	Identify actual and desirable linkages within and among arrangements and clusters.

The Level 1 assessment can be undertaken with steps one to three only. Steps four and five are optional and may need further development. The above process will be used to reduce the governance architecture for each system to a set of scores (Table 2). These will be derived from separate assessments of the issue-specific arrangements as shown in Table 3. The approaches to evaluating the arrangements may vary among systems and arrangements ranging from being based on highly expert judgment to being based on extensive analysis of multilateral agreements, protocols, institutional constitutions and other instruments, supported by sound science and knowledge of stakeholder opinion. This allows for considerable flexibility in approach within each system, but will also mean that the final summaries for the systems will be based on widely ranging degrees of analysis. For this reason it is important that there is provision in the system for extensive annotation in foot or endnotes, so that the user can understand what went into each analysis. The arrangements for clustering and linkages will be reflected in a matrix showing interactions between arrangements. Further development of this aspect of the assessment is expected to be the subject of a workshop to be held at Dalhousie University in March 2011.

It should be noted that while the conceptual basis for this methodology is well accepted, the methodology itself is being developed for this purpose and has not been previously used or tested. Therefore, its application will be exploratory and its further development with respect to both purposes above should be an integral part of its application.

Table 2: GEF IW transboundary system governance architecture - System summary.[1]

IW SYSTEM:				**TOTAL NUMBER OF COUNTRIES:**	**SYSTEM NAME:**		**REGION:**
Transboundary issue[2]		Number of countries[3]	Priority for countries[4]	Descriptive or commonly used name for the governance arrangement[5]	Completeness of governance arrangement[6]	Priority for intervention to improve governance[7]	Observations[8]
1							
2							
3							
..n							
Governance architecture indicator[9]							

1 This page provides an overview of all the arrangements in the system and their status.

2 There is the question of how far down in detail these should go. This can be a matter of choice, and is part of the flexibility of the system, but it should ideally be to the level where the transboundary issue requires a separate arrangement for management. To use a fishery example, individual species or groups of species may each require their own assessment and measures, but may all be handled in one institutional arrangement. However, for geopolitical reasons some species or groups of species may require separate processes and should be treated as separate issues needing separate arrangements. Ideally, these issues should be identified and quantified in a TDA. If not, experts knowledgeable about the system may have to identify them.

3 Indicates how many of the total number of countries are involved in the particular issue.

4 This should be based on the TDA but may have to be based on expert judgement. To be scored from 0-3.

5 Ideally this would be the name used by the participants in the arrangement.

6 The score given in this column will be derived from the scores allocated on the arrangement-specific page. This would preferably be a mathematical derivation weighted by the importance of the functions there, but could be an overall expert assessment based on what is there.

7 This would be a combination of the national priority for the issue and its status (possibly weighted by some country statistic).

8 This provides the opportunity for brief comments that may help the user interpret the information provided on the summary page, but is not intended to be a substitute for annotation.

9 Weighted average based on priority?

Table 3: GEF IW transboundary system governance architecture - Arrangement summary.

ARRANGEMENT:		**ISSUE:**			
Governance function[1]	Responsible organization or body[2]	Scale level or levels[3]	Completeness[4]	Priority for attention[5]	Observations[6]
Meta level - preparation of policy advice					
Meta level - Policy setting or decision-making					
Policy cycle - preparation of management advice					
Policy cycle - Management decision-making					
Policy cycle - Implementation					
Policy cycle - Review of implementation at strategic and operational levels					
Policy cycle - Provision of data and information					
Total[7]					

1 This column list the governance functions that are considered to be necessary at two levels (a) the policy setting level and (2) the policy cycle level.

2 Organization(s) responsible for the function should be listed here.

3 These are the institutional scale level or levels at which the function is performed.

4 Rate on a scale of 0 = absent, 1 = low (*ad hoc*, irregular, unsupported by formal documentation or little known by stakeholders), 2 = medium, 3 = high (clearly identifiable, regular, documented or supported by policy and legislation and widely known among stakeholders).

5 This is aimed at establishing where within system assessment to intervene rather than at contributing to the global comparative assessment.

6 This provides the opportunity for brief comments that may help the user interpret the information provided, but is not intended to be a substitute for annotation.

7 Assume each step is equally important and receives equal weighting?

2. *River basin resilience*

Rationale: Historically, conflicts over transboundary waters have been more frequent in regions characterized by high inter-annual hydrological variability (De Stefano, *et al.,* 2010). Under climate change, this variability is likely to increase. The level of institutional and regulatory capacity of a basin is critical to defining its resilience or vulnerability to climate change-induced water variability. This indicator assesses this capacity against the risk of variability. The results also indicate the potential for transboundary conflict within the basin, with low scores indicating greater potential for conflict.

Interlinkages: GW (indication of the likelihood of sustainable abstraction levels from aquifers), Lakes (results likely to be similar for lakes overlapping with transboundary river basins), LMEs (may be overlap of jurisdictions between river basins and LMEs)

Definition: Combination of vulnerability level according to regulatory and institutional capacity, and hazard level according to hydrological variability.

Units: Unitless – results stated in risk categories

Metrics:

- Categorisation of international water treaties – 2010 data calculated in 2010 by Oregon State University (De Stefano, *et al.*, 2010). Based on 747 country-basin units from 276 transboundary river basins.
- Identification of existence of river basin organization (RBO) – 2010 data published in 2010 by Oregon State University.
- Water variability hazard factors – described by OSU in 2010 from a hydrological model (CLIRUN II) linked results from the GCMs. Based on 'high', 'medium', and 'low'.

Computation:

1. Treaty/RBO score based on the following:

Treaty/RBO component	Possible value
At least one water treaty	0/1
At least one treaty with an allocation mechanism	0/1
At least one treaty with a variability management mechanism	0/1
At least one treaty with a conflict resolution mechanism	0/1
At least one river basin organization	0/1
Total possible value for a country-basin unit	**0 to 5**

2. Assign resilience scores for each CBU as follows:

Treaty/RBO value	Resilience score
0	1
1, 2, 3	2
4, 5	3

3. Assign the variability hazard factors for each CBU the following scores. These are lower than the resilience scores as resilience is considered more important than hydrological variability.

Hazard factor	Multiplication factor
High	0.5
Medium	1
Low	1.5

4. Sum '2' and '3' to give a vulnerability score for each CBU.
5. Calculate the proportion of the following parameters within each CBU compared to the basin: population, area, irrigation area, and runoff. Average these four values to derive a relative 'importance' weighting for each CBU within the basin. These should add up to 1.
6. Multiply '4' by '5' to get a weighted score for each CBU.
7. Add these scores to obtain a total score for the basin.

Scoring system: Basins with lower scores have lower levels of resilience to hydrological water variability.

Limitations

- The Treaty/RBO score may not take into account the age and relevance of the treaty.

Alternative approaches:

- The extent to which the hydrological variability is considered as part of this indicator may be discussed with partners during the FSP.

3. *Water legislation*

Rationale: Both the above indicators (governance architecture and basin resilience) focus on governance at the transboundary scale. It is also important to look at governance at the national scale for countries within each transboundary basin. This indicator considers the development of water resources policy and legislation in each riparian country, and the extent to which these utilise an *integrated* approach to land and water resources management.

Interlinkages: GW (indication of the likelihood of sustainable abstraction levels from aquifers), Lakes (results likely to be similar for lakes overlapping with transboundary river basins), LMEs (may be overlap of jurisdictions between river basins and LMEs)

Definition: The development of water resources policy plus water resources legislation for each country-basin unit (CBU), combined using a weighted average 'importance' of each country to the basin based on population, area, irrigation area, and runoff.

Units: Unitless

Metrics: Data for this indicator can be collected in conjunction with the 'governance architecture' indicator, and draw on the networks of TWAP FSP partners.

- Existence of national or sub-national integrated water resources management plans. These plans could be based on an IWRM, IRBM, or equivalent *integrated* land and water management approach. Some data collected in 2006 by GWP which should be updated.
- Reflection of three key components of IWRM in legislation/regulation.
  - Social equity: does domestic supply apply social criteria in the water charges?
  - Economic efficiency: are water resources clearly recognized as important for the development of the economy?
  - Environmental sustainability: is the environment considered as a sector with its own right to water?

Computation:

1. Assign scores to each CBU based on the extent to which national or sub-national integrated water resources management plans exist.

Water policy components	Score
Only initial steps taken	1
Plans in preparation	2
Plan in place	3

2. Assign scores based on if the following are *explicitly* reflected in national legislation/regulation, referring to questions above:

Water legislation components	Possible value
Social Equity	0/1
Economic Efficiency	0/1
Environmental Sustainability	0/1
Total possible value for a country-basin unit	**0 to 3**

3. Sum '1' and '2' to get a value for each CBU.
4. Calculate the proportion of the following parameters within each CBU compared to the basin: population, area, irrigation area, and runoff. Average these four values to derive a relative 'importance' weighting for each CBU within the basin. These should add up to 1.
5. Multiply '4' by '5' to get a weighted score for each CBU.
6. Add these scores to obtain a total score for the basin.

Scoring system: Basins with lower scores have lower proportions with national or sub-national integrated water resource management planning and legislation.

Limitations

- May be difficult to derive yes/no answers for the legislative components, and more definition may be required.

Alternative approaches:

-

Socioeconomics

As described in Part 3, the socioeconomic cluster consists of three indicators: economic dependency, societal well-being, and vulnerability to climate-related disasters. The underlying metrics for each indicator are presented below. The process of combining the metrics into each indicator is described in Part 3.

1. *Economic dependency*

a. GDP/Freshwater withdrawal

Rationale: Withdrawal from water systems is often related to human activities aimed at supporting /enabling production activities to sustain economic growth (Grey 2006), for example freshwater is often extracted to provide for irrigated agriculture as well as domestic and industrial needs. Understanding of how efficiently freshwater is being used in support of national and basin economies is vital in order to assess water-related stress of various kinds, including pressures such as lack of sufficient quantity and quality.

Possible interpretations: Water resources are a vital component to uphold all kinds of production to generate economic growth. An efficient water distribution system enables the least possible withdrawal while still providing sufficient amounts to support various production systems**.** Agriculture in particular is a dominant sector (WWAP 2009) with regard to both income and water usage in many countries. Thus a relationship between GDP and freshwater withdrawal where GDP values are high and withdrawal rates are low points towards efficient water use that is less likely to impact negatively on human and natural systems alike while still providing a basis for strong economic development.

Interlinkages with other water systems: Water consumption associated with economic activities that underpin growth and contribute to GDP may be associated with impacts on water resources and an upstream-downstream complex of problems. Outtakes from a river system in terms of quantity will impact linked water systems as a result of less water flowing into connected systems. Water consumption for production activities could also give rise to other negative impacts (Barua 2009) associated with consequences of production such as harmful discharges and altered sedimentation levels.

Definition: The indicator combines Gross Domestic Product (GDP)/capita/total withdrawals. GDP defined as: private consumption+ gross investment+ government spending+ exports-imports (World Bank 2010).

Units: (GDP/capita)/ km^3

Metrics

- GDP per unit area, calculated in 2005 by CIESIN based on a 2.5 minute grid, based on World Development Indicators (World Bank, 2000). It would be preferable to update these to the latest GDP data available (probably 2010).
- Population data, calculated in 2004 by CIESIN with the Gridded Population of the World (GPW) version 3. Could use 2010 estimate.
- Freshwater withdrawal per unit area, calculated by Kassel University in 2003 on a 2000 baseline using the WaterGAP 2 model based on 30 min. grid, incorporating domestic, industrial and irrigation demands (Alcamo, *et al.,* 2003). It would be preferable to update this data based on most recent data available (probably 2010). If possible, the groundwater component of freshwater withdrawals could be removed, thereby including only surface water withdrawals in the indicator.

Computation:

1. Divide GDP (US$) by population to obtain GDP per capita for each grid cell.
2. Divide '1' by total freshwater withdrawal (km^3) for each grid cell.
3. Average grid cell values to obtain an average basin value.

Scoring system: Lower scores are likely to have higher economic dependency on water withdrawals. The most at-risk basins would have a low GDP and high water withdrawal.
Limitations • This indicator requires further analysis to determine if the results delivered are useful for the prioritisation purposes of TWAP. • A basin with a high GDP and high water withdrawal may receive a similar score as a basin with a low GDP and low water withdrawal. Whilst these address slightly different issues, both may be important but require closer analysis. The average GDP per basin is provided in the River Basin Factsheet. Comparison with the societal well-being cluster may provide an indication of the likely level of development in a basin. • The available data source does not enable total separation of river systems from other freshwater systems i.e. lakes.
Alternative approaches: • CUNY is an alternative partner to Kassel/Frankfurt Universities for water withdrawals. • FAOs Aquastat database also has information on water withdrawals by country, which could be used either as data or as validation of approach. • Oak Ridge National Laboratory (2008). LANDSCAN 2007 Global Population Data set could be an alternative to CIESIN data sets. This applies for all indicators where population is required.

b. Ratio of agricultural GDP to total GDP

Rationale:

Agriculture is globally the sector that consumes by far the most freshwater. Water is of key importance to sustain irrigation schemes that in many cases provide substantial contributions to national or basin economies. In order to understand environmental impacts related to water withdrawal for agriculture, it is important to understand the agricultural contribution to national or basin economies.

Interlinkages with other water systems:

Basins with high GDPs derived from the agriculture sector can be assumed to be large freshwater consumers thus generating losses throughout the water system.

Definition: The proportion of agricultural GDP to total GDP for a basin.

Units: Proportion (agricultural GDP/total GDP)

Metrics

- Agricultural GDP for each riparian country – available at World Development Indicators (World Bank 2010). In this source 'agriculture' corresponds to International Standard Industrial Classification (ISIC) divisions 1-5 and includes agriculture (crops & livestock), forestry and fishing. It may be possible to extract data for crops and livestock only, but this was not verified at the time of writing. Value added is the net output of a sector after adding all outputs and subtracting intermediate inputs. It is calculated without deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3.
- Agricultural area for each riparian country – calculated by Kassel/Frankfurt Universities
- Agricultural area for each country-basin unit (CBU) – calculated by Kassel/Frankfurt Universities
- GDP per unit area, calculated in 2005 by CIESIN based on a 2.5 minute grid, based on World Development Indicators (World Bank, 2000). It would be preferable to update these to latest GDP data available (probably 2010).

Computation:

1. Divide the agricultural GDP for each riparian country by the agricultural land area to obtain a value of $/km^2.
2. Multiply '1' by area of agricultural land in each CBU to obtain a value of agricultural GDP per CBU.
3. Repeat '1' and '2' for each CBU.
4. Add totals for all CBUs to give a total agricultural GDP for the basin.
5. Calculate the total GDP for each CBU, and sum each CBU to get a total GDP for each basin.
6. Divide '4' by '5' to give a proportion of agricultural GDP to total GDP for the basin.

Scoring system:

Basins with high scores would have a high level of economic dependence on agriculture, and thus a greater dependence on the water resources and a higher level of vulnerability to pressures on these resources.

Limitations

- Assumes the ratio of agricultural GDP per unit of agricultural land is uniform across each riparian country.
- Does not account for water use efficiency in the agricultural sector,
- Ideally, the indicator would take more consideration of irrigation withdrawals. This may be explored further in the FSP.

Alternative approaches:

- Alternatives sources for agricultural areas include CUNY (gridded), IWMI (gridded), and FAO (country based).
- An alternative approach could be to investigate GDP per agricultural water withdrawals in each basin, similar to the GDP per total water withdrawals indicator.

c. Ratio of fish catch GDP to total GDP

Rationale:
The fishery sector is in many cases a substantial contributor to national and basin economies. This is in many cases a source for additional pressure within river basins. Overfishing in order to sustain economic benefits is common and risks affecting delicate balances within eco-systems as species decrease in stock or potentially disappear. As part of the economic dependence cluster, this indicator deals with commercial catches only, and not subsistence catches.

Interlinkages with other water systems:
The reduction of species and fish stock might alter nutrient balances between water systems or give room to invasive species. Livelihood opportunities for humans as well as feeding and breeding opportunities for various species risk being altered by reduced migration between water systems.

Definition:

- Fish catch GDP / total GDP

Units: Proportion (fish catch GDP/total GDP)

Metrics

- Total inland fish catch by riparian country – available from FAOs FishStat Plus database.
- Total GDP from fish catch only (not including post-harvest GDP) by riparian country – computed in 2010 in a joint World Bank/FAO/WorldFish Centre project (World Bank, *et al.*, 2010).
- Fish catch per country-basin unit (CBU) - calculated by CUNY in 2010 on a 30 minute grid from FishStat Plus, based on average annual catches of inland fishes from 1997-2006 by grid cell (Vörösmarty, *et al.*, 2010)
- GDP per unit area, calculated in 2005 by CIESIN based on a 2.5 minute grid, based on World Development Indicators (World Bank, 2000). It would be preferable to update these to latest GDP data available (probably 2010).

Computation:

1. Divide the inland fish catch GDP for each riparian country by the total inland national fish catch to obtain a value of $/tonnes.
2. Determine total fish catch in each country-basin unit (CBU)
3. Multiply '1' by '2' to obtain a value of fisheries GDP per CBU.
4. Repeat steps '1' to '3' for each CBU.
5. Add totals for all CBUs to give a total fish catch GDP for the basin.
6. Calculate the total GDP for each CBU, and sum each CBU to get a total GDP for each basin.

Scoring system:
Basins with high scores would have a high level of economic dependence on fisheries, and thus a greater dependence on the water resources and a higher level of vulnerability to pressures on these resources.

Limitations

- Assumes the ratio of fish catch GDP per tonne of fish catch is uniform across each riparian country.
- The study on which 'national fish catch GDP' is based has some limitations in up-scaling, but it was the most up-to-date global report at the time of writing (World Bank, *et al.*, 2010).
- Although CUNY and FishStat Plus include aquaculture, the World Bank study does not.

Alternative approaches:

- Post-harvest GDP could also be measured, but care must be taken not to double-count benefits within the industry sector.
- An alternative approach would be to investigate GDP per tonne of fish catch in each basin, similar to the GDP per total water withdrawals indicator.

d. Ratio of energy-related GDP to total GDP

Rationale:
Energy production is crucial to development, and energy production generally requires significant amounts of reliable water supply. Thus basins highly reliant on water- related energy production may be more vulnerable to pressures.

Interlinkages with other water systems:
Water withdrawal/ diversion (to lesser or larger extent) for electricity consumption impacts water flows to linked water systems. Fragmentation of river systems to facilitate power generation can affect chemical composition, oxygen levels, sediment levels of released water to downstream areas and linked water systems, and affect migration patterns for various species.

Definition: Energy-related GDP divided by total GDP for the basin, based on per capita averages.

Units: proportion (Energy-related GDP / total GDP)

Metrics

- Energy consumption per capita for each riparian country – national data from US Energy Information Administration (EIA)
- GDP per unit of energy consumption for each riparian country – national data available from World Development Indicators (World Bank, 2010)
- Population in each country basin

Computation

1. Multiply the energy consumption per capita by the GDP per energy consumption to obtain energy-related GDP per capita for each riparian country.
2. Multiply the number of people in each country-basin unit (CBU) by '1' to get the energy-related GDP per CBU.
3. Add totals for all CBUs to give a total energy-related GDP for the basin.

Scoring system:
Basins with high scores would have a high level of economic dependence on energy production, and thus a greater dependence on the water resources and a higher level of vulnerability to pressures on these resources.

Limitations

- Assumes the ratios of energy consumption per capita and GDP per energy unit consumed are uniform across each riparian country.
- Does not take into account differences in water withdrawal and consumption for different energy production types.

Alternative approaches

- Could base the indicator on *electricity generation* rather than *energy consumption*, but at the time of writing more explicit data was found on GDP per energy consumption than on GDP per energy production.
- An alternative approach could be to investigate water withdrawals per unit of electricity produced, or GDP per unit of water withdrawal for electricity. The WaterGAP 2 model has been used to identify water withdrawals for energy, converting national data to grid cell-based data.

2. *Societal well-being*

a. Access to improved drinking-water supply

Rationale:
Access to improved drinking-water supply will indicate the efficiency of the basin's water governance structure. It will also be an indication of the population health as the lack of improved drinking-water often lead to an increase in water-related diseases, such as cholera and diarrhoea.[1] Access to improved drinking-water can also provide economic benefits if less time is spent on securing household water supply. Access to improved water supply is of high global importance, as manifested by the global community in the Millennium Development Goal 7.

Interlinkages with other water systems:
The governance systems for improved drinking-water supply are not limited to river basins, but follow administrative borders. The indicator can therefore be relevant for other water systems within the same administrative borders.

Definition:
Proportion of population using an improved drinking-water source. Improved drinking-water sources include; piped water into dwellings, piped water to yards/plots, public taps or standpipes, tubewells or boreholes, protected dug wells, protected springs, rainwater. (Definition for improved drinking water is taken from the JMP, and further information can be found at http://www.wssinfo.org/definitions/infrastructure.html)

Units: % of population with access to improved drinking water.

Data:
Proportion of rural population with access to improved drinking water – available on country level from the Joint Monitoring Programme, latest update 2008.
Proportion of urban population with access improved drinking water – available on country level from the Joint Monitoring Programme, latest update 2008.
Proportion of total population with access improved drinking water – available on country level from the Joint Monitoring Programme, latest update 2008.

For basin level calculations:
Population data and land-use data (urban-rural) – Socioeconomic data and application centre (SEDAC) at CIESIN, Columbia University. Gridded data is available for population density. The latest updated data is from 2005. The ongoing Global Rural-Urban Mapping Project (GRUMP) will be able to distinguish population spatially by urban and rural areas.

Computation:
Overlay of grid-based land-use maps and population maps to get proportion of urban population. Calculate basin average using the rural and urban national figures according to the percentage of urban population in the basin per country. Aggregate to basin level based on size of population in each country.

Scoring system:
Units with the lowest % have the lowest access to improved drinking water.

Limitations:
Data is only available at country level. Difficulties can arise when determining the proportion of urban population in the basin without access to data available at country level. JMP data is based on national statistics to a large degree and definitions of improved drinking-water sources as well as urban areas can differ between countries. The definition of urban areas can also differ from the gridded data modelled at SEDAC.

Alternative methods/data sources:
The Transboundary Freshwater Data Base at Oregon State University contains data for populations with water access and sewage access from 2000 in North and South America. This data is available on basin level.

b. Access to improved sanitation

Rationale:
Access to improved sanitation will be an indication of population health as the lack of improved sanitation often lead to an increase in water-related diseases, such as cholera and diarrhoea.[1] There are also economic aspects to consider as the diseases related to poor sanitation prevent people from working. Access to improved sanitation is of high global importance, as manifested by the global community in the Millennium Development Goal 7.

Interlinkages with other water systems:
The governance systems for improved sanitation are not limited to river basins, but follow administrative borders. The indicator can therefore be relevant for other water systems within the same administrative borders.

Definition:
Proportion of population using improved sanitation facilities. Improved sanitation includes flush toilets, piped sewer systems, septic tanks, flush/pour flush to pit latrines, ventilated improved pit latrines, pit latrines with slab, composting toilets. (Definition for improved sanitation is taken from the JMP, and further information can be found at http://www.wssinfo.org/definitions/infrastructure.html)

Units: % of population with access to improved sanitation.

Data:
Proportion of rural population with access to improved sanitation – available on country level from the Joint Monitoring Programme, latest update 2008.
Proportion of urban population with access to improved sanitation – available on country level from the Joint Monitoring Programme, latest update 2008.
Proportion of total population with access to improved sanitation – available on country level from the Joint Monitoring Programme, latest update 2008.

For basin level calculations:
Population data and land-use data (urban-rural) – Socioeconomic data and application centre (SEDAC) at CIESIN, Columbia University. Gridded data is available for population density. The latest updated data is from 2005. The ongoing Global Rural-Urban Mapping Project (GRUMP) will be able to distinguish population spatially by urban and rural areas.

Computation:
Overlay of grid-based land-use maps and population maps to get proportion of urban population. Calculate basin average using the rural and urban national figures according to the percentage of urban population in the basin per country. Aggregate to basin level based on size of population in each country.

Scoring system:
Units with the lowest % have the lowest access to improved sanitation.

Limitations:
Data is only available at country level. Difficulties can arise when determining the proportion of the urban population in the basin without access to data available at country level. JMP data is based to a large degree on national statistics and definitions of improved sanitation as well as urban areas can differ between countries. The definition of urban areas can also differ from the gridded data modelled at SEDAC.

Alternative methods/data sources:
The Transboundary Freshwater Data Base at Oregon State University contains data for population with water access and sewage access from 2000 in North and South America. This data is available at basin level.

c. Adult literacy

Rationale: Adult literacy will indicate the level of education in the basin and provide an indication of the knowledge capacity to deal with issues in the basin. An educated population can more easily take on the development challenges it faces, such as ensuring environmental sustainability, increasing productivity and empowering women and creating gender equality.
Interlinkages with other water systems: Adult literacy is dependent on the level of education available and this follows administrative borders. The indicator can therefore be relevant for other water systems within the same administrative borders.
Definition: Proportion of population aged 15 or above that can both read and write a short simple statement on their everyday life. The definition is taken from the HDR indicator on adult literacy.
Units: % of population aged 15 or above that can read and write.
Data: Data is collected by the UNDP's Human Development Report on a regular basis. The latest data is from 2007. All data is collected at national level. Population density data (urban-rural) – Socioeconomic data and application centre (SEDAC) at CIESIN, Columbia University. Gridded data is available for population density. The latest updated data is from 2005.
Computation: Aggregate to basin level based on the size of population per country.
Scoring system: Units with the lowest % have the lowest levels of adult literacy.
Limitations: Data is only available at country level. When using HDR data an assumption must be made that the literacy rate in the basin is the same as the national average.
Alternative methods/data sources:

d. Life expectancy

Rationale: Life expectancy is an indication of the level of several functions and patterns in society. A higher life expectancy is an indication of a society where the population has access to nutritious food and healthcare. This enables people to be work longer and therefore also has an economic benefit.
Interlinkages with other water systems: Life expectancy is one of many parameters related to the health care service available to the population and this follows administrative borders. The indicator can therefore be relevant for other water systems within the same administrative borders.
Definition: The number of years a newborn infant could expect to live if prevailing patterns of age-specific mortality rates at the time of birth were to stay the same throughout the child's life. (Definition taken from HDR indicator.
Units: Number of years a child is expected to live at the time of birth.
Data: Data is collected by the UNDP's Human Development Report on a regular basis. The latest data is from 2007. All data is collected at national level. Population density data (urban-rural) – Socioeconomic data and application centre (SEDAC) at CIESIN, Columbia University. Gridded data is available for population density. The latest updated data is from 2005.
Computation: Aggregate to basin level based on the size of population per country.
Scoring system: Units with the lowest value have the lowest life expectancy.
Limitations: Data is only available at country level. When using HDR data an assumption must be made that the life expectancy in the basin is the same as the national average.
Alternative methods/data sources:

e. Economic disparity – Gini Index

Rationale:
The level of inequality in a basin is an important dimension of welfare, and indicates likely levels of participation in governance, representation in public authorities, and capacity for sound environmental management where conflict may occur between welfare needs and environmental concerns. Gross inequality may lead to social or political unrest, which puts at risk efforts to create healthy, educated societies resilient to pressures on their water resources.

Interlinkages with other water systems:
The potential impacts related to economic inequalities within political units effect water systems with little differentiation with regard to type of water system. Thus the problems related to poor wealth distribution will potentially add to existing problems within basins and existing linkages between water systems.

Definition:
The *Gini index* is an estimate of inequality. It measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution. A Gini index score of zero implies perfect equality while a score of 100 implies perfect inequality (*World Development Indicators Online. World Bank, 2009)*

Units: Unitless

Metrics

- Gini coefficient for each riparian country – calculated by UNDP
- Population per unit area, CIESIN

Computation:

1. Aggregate national GINI values to the basin level based on a weighted average by population in each country-basin unit (CBU)
2. Take the inverse of the scores (100 minus score) to give low scores high risk.

Scoring system:
Low scores indicate high income disparities in a basin.

Limitations:

- By averaging the GINI coefficients from each CBU, this is likely to reduce the differences between CBUs, potentially portraying a more positive picture than reality.

Alternative approaches:

- If data is available at the country-basin unit (CBU) level, it may be possible to calculate the basin GINI coefficient in the same way as country Gini coefficients (deviation from even distribution).

3. *Vulnerability to climate-related natural disasters*

Rationale:
Floods and droughts cause the greatest loss of life and economic losses of all natural disasters each year, and the likelihood and severity of floods and droughts is likely to increase with climate change. Impacts of floods and droughts are felt by humans and ecosystems, and include impacts on food security, damage to infrastructure, and displacement of people. A global analysis has already been undertaken by CIESIN in 2005 (Dilley, *et al.*, 2005), though would benefit from updating and modifying for the purposes of TWAP.

Interlinkages:
Hydrological variability induced by climate change will affect flow patterns in river systems. The risk of droughts and floods will increase, affecting both quantity and quality of water being transported through water systems. Potential human efforts to mitigate climate change effects by constructions on river systems will probably further impact downstream areas.

Definition:
A combination of drought- and flood-related risks of mortality and economic losses (as a proportion of GDP). Risk is based on a given hazard, and a spatially variable vulnerability map.

Units: Unitless

Metrics:

- Drought hazard – calculated by CIESIN in 2005 on a 2.5 degree grid, based on average data from 1980 – 2000. The method uses the Weighted Anomaly of Standardized Precipitation (WASP) (50% below normal precipitation for a 3-month period), from the IRI Climate Data Library. Deserts and dry seasons are excluded from the analysis.
- Flood hazard – calculated by CIESIN in 2005 on a 1 degree grid based on data from 1985 – 2003. The method uses a database of geo-referenced extreme flood events from the Dartmouth Flood Observatory.
- Mortality-related vulnerability coefficients – calculated by CIESIN in 2005.
- Economic loss-related vulnerability coefficients - calculated by CIESIN in 2005.
- GDP per Unit area, CIESIN
- Gridded Population of the World (GPW), CIESIN.

Computation:
The computation may be based on the methodology described in Dilley, *et al.* (2005). This is a complex process but involves combining hazard exposure with historical vulnerability using gridded population (disaster-related mortality risks) and GDP (risks of total economic losses) per unit area. As the risks are calculated in each grid cell, a basin average can be derived.

Scoring system:
Basins considered highly vulnerable to climate-change impacts receive low scores.

Limitations

- Data are inadequate for understanding the *absolute* levels of risk, but adequate for identifying *relative* levels of risk. This is suitable for the purposes of TWAP Level 1.

Alternative approaches:

It is worth noting that the above are proposed methodologies for the calculation of each indicator. However, methodologies may be modified, for example as a result of changes to funding or the need for coordination with other TWAP working groups. Importantly, it is believed the right mix of partners has been identified, such that methodologies can be enhanced if necessary during the FSP.

ANNEX 4
GLOSSARY OF TERMS

In addition to this glossary, please refer to the Volume 1 glossary which contains terms for TWAP common to all five groups. Additional terms specific to the River Basins methodology are explained in the text of this volume as appropriate.

Acceptability: Regarding development of indicators, 'acceptability' refers to the perceived likelihood of stakeholder 'ownership' of indicators.

Aggregation: Regarding development of indicators, 'aggregation' refers the process of aggregating data from the national to the river basin level. Aggregation is in most cases addressed through modelling.

Applicability: Regarding development of indicators, 'applicability' refers to the specific indicators relevant to transboundary issues at the global scale in the context of TWAP, including relevance to other water systems where possible.

Availability: Regarding development of indicators, 'availability' refers to data availability at the global scale, fit for the purposes of TWAP and which are cost-effective to acquire (either through direct data or modelling).

Basin resilience: Indicator that is part of the 'governance indicator group' that assesses regulatory and institutional capacity at the transboundary level.

Biodiversity: the variability among living organisms - animals, plants, their habitats and their genes - from all sources including terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part. This includes diversity within species, between species, and of ecosystems[1].

Cluster: Collection of related core indicators grouped together to address a particular overarching issue.

Core indicator: Indicators that constitute the essential pillars of the assessment. The indicators have been selected through lengthy evaluation processes.

Governance architecture: The concept refers to the existence of transboundary governance 'architectures', or arrangements, in place to address selected issues relevant to transboundary river basins. It considers the completeness of the policy cycle, from the preparation of advice, through implementation and monitoring and evaluation of impacts.

Human water stress: In this report defined as the quantity of water available per person per year, on the premise that the less water available per person, the greater the impact on human development and well-being, and the less water there is available for other sectors.

Improved drinking-water supply: An improved drinking-water source is defined as one that, by nature of its construction or through active intervention, is protected from outside contamination, in particular from contamination with faecal matter[2].

Improved sanitation: An improved sanitation facility is defined as one that hygienically separates human excreta from human contact[3].

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[1] As defined by the International Union for Conservation of Nature (IUCN)
[2] As defined by WHO / UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP)
[3] As defined by WHO / UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP)

Invasive Alien Species: Refers to animals, plants or other organisms introduced into places out of their natural range of distribution, where they become established and disperse, generating a negative impact on the local ecosystem and species[4].

Natural Disaster: Natural disasters are the consequence of natural hazards.

Natural Hazard: Natural hazards are naturally occurring physical phenomena caused by either rapid or slow onset events having atmospheric, geologic and hydrologic origins at the global, regional, national or local scale. They include earthquakes, volcanic eruptions, landslides, tsunamis, floods, tropical cyclones, and drought and desertification[5].

Nutrient pollution: Nutrient pollution is primarily caused by agricultural activities (fertiliser use and wastes from livestock) and urban wastewater. Contamination by nutrients (particularly forms of nitrogen and phosphorous) increases the risk of eutrophication (e.g. algal blooms) in rivers, which can pose a threat to environmental and human health.

Persistent Organic Pollutants: Certain chemical substances that persist in the environment, bio-accumulate through the food web, and pose a risk of causing adverse effects to human health and the environment[6].

River Basin Organization: Organization with the purpose of improving water governance and water resource management in transboundary river basins.

River basin resilience: The concept refers to the institutional and regulatory ability or capacity of a river basin to withstand changing circumstances, including climate change-induced water variability.

River fragmentation: Refers to the degree to which a river system is spatially fragmented by dams. The concept can be assessed by the longest segment of the main river channel without dams and whether dams exist in the major tributary, minor tributaries, or both.

Water legislation: Indicator that is part of the 'governance indicator group' that assess the extent to which 'modern', integrated water management is reflected in the national legislation of riparian countries.

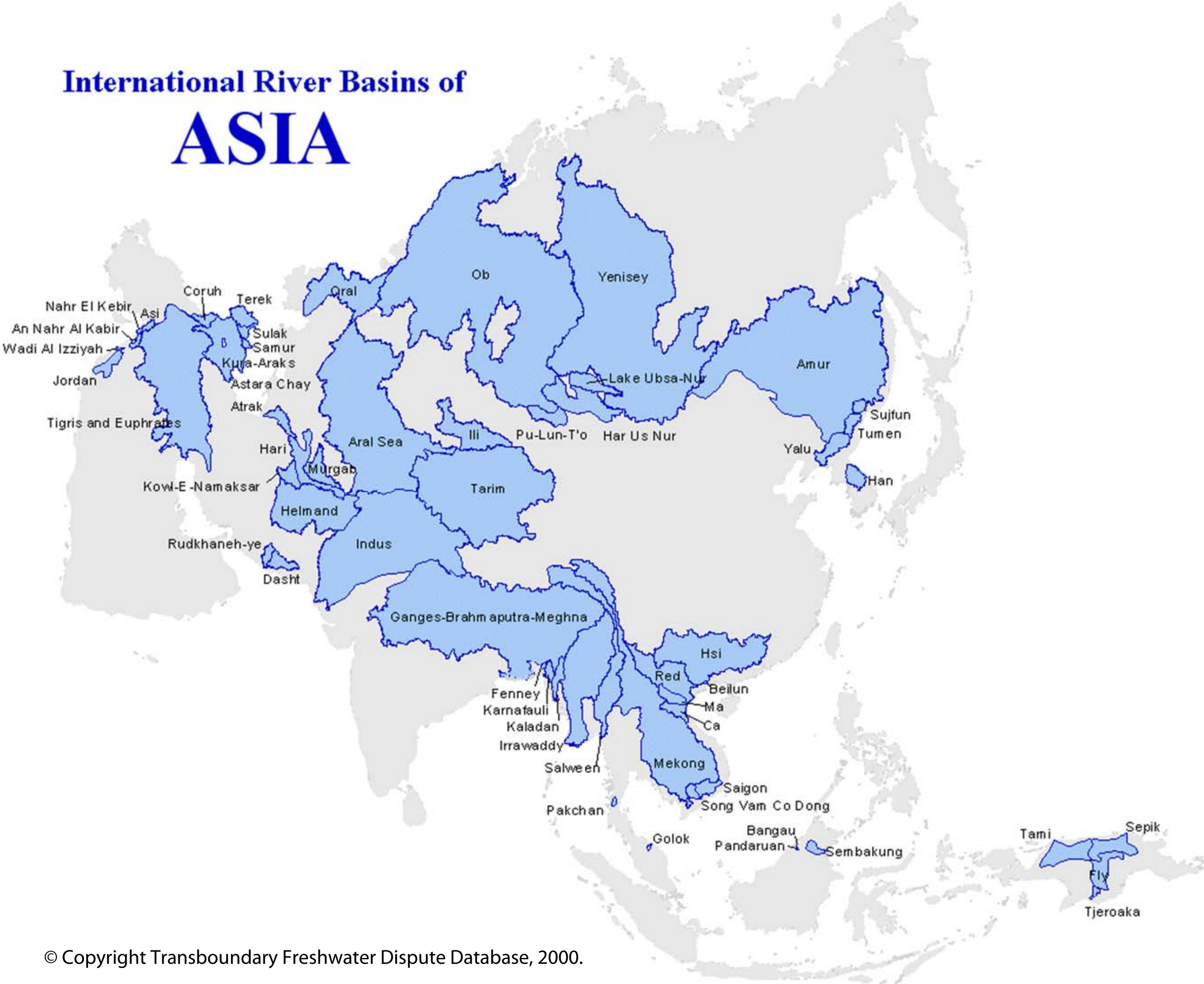
[4] As defined by United Nations Environment Program (UNEP)
[5] As defined by the United Nations Educational, Scientific and Cultural Organization (UNESCO)
[6] As defined by the International Union for Conservation of Nature (IUCN)

ANNEX 5
MAPS OF TRANSBOUNDARY RIVER BASINS BY CONTINENT

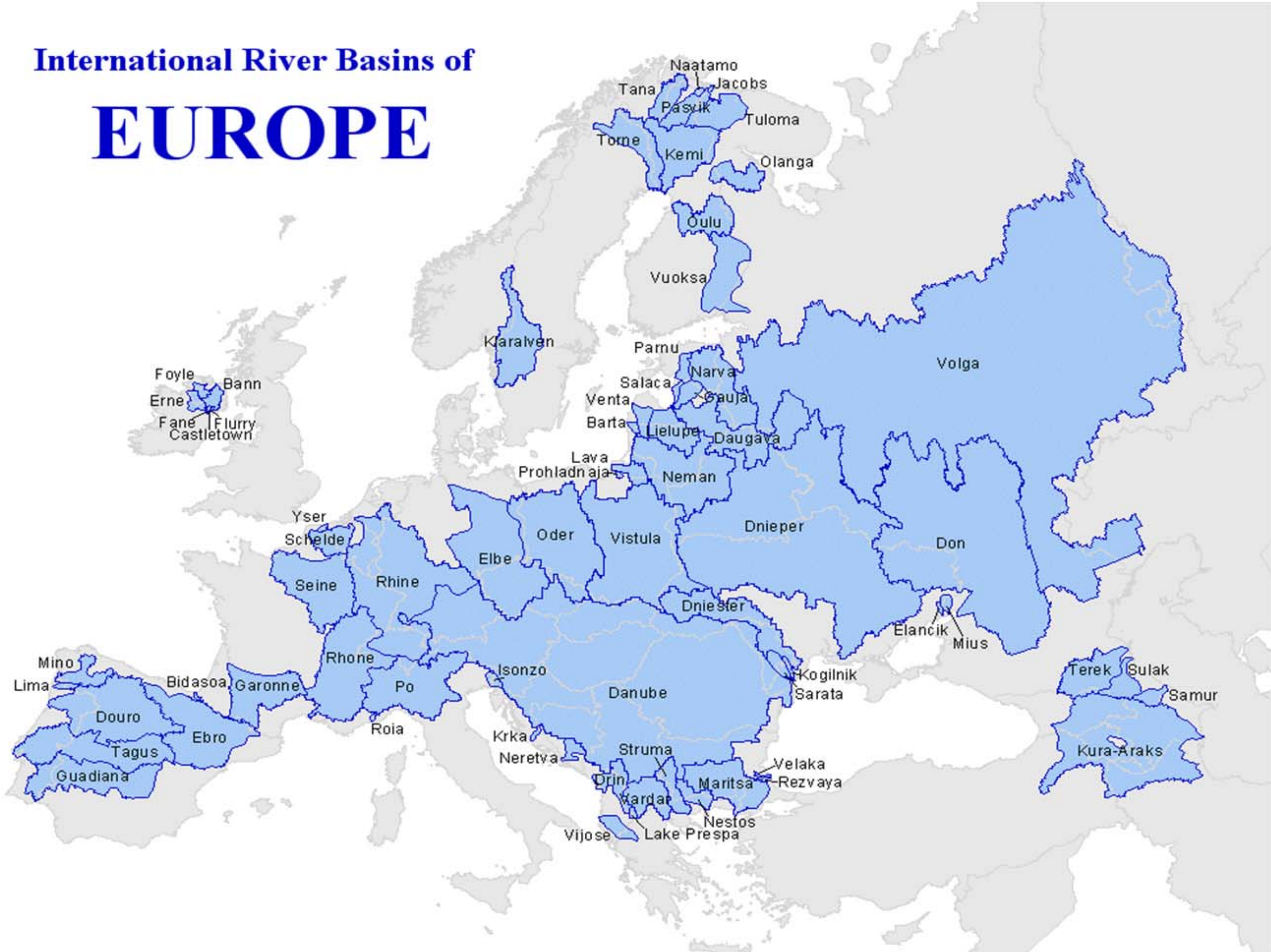
Note: these maps were produced in 2000, and are likely to have been updated, but provide an idea of the extent and total number of transboundary basins on each continent.

Africa total: 59

Asia total: 57



Europe total: 69



North America total: 40

South America total: 38

ANNEX 6
DEVELOPMENT OF ASSESSMENT FRAMEWORK

This section shows the development of the assessment framework and underlying indicators in six stages.

Stage 1

After the TWAP Inception Meeting in July 2009 a provisional list of indicators for the River Basins component of TWAP was identified based on environmental state, stress reduction, governance processes and socioeconomic variables (Table 1 extracted from the Draft Inception Report circulated September 28, 2009)

Table 1 below shows the provisional indicators for the River Basins component of TWAP, as they appeared after the TWAP Inception Meeting in July 2009.

Table 1. River Basins (provisional indicators from TWAP Inception Report, July 2009)

STATE INDICATOR	STRESS REDUCTION	PROCESS	SOCIOECONOMIC
Discharge ▪ Max, ▪ Min ▪ Average, ▪ Variability	Water Intake Regulation Water savings Climate change remediation Groundwater impact	▪ Policy and law ▪ Institutional framework ▪ Planning instruments ▪ Economic instruments ▪ Awareness and participation	▪ Population (distribution, migration, GNP/cap) ▪ Public health ▪ Food security ▪ Poverty alleviation ▪ Income generation ▪ Urbanization ▪ Industrialization ▪ Agriculture ▪ Forestry ▪ Energy ▪ Transport ▪ Tourism ▪ Recreation ▪ Human safety and resilience ▪ Private sector involvement
Pollution ▪ DO ▪ BOD ▪ Bacteria ▪ Toxics	Treatment Recycling Clean technology Mining		
Nutrients ▪ N, P	Agriculture practice ▪ Fertilizer efficiency		
Pesticides	Agriculture practice		
Sedimentation	Land use		
Flooding risk	Flood Regulation Wetlands restoration Forecasting		
Drought risk	Land use Water efficiency Agriculture practice Forecasting		
River and wetland Ecosystems assets	Water quality improvement Flood plain characteristics Fisheries Fuel and fiber harvesting Land use Invasive species Climate change remediation		

Stage 2

In an attempt to further elaborate on these indicators, they were organized more systematically according to the following aspects of environmental state: water quantity (including flow, scarcity, floods and droughts), water quality (including organic pollutants, bacteria, nutrients, toxics, and sedimentation) and ecosystem assets (including ecosystem services, wetlands, biodiversity and habitats) (Table 2).

Table 2. TWAP Indicators for River Basins Component (intermediate step)

STATE	STRESS REDUCTION	PROCESS
Discharge ▪ Max, ▪ Min ▪ Average, ▪ Variability	Water Intake [=withdrawal?] Regulation [process?] Water savings Climate change remediation Groundwater impact	
Flooding risk		Flood Regulation Wetlands restoration Forecasting
Drought risk	Land use Water efficiency Agriculture practice Forecasting	
Pollution ▪ DO ▪ BOD ▪ Bacteria ▪ Pesticides ▪ Toxics	Treatment Recycling Clean technology Mining Agriculture practice	
Nutrients ▪ N, P	Agriculture practice Fertilizer efficiency	
Sedimentation	Land use	
River and wetland Ecosystems assets	Water quality improvement Flood plain characteristics Fisheries Fuel and fiber harvesting Land use Invasive species	
		General IWRM indicators: ▪ Policy and law ▪ Institutional framework ▪ Planning instruments ▪ Economic instruments ▪ Awareness and participation

All the sub-issues so identified have high relevance in a transboundary context because of upstream-downstream considerations. For biological variables, the indicator framework covers those aspects of ecosystem integrity, function and structure that require international cooperation and management to minimize negative impacts. These impacts can result from region-wide human activities (e.g. land-use change, resource extraction, road development or watershed alteration) or threaten key ecological processes and viable populations of native species that naturally occur across geopolitical borders.

The organization of the state variables into water quantity, water quality and ecosystem assets was adopted in consideration of potential application to other TWAP components (with the exception of water quantity aspects for the marine component or ecosystem aspects for the groundwater component). The socioeconomic indicators identified at that stage were felt to be too generic as they could be found in any development report framework. Water governance (including policy, law, institutions and finance) was later added as the last group of issues instead.

Stage 3 – From states to processes

As a third step, the classification into environmental status, stress reduction and process indicators was clarified and refined following a precise requirement in the TWAP Project Document (Table 3). These typologies originate from the GEF M&E Working Paper (Duda 2002).

Table 3 . TWAP Indicators for River Basins Component (proposed revised indicator framework)

	STATE	STRESS FACTORS	(IWRM) PROCESSES
WATER QUANTITY	**Flow regime:** ▪ Average discharge ▪ Min discharge ▪ Max discharge ▪ Inter-annual variability and history ▪ Channel modification	Water withdrawal/consumption for: ▪ Irrigation ▪ Industry/energy ▪ Domestic use Canals, dams/reservoirs, barrages Glacier retreat	Infrastructure Management Water Demand Management
WATER QUANTITY	**Floods:** ▪ Flood plain areas (*gw recharge*) and frequency/residence (*fragmentation of river from flood plain*) ▪ Area/population affected by extreme floods	Degradation of wetlands and forest cover Glacial Lake Outburst Flood (GLOF) risk Climate Change	Flood regulation/control/risk assessment Wetlands restoration Forecasting, early warning, alerts Disaster Risk Reduction and response
WATER QUANTITY	**Droughts*:** ▪ Drought frequency, type, and risk ▪ Water scarcity ▪ Area/population affected	AFOLU (*Agriculture, Forestry and Other Land Uses*) Land use Agriculture/livestock practice Climate Change	Building resilience Forecasting Response measures Sustainable Land Management Water Demand Management
WATER QUALITY	**Pollution:** ▪ Organic matter ▪ Bacterial/pathogenic ▪ Pesticides/POPs ▪ Metals and poisons	Municipal wastewater Industrial/manufacturing wastewater Mining/Quarrying and Energy production Agriculture/livestock practice	Wastewater treatment Clean technology schemes Sustainable pest management Polluter Pays Principles Water Safety Plans (quality management)
WATER QUALITY	**Nutrients:** ▪ N ▪ P	Agriculture/livestock practice Point Sources	Sustainable Land Management Wetlands (buffer zone) restoration
WATER QUALITY	**Sedimentation/siltation:** ▪ Sediment transport (TSS) ▪ Siltation rate	Land use Deforestation Dams/hydropower	Infrastructure Management Sustainable Land Management

	STATE	STRESS FACTORS	(IWRM) PROCESSES
ECOSYSTEM ASSETS	**Ecosystems services:** ▪ Environmental flows (*quantity, quality, variability, flow regime understanding*) ▪ Fish stocks and aquaculture ▪ Other Provisioning services ▪ Tourism potential ▪ Cultural value	Impairment/degradation/over-exploitation (*all of the above*) Fisheries Understanding and awareness	Fisheries management Multi-level stakeholder involvement Valuation of services and PES schemes Awareness raising
ECOSYSTEM ASSETS	**Wetlands:** ▪ Fuel and fibre harvesting ▪ RAMSAR sites/condition (connectivity/fragmentation)	Drainage and Diversion	Wetlands restoration/mitigation
ECOSYSTEM ASSETS	**Biodiversity/habitats:** ▪ Endemic species ▪ Endangered species	Invasive species Land Management	Protected areas Habitat areas Biodiversity assessments
GOVERNANCE	**Legal:** ▪ Framework and Agreements/Directives/Treaties ▪ Capacity ▪ Transboundary fiduciary arrangements ▪ Rights and Obligations	Conflict and Security Development priorities	IWRM Planning Framework TDA/SAP Inter-State Dialogue and Dispute Management Information management and sharing Policy
GOVERNANCE	**Institutions:** ▪ Regulation and Monitoring ▪ Capacity ▪ Sectoral/Cross-Sectoral ▪ Transparency ▪ Basin-Border Management	Centralised/Decentralised decision making Institutional environment Education (brain drain) Stakeholder engagement	TDA/SAP Inter-Ministerial cross collaboration Water Apex Body IWRM Planning and Multi-level stakeholder consultation Stable dialogue networks Historical Cooperation
GOVERNANCE	**Investments:** ▪ Asset management/inventory ▪ Budget (loans, grants, trust funds, national revenue) ▪ Donor coordination ▪ Capacity	Development priorities Poverty and Livelihoods Donors GDP/External Economic Influence	Infrastructure Management Water Demand Management (*revenue generation*) Investment planning

It is noteworthy that this indicator typology was developed to allow adequate monitoring and evaluation of the progress and impacts of GEF IW projects and consequently the indicators are defined as *changes* (stress reduction, improved status) that can be measured *ex-post*. Even the environmental status indicators are defined as the improvements in environmental status that will follow from the stress reduction. By contrast, the explicit purpose of TWAP is to initially provide a global *baseline* that primarily can serve as a basis for *ex ante* identification of hotspots and priority areas. As such, the chosen typology had to be modified to accommodate the need for baseline indicators.

The most practical modification possible was to classify the indicators into actual environmental status (as opposed to improvement of status), environmental stress (as opposed to stress reduction) and environmental governance (broadly understood, including regulatory framework, institutional framework, structures for information exchange and stakeholder engagement, etc.[1]). The last category is quite similar to the 'process' indicators listed in the M&E Working Paper (Duda 2002) and could still be called process indicators. With this proposed modification, the TWAP indicator typology would also become more aligned and compatible with established typologies for environmental assessments. The PSR (Pressure – State – Response) framework originally developed by OECD has been widely accepted and applied. The PSR Pressure category is similar to the Stress category and the PSR Response category is compatible with the Process category.[2]

Stage 4 – From issues to indicators

The goal was to identify a core set of indicators that could support the framework in an operational and cost-effective way. Table 3 was used as a basis for further development of the draft indicator source framework. At this stage, the assessment concerns could be summarized into four major issues each including three sub-issues:

- Water quantity;
    - Flow regime, floods, droughts
- Water quality;
    - Pollution, nutrients, sedimentation/siltation
- Ecosystem assets; and
    - Ecosystem services, wetlands, biodiversity/habitats
- Water governance.
    - Water policy/law, institutions, finance.

For each issue, this process included scrutinizing stress factors and process variables against state variables, simplification to remove redundancies yet ensure that all important aspects of IWRM are represented, and development of measurable indicators out of the generic issues. Several interactions between indicators across the table were found that needed disentangling. For example, sedimentation / siltation are strongly linked to the river flow regime, water quality affects biodiversity, and wetlands are also buffer zones for floods and droughts, and may contribute to groundwater recharge (depending on parent material). In addition, the earlier classification was found particularly blurry for stress factor and process variables. These are all different aspects of IWRM and fragmenting them was somehow felt in conflict with the integration principle of IWRM. In summary, it was more challenging to identify operational indicators going from top to bottom and from left to right of Table 3 in Annex 3.

Consequently, a modified DPSIR approach has been adopted as the guiding framework, rather than an ecosystem services framework. Ecosystem services have naturally been considered at the sub-issue level under State, Pressure, and Impact/Vulnerability. It is difficult to measure ecosystem services , both direct and indirect, in practice (MA, 2005; Carpenter, *et al.,* 2009). This is especially true for ecosystem services other than provisioning (e.g. food water, fibre, fuel), which is still a challenge at different scales. In the suggested Core Indicator framework, fish catch will be used as the example of provisioning services, and also usefully implies the possible condition of the water quality (although it is recognized

[1] Water 'governance' can be interpreted in many different ways, depending on the sectoral focus. However, it is generally agreed that elements concerning participation, the legal framework and rule of law, transparency and accountability, institutions and processes make up a governance framework. How interpretation of these translates in a transboundary setting, and can be of use for monitoring and indicator development is dependent on elements concerning national and regional governance approaches, historical context, and security and sovereignty issues.

[2] The DPSIR framework (Drivers, Pressures, State, Impact, Response) is a further development of the PSR framework that has been promoted by the European Union, UNEP and others, and applied for State of the Environment assessments. Interestingly, the forthcoming WWDR-4 also operates with a distinction between drivers, pressures and impacts. At present, however, it would not be feasible to apply this framework to TWAP.

that fish catch and water quality may remain 'good', but population growth may outstrip local fish stocks).

Furthermore, all the proposed core indicators will be impacted in some way by each other, which demonstrates the feedback loops inherent in freshwater systems, affecting ecosystem processes and landscape structure. Structuring the framework in the providing, regulating, cultural and supporting services framework is understandable for lentic (slow flow) water systems which operate as drainage basins between water bodies. This allows data capture based on flows in and out of the system, and water residence time. However for lotic (fast flow) water systems such as rivers, many of which are long in length and effectively un-monitored between control points (where they exist) it is more difficult to determine the range of ecosystem services provided by the river system beyond those which can actually be measured or assumed.

Short-listing criteria

Eventually, the assessment framework generated around one hundred potential indicators, which were screened against the following SMART-like criteria[3] in order to reach a manageable set of core indicators:

- availability (i.e. cost efficiency in acquisition),
- acceptability (i.e. ownership to information among stakeholders),
- applicability (i.e. relevance to transboundary issues),
- aggregation at river basin level and comparability between basins (IGA WG 2009).

Identification and ranking of indicators can be done in a variety of ways using different criteria. The literature abounds with generic requirements for indicators and how to apply them in the context of result-based monitoring and evaluation. Every attempt has been made to avoid field collection of data due to the cost, time limitations, complexity, lead-in time for capacity building, and the challenge of developing new approaches in basins that are strongly project-orientated. Strong project focus will not necessarily lead to regular collection and monitoring of new data for further use. Furthermore, 'higher-level' indicators have been used which could encompass more detailed indicators than their 'component parts'. Ultimately, the decision to focus the indicators was based on accessibility of data.

The next step in the assessment framework, the screening of the long list from table 3, led to the core indicators presented in table 4. During this process, socioeconomic indicators were re-considered, and included as part of the framework.

[3] SMART stands for Specific, Measurable, Attainable, Realistic, and Timely.

Table 4. 28 Core indicators.

	STATE	PRESSURE	IMPACT / VULNERABILITY
Water Quantity (8)	1. Average discharge	2. Size of irrigated area of total cultivated area 3. Irrigation water withdrawal 4. Water Stress 5. Developed hydropower potential	6. Standard Precipitation Index (SPI) 7. Flood Frequency 8. Glacier Melt
Water Quality (5)	9. Water Quality Index (WQI) 10. Nutrients 11. TSS	12. Industrial Wastewater 13. Municipal Wastewater	*Please note that other indicators also cover the vulnerability of water quality, particularly those related to water quantity.*
Ecosystem Habitat & Community* (6)	14. Wetland coverage 15. Ramsar sites	16. Impoundment density 17. Invasive Species	18. Endangered species 19. Fish catch
Governance (5)	20. Pesticide Regulation Index 21. RBO 22. River Basin Plan 23. Joint monitoring programme 24. Basins-At-Risk (BAR)		
Socioeconomic (4)	25. Human Development Index (HDI) 26. GDP/Total Freshwater Withdrawal 27. Improved Water Supply & Sanitation 28. Climate Vulnerability Index (CVI)		
Total No. of Indicators = 28			

* This was changed from 'ecosystem services' as many of the indicators will affect ecosystem services.

Stage 5

The above table was presented in the River Basins report draft version 0.3 in June 2010, and shared with the GEF, the TWAP secretariat, and other working groups. Feedback from the GEF included the following:

- 28 indicators were too many, and too complicated to interpret.
- The framework should include *current* status indicators (approximately 8), and *projected* stress indicators (approximately 5).
- A recommendation for 13 indicators (8 current and 5 projected) as shown in column E in table 5 below.
- A reservation about the completeness of data available in GEMS Water.

On 30 September 2010 the work of Vorosmarty, *et al.*, (2010) was released. This was a global study of the threats to the world's rivers, measuring impacts on humans and biodiversity separately. This study was therefore highly relevant to TWAP, and the 23 indicators used for the study (or 'drivers'), are presented in column B of table 5. The purpose of table 5 is to show a cross-check and development of indicators from the previous draft 28 (column A), with the 23 from Vorosmarty, *et al.*, (2010) (column B), with suggested indicators (column C), and suggested combinations of these indicators into indices (column D), and cross-checked against the GEF's recommended 13 indicators.

Table 5. Cross-check table with alternate indicators.

A **Original River Basins 28**	B **'River Threat' Drivers**	C **Updated River Basins Suggested Indicators**	D **Suggested Indices**	E **GEF Sec's suggestions** (to cross-check with column D)
Water Quantity			**Current Status (13)**	
1. Average discharge (move to factsheet)				
2. Size of irrigated area of total cultivated area	1. Cropland *(doesn't distinguish between irrigated and non-irrigated)* 18. Agricultural water stress *(water available per cropland. Doesn't distinguish between irrigated and non-irrig)*	1. Size of irrigated area (OSU (basin) from Kassel 1999 – 30 min pixels) of total cultivated area (CUNY from McGill 2000 – 30 min pixels)	1. Agricultural Water Stress (made up of C1 & C2 suggested 50% weighting). C1 indicates dependence on irrigation of total cropland. C2 indicates water availability per area cropland. Uses both Kassel and CUNY data. Note that only 16-18% of the world's croplands are irrigated (although those lands yield some 36% of the global harvest).	
3. Irrigation water withdrawal *(available at pixel level Kassel or CUNY) (discarded)*		2. Agricultural water stress (CUNY 2000, 30 min pixels)		
4. Water Stress	17. Human water stress	3. Human water stress 4. Environmental water stress [new]	2. Human water stress (CUNY) (already exists, 2000) – Filtered with a 'disparity index' of water stress? (Lakes group had advised us to include a water quality parameter in this index...) 3. Environmental water stress (IWMI/WRI/University of Kassel (WaterGAP2.1 model).	1. Downstream Water Supply Scarcity 2. IWMI/WRI water in excess of environment al needs
		5. Consumptive water loss [new] (CUNY – proportion of consumption of agriculture & industry compared to availability) (not included in any index)		
5. Developed hydropower potential *(remove – this is covered by fragmentation)*				
6. Standard Precipitation Index (SPI) *(only up to 2002, looks a little neglected?)*		6. Drought Risk Index	4. Drought Risk Index (IRI/CIESIN) World Bank/CIESIN used 'weighted anomaly standard precipitation' (WASP) in a 2005 study of droughts http://sedac.ciesin.columbia.edu/hazards/hotspots/synthesisreport.pdf	
7. Flood Frequency *(only up to 2002)*		7. Flood Risk Index	5. Flood Risk Index (Dartmouth Flood observatory/CIESIN) (same WB/CIESIN report).	

A Original River Basins 28	B 'River Threat' Drivers	C Updated River Basins Suggested Indicators	D Suggested Indices	E GEF Sec's suggestions (to cross-check with column D)
8. Glacier Melt *Good in that it shows vulnerability to climate change, but maybe not so useful for the global comparison in L1)*				
Water Quality				
9. Water Quality Index (WQI) *(discard as it is too much of a complex index already and possibly determined on relatively poor data)*	5. Soil Salinization 6. Nitrogen Loading 7. Phosphorous loading 10. Sediment loading 11. Organic loading 12. Potential acidification	8. Soil salinization (CUNY) (note that Egypt doesn't feature on this global map, although it is documented that salinity is a severe problem in Egypt. Pakistan seems to also be under-represented). If used, not included in any index		
10. Nutrients *(retain)*		9. Nitrogen Loading (NEWS) 10. Phosphorous Loading (NEWS)	6. Nutrient Pollution Index (TN, TP - Global NEWS). Level 1, provide average (river mouth) values only. However, as a cross-cutting issue, interest in providing data to Lakes & GW on a pixel basis.	3. pollution indicator (from Global NEWS)
11. TSS *(retain)*		11. TSS (not included in any index)		
12. Industrial Wastewater *(retain)*		12. Industrial Wastewater	7. Urban Effluent Index (made up Industrial & Municipal Wastewater (C12 & C14)). *(proxy for water quality issues (BOD, eutrophication etc, as well as POPs/metals)*	
		13. Mercury Risk Index [new] (CUNY from Harvard & Washington Univ) (cross-cutting issue)		
13. Municipal Wastewater *(retain)*	2. Impervious Surfaces	14. Municipal Wastewater		
Ecosystems				
14. Wetland coverage	4. Wetland disconnectivity	15. Wetland disconnectivity (CUNY)	8. Biodiversity and habitat index (made up of wetland disconnectivity (CUNY) and endangered species threat (IUCN redlist) (C15 and C19)).	4. water-related ecosystem indicator (partly made up of wetland loss)
15. Ramsar sites *(discarded)*				

A **Original River Basins 28**	B **'River Threat' Drivers**	C **Updated River Basins Suggested Indicators**	D **Suggested Indices**	E **GEF Sec's suggestions** (to cross-check with column D)
16. Impoundment density	14. Dam Density 15. River Fragmentation 19. Flow disruption	16. Dam Density 17. River Fragmentation 18. Flow disruption	9. Ecosystem Fragmentation Index (made up of C16,17,18, CUNY)	5. fragmentati on and flow changes from structures VS assumed normal
17. Invasive Species *(discarded)*	20. non-native fish (%) 21. non-native fish (#)			
18. Endangered species		19. Endangered species (IUCN)		
19. Fish catch *(retain)*	22. Fishing pressure	20. Fishing pressure (CUNY)	10. Fishing Pressure (CUNY – from FAO & primary productivity from University Wisconsin) (C20)	6. fisheries (reports of overfishing in basins where they exist)
Governance				
			11. Governance Index – based on existence of framework to address certain issues at the transboundary level. (e.g. water distribution, water quality, fisheries, biodiversity, habitat destruction)	7. Governance #1 (transbound ary basin legal agreement)
20. Pesticide Regulation Index *(could combine with 'pesticide loading' (B9) to form Pesticide Pollution Index)*	9. Pesticide Loading			
21. RBO *(move to factsheet)*				8. Governance #2 (inventory of % basin with modern, IWRM-like national water legislation)
22. River Basin Plan *(move to factsheet)*				
23. Joint monitoring programme *(move to factsheet)*				
24. Basins-At-Risk (BAR) *(updated to Basin Resilience Index)*		21. Basin Resilience Index (OSU)	12. Basin Resilience Index (OSU)	
Socioeconomic				
25. Human Development Index (HDI) *(disaggregate to literacy & life expectancy)*		22. Adult literacy (HDI) 23. Life Expectancy	13. SocioEconomic Index . Attempt to disaggregate national data to basin level. (made up of following clusters): **a. Social cluster:** i. *Well-being*: C22,C23, C5, C26 ii. *Vulnerability*: C27	
26. GDP/Total Freshwater Withdrawal *(retain)*		24. GDP/Freshwater Withdrawal		

A **Original River Basins 28**	B **'River Threat' Drivers**	C **Updated River Basins Suggested Indicators**	D **Suggested Indices**	E **GEF Sec's suggestions** (to cross-check with column D)
27. Improved Water Supply & Sanitation *(retain)*		25. Access to improved water supply 26. Access to improved sanitation	**b. Economic cluster:** i. *Dependency*: C24, total water based GDP? (or split into sectors, e.g. fisheries, agriculture, energy). ii. *Vulnerability*: C28, C29, C30	
28. Climate Vulnerability Index (CVI) *(remove? Complicated index, covering many issues. CEH – not updated).*		27. deaths per 100,000 inhabitants caused by climate related natural disasters (CRI) 28. per capita damages in ppp caused by climate related natural disasters (CRI) 29. Average losses per unit total GDP (from climate related natural disasters) (CRI)		
		30. income inequality using wealth GINI coefficient		
			Projected (5)	**Projected stress**
			1. Human water stress (2030/2050) (CUNY) *(currently does not take into account changes in demand, but changes in water available due to changes in popn. Ideally would do this. Taking CC into account probably too complex and possibly not as important as demand in this timeframe?)*	9. projected future irrigation/water use demand (2030; 2050)
			2. Environmental water stress (2030/2050) (IWMI/Kassel)	
			3. Nutrients Index	10. projected pollution indicator (2030; 2050)
			4. Population density (2030/2050)	11. projected population (2030; 2050)
			5. River Basin Resilience (2030/2050) (OSU)	12. projected additional water stress/droughts/ floods from global warming (2030; 2050) 13. basins at risk?

It can be seen from table 5 above that many of the issues covered by the 23 River Threat drivers (column B) were also covered by the previous 28 suggested indicators (column C). As the River Threat study was a culmination of several years work with multiple partners, this serves as some form of verification of the River Basins group approach and indicators.

Although column D was labelled 'indices', it was subsequently decided to refer to the final core set (Level 1) as indicators, as there were varying complexities in the 'indices' described in column D. Furthermore, this allows for the combination of the final core indicators (Table 1, Part 3) into indices during the FSP if required.

It can also be seen from table 5 above that the GEF's recommended indicators are essentially incorporated in columns C and D.

Stage 6

The final stage involved closer analysis of columns C and D, leading to the Level 1 indicators described in table 1, Part 3.

ANNEX 7
MAIN FINDINGS OF THE STAKEHOLDER WORKSHOP

First Stakeholder Consultation Workshop
RIVER BASINS and LAKE BASINS Workgroups
10 August 2010
Hotel Windsor Suites, Bangkok
Final Report

Item 1: Opening of the Workshop

The workshop was opened with remarks from Mr. Ganesh Pangare, the Water Coordinator for the Asia Regional Office of IUCN. He acknowledged that the Transboundary Waters Assessment Programme (TWAP) was a global assessment, and that the Asia region had some of the most pressing water management concerns that would be useful for the TWAP design phase to take into account. This was especially important for a region with a rapidly expanding population who gain their livelihoods from water based services.

Item 2: Introduction to the Transboundary Waters Assessment Programme (TWAP)

Dr. James Dalton, Water Management Adviser to the IUCN, and a member of the River Basins workgroup invited participants to introduce themselves, and the agencies they represented. Dr. Dalton presented the objective of the workshop which was: *to share the TWAP methodology for the River Basins and Lake Basins workgroups and seek stakeholder input for validation of the approach.*

Dr Dalton gave the opening presentation on TWAP. He mentioned that TWAP was a global assessment and was currently still in the methodology design phase. TWAP is split into five separate water system workgroups, from river basins, lake basins, groundwater, large marine ecosystems (LMEs), and open oceans. Results are needed to improve basin management to allow GEF to improve the allocation of financial resources for their International Waters focus area. He mentioned that a two-level assessment is planned. Level One is a global assessment of all five water systems, using regional expert information and globally available data sets. Level Two would be a pilot stage for a small subset of each of the five water systems, allowing for a more in-depth study of the water problems utilizing existing GEF approaches such as the Transboundary Diagnostic Analysis (TDA). This would allow investigation and review on how the new TWAP development methodologies can support existing tools, and also validation of the global assessment results under Level One, which are reliant on global level data sets. An overview of TWAP, links from the Medium Sized Project to the Full Sized Project were also explained, in order to allow participants to understand the context of the workshop, and the information which would be presented over the remainder of the day from the River Basins and Lake Basins workgroup perspectives.

Item 3: Presentation of the RIVERS workgroup methodology

Dr. Dalton presented the River Basins workgroup approach to designing the methodology for TWAP. This was based on the current River Basins Working Group Methodology, Draft Report 0.3, dated 23 June 2010. The presentation described using the issues based approach to determine the pressing concerns for transboundary rivers systems based on a global review, using a modified DPSIR approach. The presentation also presented the structure of the methodology, and the splitting of the approach into two levels, and the potential architecture of the TWAP process in terms of data providers, information sourcing and review, and presentation of information to the GEF and other partners who would find the information TWAP could produce useful.

Item 4: Presentation of the River Basins workgroup indicators

The draft indicators developed by the VS workgroup were presented to the participants on the screen and through printed information on the indicators and the recent development on moving from individual indicators into a small set of approximately 13 indices based on feedback from the GEF Secretariat. The indicator short-listing criteria of Availability, Acceptability, Applicability and Aggregation were presented, including the range of scoring bands designed to show any similarities in solutions, possible basin twinning, the basins potentially at most *risk*, and those which demonstrate best practice. The River Basins draft 28 indicators were presented, and additional information provided on the data sets for these indicators.

The draft presentation of the results using this indicator based approach was shown to participants, together with the interlinkages between the different water systems in TWAP, and the indicators to indices tables in order to gather feedback on the indicators, the move to indices, and how scoring would be presented in a transparent manner.

Item 5: Paired Review of Draft Indicators

Following discussion amongst the participants, it was felt that a paired review approach was not relevant at this stage as they needed more information on the indicators, including background information, further analysis of the decision-making process to decide on these final indicators, and the scoring approach. As time was short, participants requested an informal plenary discussion on the River Basins approach, and the indicators selected. The points raised in this discussion are summarized below in the section titled Discussion.

Item 6: Critique Session of the River Basins Methodology

The points raised are summarized below and continue in the section titled Discussion.

- Many of the indicators are science based – and the data sets to be used as presented in the report are from scientific disciplines. Yet, in the Asia region many of the decisions concerning rivers are based on social and economic needs, and not hydrology, environment, or governance issues. It is doubtful that any of these indicators could be used in this region with a good degree of acceptability, and it would be hard to use these types of indicators to persuade countries to change their practices, or to foster support and encouragement for what GEF would like to support and change.
- There was a general feeling amongst participants that the weighting of indicators, and the priority given to indicators in any future indices should be transparent and should not be technologically and *science* driven. Some participants highlighted that they would need to see more livelihood and socioeconomic issues included in TWAP, and questioned the reliability of the weighting process if this was to be done from Washington, or even through offices based in the regions but from external agency perspectives. Weighting, if this is to be done should be transparent and regionally determined to provide a global assessment with global data-sets, but with regional grounding to improve the reliability of the approach and the results.
- Further analysis should perhaps be included based on evaluation reports from the Asia region of support from different donors such as the World Bank, to see if the past 10 years of support for water and the environment in transboundary settings has been appropriately targeted or not. Has TWAP, or will TWAP be reviewed by regional agency offices and not just headquarters of agencies?

- Governance indicators appear confused based on the information presented. The confusion lies in mixing management priorities and governance as the operating environment. This may cause problems in trying to determine what good governance is, and what is simply a management practice. From a global perspective, management practices will differ, but there are some fundamental governance elements which should be included as they will be globally comparable (although will be named differently).
- Fragmentation of river systems should be prioritised as the most urgent, and potentially devastating impact on ecosystem services, including lost or significantly changed hydrological connectivity between systems such as rivers floodplains, lakes, wetlands, and groundwater.
- It is not clear from the scoring at present if important issues will be hidden under the cumulative scoring approach, or will all the indicators be scored individually to make it more transparent. Will weighting be transparent?
- Major technical data and knowledge gaps for the Mekong are issues such as floodplain responses and the impact of river flows on coastal fisheries and near-shore marine resources, deforestation impacts and other upstream, possibly cross-border land management issues, dam development and alteration of water and sediment flows.
- Livelihoods should be the most important data set used.
- Political risk should be included in the indicators, or is this included under Basins-at-Risk, and how often is this updated, as politics can change quickly in the Asia region, therefore how relevant is this at global scale?
- Decisions made by River Basin Organizations are not static and therefore static data used by TWAP may not resonate with transboundary basin decision makers.
- Determining which the most important water bodies are is very much a value judgment, despite what TWAP is trying to do.

Discussion

Transboundary rivers are normally long in length – and are generally not well monitored between specific hydrological stations, urban centre's (although this is not always the case) and other types of *control points*. One type of control point would be a lake, or reservoir. Normally, at these points water is specifically required for something in the case of built infrastructure, (energy, tourism, water supply for cities, or agriculture) or protection (from sudden ice melt, flash floods, etc) or a combination of these as multiple-use structures. In the case of natural infrastructure, such as natural lakes, wetlands, delta river systems, mangrove areas – these are normally the reason why human development has occurred in the basin apart from a few solely groundwater dependent locations. Consequently, in almost all cases these static water systems, or sinks tend to be better managed and monitored, and provide control point functions for measurement of flows, quality, and other socioeconomic information (possibly including some form of ecosystem services information other than just provisioning services). Does this provide the opportunity to use lakes and reservoirs as point source information in river basins which can then be verified and checked using global data sets to allow a picture to be developed between these control points of the river flows and use.

Something on Emerging Issues should be included. There are new issues being discussed such as biofuels, and mitigation and transboundary adaptation actions. If TWAP is to become a go-to resource, or a global benchmark for information it needs to have the capability to take into account new and emerging issues, otherwise it will remain static like many other global assessments become.

Many rivers in the Asia region are data rich in terms of the agencies and organizations which monitor them and compile information, but a lot of this information is socioeconomic driven, and not environmentally, or even hydrologically driven or accurate. This highlights the strong livelihood resource that rivers present in the Asia region. How will TWAP take this into account, as global data may not demonstrate this type of reliance on the water resource where global indicators have to become so generic in order to allow regions around the world to be comparable? This could mean that TWAP is actually missing the main point in some transboundary river systems, that of livelihood dependency and the changes which could occur due to upstream development on the river systems.

Many of the indicators presented are very broad, and whilst it is recognized that this is still a work in progress, the need to keep indicators broad in order to use globally available data sets may not provide a real picture for GEF to use meaningfully.

It is not clear how ecosystem services will be incorporated into this, as in Asia many of the livelihoods are reliant on seasonal flooding water based environmental services, and these are all at risk and can be significantly affected by transboundary decision making. Yet, this data only exists at more local or project scales, and many times the environment is seen as a multiple resource which can be extracted from – we do not know how far we can push our river systems before things start to fail. It is not clear how TWAP at present can help with this, but perhaps it could?

Concerning the governance indicators proposed, the current indicators are only for 1/3 of governance – the rules. The governance status index needs 3 indicators, one for each of the fundamental components of governance – rules (i.e. laws and other 'norms), institutions (the who and the how, formal/statuary, informal/customary) and processes (who and how, formal/statuary, informal/customary), for example:

1. **Governance #1** – rules (this includes treaties, legislation, regulations, other legal instruments)

Indicator 1: existence of a bilateral or multilateral agreement governing a river/lake/aquifer that creates a decision-making and/or implementing authority/institution

Indicator 2: national IWRM-type laws in force in countries in the basin

OR

% of basin governed by national IWRM-type laws that create a decision-making authority/institution

2. **Governance #2** – institutions (formal and informal/customary)

Indicator 1: existence of a RBO/similar body for lake/aquifer with decision-making and/or implementing authority

Indicator 2: evidence that the RBO functions effectively – could be a basin plan that is being implemented or some similar indicator

3. **Governance #3** – processes (formal and informal/customary)

Indicator 1: existence of/number of processes that contribute to decision-making

Indicator 2: existence of/number of processes that contribute to implementation of decisions

Of the River Basins Draft v.0.3 original 28 Indicators, #20-24 are listed as under governance, but in reality only 20 and 21 are governance indicators. 22 and 23 are management indicators. It is not clear, from a governance perspective, what #24 is.

It is also not clear why the only rule that is important for river governance is pesticide regulations? A more comprehensive indicator is suggested above. It was also generally agreed that a River Basin Organization is clearly an institution. It was also noted that in the draft indicators presented, there is nothing which clearly relates to processes for governance.

TWAP was also further discussed by a smaller group of experts who attended the Basin Management in Asia Pacific Region Brainstorming Workshop on the 11th August. This smaller workshop focused on the development of a publication designed to increase the awareness among decision makers at the highest level about basin management practices, highlighting specific examples from the Asia-Pacific region.

Conclusions and Recommendations to River Basins and Lake Basins Workgroups

It was generally agreed amongst all participants that:

1. TWAP needs to be more focused on governance and socioeconomic indicators;
2. A clearer although this is obviously difficult ecosystem services framework needs to be present through TWAP, as it is expected this is not clear across the five water system workgroups. Ecosystem services are the main link between water systems, and the information used to determine this is not always presented in technical science approaches, which is the approach which seems to be dominating TWAP at present;
3. Strong links and use of socioeconomics and ecosystem services would be more politically relevant to decision makers in the Asia region, in order to gather support for TWAP, co-investment, and data in the future;
4. It is also worth noting that amongst the participants, GEF was not considered very active in the region on freshwater, so the more support for TWAP would potentially mean that GEF approaches, possible investments and partnerships could be strengthened be recognizing the need to make TWAP relevant to regions;
5. Some concerns were raised over who would use and have access to the data held by TWAP in the future, if agencies and transboundary water management institutions and governments do share information;
6. Should TWAP be used to determine where the problems are the worst, or where the greatest impact could be had – these are two separate decisions and GEF needs to think about this and be transparent in decisions. As GEF is a donor, is the decision for funding of TWAP identified priorities the best return on investment?
7. Recommend using TWAP to invest for decision making and good return from transboundary river systems in terms for preserving and expanding ecosystem services for livelihoods and economic growth;
8. The hydrologic linkages between rivers and lakes, and their environmental and management implications, justifies substantial and significant collaboration between the River Basins and Lake Basins Working Group in carrying out their assessments under the Full Size TWAP Project; and
9. The GEF should stress the hydrological linkages, and their relevant assessment and management implications, in making decisions about international waters funding allocations. Continuing to consider these water systems in an isolated manner is both inconsistent with the realities of nature, and will continue to dissipate the limited GEF funds in a manner that does not provide the most cost-effective use of these funds.

ANNEX 8
INTERLINKAGES DISCUSSIONS AND ILLUSTRATIONS FROM DRAFT INDICATOR SETS

The following is a draft set of 'interlinking' indicators and cross-cutting issues shared with the Lakes and LME groups in June 2010. The Groundwater group preferred not to comment at that time. This provides an *illustration* of the process taken only, and should not be viewed as a final methodology. Please refer to section 4.1 for discussion on this.

Interlinkage issues

River Basins ⇨ Lake Basins

Input-output indicators (Indicators chosen to represent issues that can be used for input – output analysis, even if they are not exactly the same indicator across the systems).

RIVER BASINS INDICATOR	OUTPUT FROM RIVER BASINS WG	COMMENT/OUTPUT FROM LAKES WG
Water quality index	Composite index value, covering five parameters: Dissolved Oxygen (DO), Electrical Conductivity (EC), pH, Total Phosphorus (P) (or Ortho-phosphorus), Total Nitrogen (N) (or Dissolved Inorganic Nitrogen, Nitrate/Nitrite, Ammonia)	Limnological variables commonly measured in lake studies include: Dissolved Oxygen (DO), Electrical Conductivity (EC), pH and temperature. Regarding eutrophication, Total Phosphorus (TP), Orthophosphate or dissolved reactive phosphorus, Total Nitrogen (TN), Ammonia, and Nitrate/Nitrite-nitrogen are primary nutrients to consider.
Industrial effluent	Proportion of industrial effluent produced compared to total basin discharge.	Total quantity and types of industrially-produced pollutants to a lake, expressed as total load.
Municipal effluent	A combination of population (number), sanitation coverage (percentage), and likely level of effluent treatment (Water Quality Index (WQI) score)	Total quantity of wastewater treatment plant effluent (including nutrient and microbe contents) discharged to lake (via river input or directly); in the absence of relevant data, basin population numbers and estimated per capita nutrient and microbial loads to lake, modified by type — if any — of wastewater treatment.
Soil erosion vulnerability	The level of risk of soil erosion (water-induced, as opposed to wind-induced). Expressed in risk categories, low to high. In addition to algal blooms, increased in-lake turbidity from excessive sediment concentrations can significantly affect water column transparency. Sediment levels in water are usually measured as Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) concentrations. They also can be estimated from Secchi disc transparency measurements.	Sediment concentrations in influent waters to lakes, and identification of likely erosion sources in drainage basin. In reservoirs with large drainage area to surface area ratios, located in areas with highly erodible soils, sediments can significantly reduce in-lake water storage capacity and reservoir operational 'life'. High sediment levels also can negatively affect fish gills in lakes and cover coral reefs in LMEs
Impoundment density	The degree of river fragmentation and altered flows is rated in three categories: Strongly affected, Moderately affected, and Not affected.	The influences of the presence of a lake or reservoir in a drainage basin should be assessed on the basis of the changes in water quality in the influent river(s) and the river discharges from the lake/reservoir.

RIVER BASINS INDICATOR	OUTPUT FROM RIVER BASINS WG	COMMENT/OUTPUT FROM LAKES WG
Pesticide regulation index	Indicator of the legislative status of riparian countries on two landmark agreements on pesticide usage, the Rotterdam and Stockholm conventions, as well as the degree to which these countries have followed through on the objectives of the conventions by limiting or outlawing the use of certain toxic chemicals. Based on yes/no criteria, scored using a 22 point scale.	Pesticides and other synthetic organics may be long-lived in the environment (at least for 'legacy' pesticides); a relevant factor regarding human uses is that they tend to bioaccumulate in the tissues of fish and/or in organic sediments. Accordingly, their concentrations in these environmental compartments can be correlated with lake basin pesticide use.

Governance indicators

RIVER BASINS INDICATOR	OUTPUT FROM RIVER BASINS WG	COMMENT/OUTPUT FROM LAKES WG
RBO/RBCs (including Lake Basin Management structures when it also covers TBR.)	This indicator determines the existence and level of membership of transboundary River Basin Organizations and Commissions (RBOs/RBCs)	The situation is similar for lake basins, in that the existence, level of membership, and range of authority and activities of transboundary lake basins should be evaluated against the stated mandates, the desired long-term condition for a given lake system, and the status of several governance elements, including institutions, policy, stakeholder participation, public awareness; and sustainable finances.
River Basin Plan (or common plans for rivers and lakes)	This indicator measures the existence, and level of implementation, of transboundary river basin plans (RBPs)	The situation is that expressed above, in that the existence and level of implementation of a lake basin management plan should reflect an 'integration' approach that considers institutions, policy, stakeholder participation, public awareness, and sustainable finances.
HDI	The HDI is an index value (0-1) of development by combining indicators for health, knowledge and standard of living.	The Lakes WG can utilize the same indicator as the River Basins WG, although efforts will be necessary to correlate the HDI with the water quantity and quality issues affecting lakes/reservoirs, their basins, and their management challenges.
GDP/total freshwater	Gross Domestic Product for the basin divided by the total freshwater withdrawal in the basin	It would be useful to determine how much freshwater is withdrawn from lakes and reservoirs in the basin, in contrast to that withdrawn directly from rivers.
Access to water and sanitation	Percentage of population (rural and urban separate) with access to improved sanitation	The Lakes WG can utilize the same information as the River Basins WG, although it will be necessary to correlate such information with the water quantity and quality issues affecting lakes/reservoirs, their basins, and their management challenges.

River Basins ⇨ LMEs

Input-output indicators (Indicators chosen to represent issues that can be used for input – output analysis, even if they are not exactly the same indicator across the systems.)

For River Basins-LMEs, the main interlinkages will be outputs from River Basins to LMEs and associated socioeconomic activities (such as agriculture, industrialization, urbanization, deforestation) and responses, rather than from LMEs to rivers. Nutrients, chemical pollutants, freshwater and sediment discharge from rivers to LMEs would be among the major issues. In the other direction (LMEs to River Basins) interlinkages would include saline intrusion and flooding from sea level rise, transport and deposition of pollutants including from sea-based sources, but perhaps a localized problem and does not warrant inclusion unless for an important transboundary hotspot

RIVER BASINS INDICATOR	OUTPUT FROM RIVER BASINS WG	COMMENT/OUTPUT FROM LAKES WG
Water quality index	Composite index value, covering five parameters: Dissolved Oxygen (DO), Electrical Conductivity (EC), pH, Total Phosphorus (P) (or Ortho Phosphorus), Total Nitrogen (N) (or Dissolved inorganic Nitrogen, Nitrate/Nitrite, Ammonia)	Output from LMEs to River Basins would probably be minor compared to output from rivers to LMEs (pollution originating at sea or transport of pollutants by coastal currents could affect rivers but to what extent? – might not warrant inclusion in output from LMEs to rivers. Also data availability might be of concern. Saline intrusion to rivers and flooding from sea level rise). Water quality in rivers could ultimately affect coastal areas through river runoff (or where appropriate interventions exist, such as pesticide regulation). Therefore, these indicators will be relevant to LMEs (esp. nutrients), but some might not be explicitly included in the LME suite of indicators. GESAMP experts in the LME WG will be able to provide comments on pollution aspects (still under development for LMEs)
Industrial effluent	Proportion of industrial effluent produced compared to total basin discharge	Same as above for output from LMEs to River Basins - major direction of interlinkage will be from River Basins to LMEs
Municipal effluent	A combination of population (number), sanitation coverage (percentage), and likely level of effluent treatment (Water Quality Index (WQI) score)	Same as above for output from LMEs to River Basins - major direction of interlinkage will be from River Basins to LMEs
Soil erosion vulnerability	The level of risk of soil erosion (water-induced, as opposed to wind-induced). Expressed in risk categories, low to high	Relevant to LMEs re changes in sediment loads and impact on coastal habitats. LMEs to River Basins – transport and deposition of sediments in river mouths?
Impoundment density	The degree of river fragmentation and altered flows is rated in three categories: Strongly affected, Moderately affected, and Not affected.	Relevant to LMEs re changes in freshwater discharge to coastal areas and impact on coastal habitats (one of the LME indicators)
Pesticide regulation index	Indicator of the legislative status of riparian countries on two landmark agreements on pesticide usage, the Rotterdam and Stockholm conventions, as well as the degree to which these countries have followed through on the objectives of the conventions by limiting or outlawing the use of certain toxic chemicals. Based on yes/no criteria, scored using a 22 point scale.	Relevant to LMEs

Governance indicators

INDICATOR	OUTPUT FROM RIVER BASINS WG	COMMENT/OUTPUT FROM LME WG
HDI	The HDI is an index value (0-1) of development combining indicators for health, knowledge and standard of living.	Could be aggregated by LMEs. Used in LME socioeconomic assessment framework of Hoagland and Jin (2006)
GDP/total freshwater	Gross Domestic Product for the basin divided by the total freshwater withdrawal in the basin	
Access to water and sanitation	Percentage of population (rural and urban separate) with access to improved sanitation	
(LMEs) Adoption/ implementation of frameworks such as ICZM, IWCAM, GPA and associated monitoring programmes		Adoption by countries of approaches and frameworks that address land-sea interactions are of direct relevance to interlinkages between rivers and LMEs

Cross-cutting Issues

This is the first suggested draft for indicators for the cross-cutting issues from the River Basins group. It expresses the view of the River Basins WG on how we see the cross-cutting issues possibly reflected in the indicator-based assessment. It is not necessarily intended to define indicators that are or should be identical across the water systems – rather, they reflect how the cross-cutting issues could be dealt with in ways that are specific and relevant for each water system. Comments/suggestions from other WGs are most welcome.

ISSUE	INDICATOR – RIVER BASINS	DEFINITION OF INDICATOR	INTERLINKAGES WITH OTHER WATER SYSTEMS
Water quantity	Average discharge (modelled)	Average volume of water discharged from the river, ideally measured daily. The time series of measurement should be minimum 5 years, more for arid rivers (up to 20 years) [to be modified, according to possible new approach using models]	The average discharge is important to lakes, groundwater and LMEs. It will affect the health and functioning of the ecosystems. Agreed. Change in river discharge of importance to LMEs
Nutrients/ Eutrophication	Fertiliser consumption (might be changed if the NEWS model can provide accurate information on eg phosphorous concentrations of rivers.	The quantity of fertilizer used in a basin each year [to be modified, pending outcome of analysis of NEWS modelling capabilities on nutrients]	The level of fertilizers (nutrients) in a river system is also important to lakes, groundwater, and LMEs. Nutrients are transported either dissolved in water, or with particles, such as soil. Eutrophication is a major problem for lakes and coastal areas. Nutrients, particularly nitrogen in the form of nitrate, can contaminate groundwater, making it unfit for drinking Nutrient discharge is also included in LMEs component and Global NEWS model will be part of the LMEs methodology. Nutrients inputs and impacts in coastal areas will be one of the major issues expressing interlinkage between rivers and LMEs.
Vulnerability to climate change	Standard Precipitation Index	Index to measure drought periods, probability for (lack of) precipitation, based on history	Droughts will affect the river flows and therefore affect groundwater, lakes and LMEs Sea level rise and effect on rivers (salinization, water level) is an input from LMEs to rivers (but how far into rivers to warrant concern?)
	Climate Vulnerability Index	The climate vulnerability index expresses the degree of vulnerability of human communities to climate change and variability.Variables included in the CVI can be found in the following six broad categories; the water resource, access to water & sanitation, capacity to cope within the community, use of water, environment pressures and geospatial information.	If a river basin shows vulnerability to climate change and variability, the vulnerability will spill over to the interlinked water systems. The effects of climate change, such as drought, floods, and changed climatic patterns will impact the river flows and therefore affect groundwater, lakes and LMEs. Through the geospatial component of the CVI it considers water-related issues relevant for all water systems that affect the communities dependent on them. Climate change impacts on river discharge to LMEs and impact of sea level rise on rivers. Another issue is the impact on vulnerable coastal populations and infrastructure
	Flood frequency	Average of 5-year floods in the river annually over the last 10 years.	Changes in flood patterns are an indication of changed climatic conditions in the basin. In most river basins in the world floods are expected to increase due to climate change. Even if increased flood frequency doesn't necessarily mean an increase in the yearly discharge, the flow pattern will change. This affects the ecological systems in downstream lakes and LMEs. Agreed

ISSUE	INDICATOR – RIVER BASINS	DEFINITION OF INDICATOR	INTERLINKAGES WITH OTHER WATER SYSTEMS
Biological Productivity	Fish Catch	The amount of fish caught in a basin each year	Due to fish ecology, the abundance of fish populations can be negatively affected by reduced wetland coverage and increased impoundment density. Critical life stages may also be associated with periodical flooding as an extreme event.
Metals - Mercury	Mercury	Under investigation. Could be very hard to provide within feasible budget	Mercury is a highly toxic and persistent substance, important to the environmental quality in all water systems and transported between them through various mechanisms GESAMP has a working group on mercury, and GESAMP experts have recently joined the LME WG. They will be looking at mercury in the marine environment

Cross-cutting Issues

This is a draft focusing on cross-cutting issue indicators from the Lakes Group. It expresses the view of the Lakes WG on how it views the cross-cutting issues reflected in the indicator-based assessment. The indicators are not necessarily identical across the water systems. Rather, they reflect how cross-cutting issues might be considered in a manner that is specific and relevant for each water system.

ISSUE	INDICATOR – LAKES	DEFINITION OF INDICATOR	INTERLINKAGES WITH OTHER WATER SYSTEMS
Water quantity	Minimum, mean, and maximum lake volume, depth and/or surface area	(i) Average lake volume, as well as increases and decreases, over the annual cycle; (ii) Minimum, mean, and maximum lake depths, annual and seasonal; and (iii) Average lake surface area, based on average lake volume.	A lake functions as a water storage unit, during both periods of water scarcity and water excess (flood); management of lake water releases can affect the health and functioning of downstream water systems, ecosystems, and water users and uses; management of the upstream watershed can affect water quality and quantity in a lake. In this latter context, inflows are influenced by groundwater discharge and riverine base flows.
Nutrients/ Eutrophication	In-lake nutrient (particularly total and inorganic P and N) concentrations that limit maximum algal biomass, annual and seasonal averages; also N:P ratios as a means of determining maximum algal biomass-limiting nutrient; trophic status, based on OECD trophic status criteria.	Measured nutrient concentrations taken in situ from appropriate lake sampling sites (generally the 'deep hole' in natural lakes, and upper, middle and dam-area sites in reservoirs); with particular emphasis on the biologically-available fractions of the nutrients, including concentrations and ratios.	A lake is a sink for influent pollutants, including nutrients. Being a lentic water system, it changes the flowing (lotic) water nature of rivers (and the pollutants carried in the inflows), allowing them to settle in the lake water column. This shift from a lotic to a lentic water system, defined by the water retention time, allows for eutrophication symptoms to become visible (e.g., algal blooms and associated water quality deterioration). The presence of a lake reduces the nutrient concentration of the influent waters, but can also degrade the water quality in the lake to the degree that it can have significant negative downstream water quality impacts on effluent rivers, wetlands and estuaries. Eutrophication is a major problem for lakes and coastal areas.
Vulnerability to climate change	Standard Precipitation Index	Index to measure drought periods, probability of (lack of) precipitation, based on history	Droughts will affect river inflows to lakes, thereby affecting lake volumes, depths, surface areas, and water retention times.

ISSUE	INDICATOR – LAKES	DEFINITION OF INDICATOR	INTERLINKAGES WITH OTHER WATER SYSTEMS
	Climate Vulnerability Index	The climate vulnerability index expresses the degree of vulnerability of human communities to climate change and variability. Variables included in the CVI can be found in the following six broad categories: the water resource; access to water and sanitation; capacity to cope within the community; water uses; environment pressures; and, geospatial information.	If a lake's basin exhibits vulnerability to climate change and variability, the vulnerability will spill over to its interlinked water systems, including influent and effluent rivers, downstream wetlands, and LMEs. The effects of climate change, such as drought, floods, and changed climatic patterns will impact lake volumes, surface areas, average and maximum depths, and water retention times.
	Water retention time	Calculated as the ratio of annual inflowing water volume and in-lake volume, longer water retention times provide the opportunity for algal blooms to develop; depending on the N:P ratio and concentrations, among other variables. These blooms can include cyanobacteria, some being toxic to humans and wildlife.	Lakes and reservoirs provide a buffering influence on floods by serving as water storage facilities, allowing release of the excess water in a more controlled manner, thereby also protecting downstream ecosystems and human lives and property.
Biological Productivity	(i) Algal biomass; (ii) aquatic plant/ periphyton biomass; and (iii) fish yields	(i) algal biomass (expressed as µg /L chlorophyll-a); (ii) surface area coverage of aquatic plants/periphyton; and (iii) quantity of fish catch over an annual cycle, and fish catch per unit effort.	The abundance of algae and aquatic plants can be stimulated to excessive levels by excessive nutrient inputs from groundwater and/or riverine sources, with significant negative impacts on lake ecology and water quality. These impacts can affect downstream ecology and water uses. Fish catches and fish community composition are related to water quantity and/or quality changes, and overfishing can affect lake community livelihoods.
Metals - Mercury	Mercury	Mercury can bioaccumulate in fish tissues and organic sediments. Mercury contamination risks, however, may be underestimated in view of the fact that it is not always measured as a routine pollutant. Further, sample contamination from a variety of sources, including tooth fillings, can be a problem.	Mercury is a highly toxic and persistent substance, important to environmental quality in all water systems and transported between them through various mechanisms.

ANNEX 9
CROSS-CHECK REPORT CONTENT AGAINST TWAP FINAL FRAMEWORK METHODOLOGY

The following is a cross-check against the 22 elements of the TWAP final Framework Methodology as listed in the TWAP-IMAIG Meeting Geneva-Final Report August 2010

COMMON ELEMENTS	ADDRESSED IN SECTION OF THE REPORT	COMMENTS
1. scope and framework;	1.2 and 1.3	Framework development in Annex 6
2. assessment units/boundaries;	2.1	
3. inventory of agencies, programmes, data sets and sources;	2.2 and 2.3	Total inventory in Annex 2
4. interlinkages among water systems;	Part 4	Summary of interlinkages in section 4.1 and Annex 8
5. a) indicators,	Part 3	Full Description Sheets in Annex 2
b) cross-cutting issues;	4.3	
6. vulnerability;	1.4, 3.1 and 3.3	Also dealt with through many indicators, particularly socioeconomic indicators
7. partners;	2.3	
8. inputs-outputs approach;	4.2	
9. validation of methodologies;	6.2	Annex 7
10. priority issues, emerging issues & hotspots;	2.4	2.5 on level 1/ level 2 distinction
11. capacity building;	6.3	
12. data management;	5.1	
13. glossary of terms;	Annex 4	
14. assessment products;	5.3	
15. institutional framework;	6.1	
16. arrangements for carrying out assessment	6.1	
17. time scale of assessment;	6.5	
18. roles/responsibilities;	6.1	
19. improved interaction between the assessment process and relevant decision making authorities;	2.2, 2.3, 2.4 and 5.3	Role of RBOs as data providers and users described in Part 2
20. global coordination and harmonization framework among water systems;	Part 4	Coordination included in many parts of the report, such as short-listing of basins for Level 2 in section 2.5
21. align with UNGA Regular Process;	N/A	Only relevant for Marine systems?
22. estimate for required financial resources.	6.4	

ANNEX 10
DRAFT DETAILED BUDGET, INCLUDING 'CORE' AND 'OPTIONAL' ACTIVITIES

This budget is draft only, and finalization will be undertaken during the project preparation phase. For discussion on this annex, please see section 6.4.

CLUSTER	TWAP INDICATOR	EXISTING DATASET	CORE					OPTIONS FOR ADDING VALUE				
			Core Additional activities required for TWAP [1]	Total cost	Partner Co-financing: Cash [2]	Partner Co-financing: In-kind [3]	Requested GEF contribution	Optional activities required for TWAP	Total cost US$	Co-financing : Cash US$	Partner Co-financing : In-kind US$	Requested GEF [4] contribution US$
WATER QUANTITY	1. Environmental water stress (TBD)	a. Kassel/Frankfurt, WaterGAP, MAR (1961-1990 or 1971-2000 pub. ?][5] (WaterGAP3: 5', WaterGAP2: 30')	Improve baseline hydrology & make consistent			150 000	40 000	Update WaterGAP3			225 000	225 000
		b. WaterGAP, total withdrawals [2000], (2005 update exp. 2012)	Expansion of european irrigated areas map to reflect *actual* irrigation & crop type at global scale			100 000	70 000	Update non-european values of withdrawals based on measurements (rather than projections forward)			100 000	80 000
		c. WaterGAP, reservoirs [2000, pub. 2009] (TBC)	none									
		d. IWMI, EWR [2000?, pub. ??] (TBC)	None: not essential for indicator					2010 update			50 000	50 000
			Indicator processing[6] (Kassel/Frankfurt)				30.000					
			Sub-total	**390 000**	**0**	**250 000**	**140 000**	**Sub-total**	**730 000**	**0**	**375 000**	**355 000**
	2. Human water stress	a. CUNY, WBM, water availability (Lakhankar, *et al.,* in preparation; Vörösmarty, *et al.,* in preparation), based on Pilot Study on Indicators (PSI) work with WWAP	Improve baseline hydrology & make consistent			200 000	40 000	Update hydrology			200 000	200 000
		b. CIESIN, Gridded Population of the World (also used for indicators 5, 12, 13, 14). [yr, pub.?] update exp. 2012	None: use existing or expected update (2012)			300. 00	30 000					
			Indicator processing (CUNY)				30 000					
			Sub-total	**600 000**	**0**	**500 000**	**100 000**	**Sub-total**	**400 000**	**0**	**200 000**	**200 000**

[1] For example if an update is required that is not already budgeted for, or if a different resolution is required, or if data needs re-aggregating, e.g. from national to basin level.
[2] Can include staff-time that will be directly managed by the project and specifically allocated to the project.
[3] Mainly includes baseline programmes/datasets which will be directly used in the assessment.
[4] This may also come from other sources if they can be identified
[5] Year of most recent baseline or planned baseline which will coincide with TWAP, with the year of publication of the dataset.
[6] This may involve collation of datasets, re-aggregation of data from national or pixel level to basin level, calculation of the indicator, and reporting & mapping.

CLUSTER	TWAP INDICATOR	EXISTING DATASET	CORE: Core Additional activities required for TWAP [1]	CORE: Total cost	CORE: Partner Co-financing: Cash [2]	CORE: Partner Co-financing: In-kind [3]	CORE: Requested GEF contribution	OPTIONS FOR ADDING VALUE: Optional activities required for TWAP	OPTIONS FOR ADDING VALUE: Total cost US$	OPTIONS FOR ADDING VALUE: Co-financing : Cash US$	OPTIONS FOR ADDING VALUE: Partner Co-financing : In-kind US$	OPTIONS FOR ADDING VALUE: Requested GEF [4] contribution US$
	3. Agricultural water stress	a. WaterGAP, MAR [2000?, pub.?] See 1a	See 1a									
		b. WaterGAP, total withdrawals [2000, pub.?] See 1b	See 1b									
		c. IWMI, Global Map of Rainfed Cropland Areas [2000?, pub. ??] TBD	None: use existing					2010 update			50 000	50 000
			Indicator processing[5] (Kassel/Frankfurt)				30.000					
			Sub-total	**30 000**	**0**	**0**	**30 000**	**Sub-total**	**100 000**	**0**	**50 000**	**50 000**
WATER QUALITY	4. Nutrient pollution	a. IGBP, Global NEWS, N & P [2000, pub. 2005 & 2010]	2010 update expected in collaboration with LME/GW/Lakes groups			133 000	80 000					
								Option for finer resolution outputs for (0.5°)			25 000	247 000
			Indicator processing (IGBP)				30 000					
			Sub-total	**243 000**	**0**	**133 000**	**110 000**	**Sub-total**	**272 000**	**0**	**25 000**	**247 000**
	5. Urban water pollution	a. FAO Aquastat, municipal & industrial water withdrawal (periodic updates made with Aquastat budget) (alternatively use WaterGAP)	None (dependent on whether Aquastat or WaterGAP is used)					Integration of Aquastat/WaterGAP data		XXX	XXX	XXX
		b. CIESIN, Gridded Population of the World, see 2b	See 2b									
		c. WaterGAP or WBM, water availability, see 1a	See 1a									
		d. WHO/UNICEF Joint Monitoring Programme, access to improved sanitation	None (updates made through JMP budget)			150 000						

CLUSTER	TWAP INDICATOR	EXISTING DATASET	CORE					OPTIONS FOR ADDING VALUE				
			Core Additional activities required for TWAP [1]	Total cost	Partner Co-financing: Cash [2]	Partner Co-financing: In-kind [3]	Requested GEF contribution	Optional activities required for TWAP	Total cost US$	Co-financing : Cash US$	Partner Co-financing : In-kind US$	Requested GEF [4] contribution US$
		e. Stockholm Convention Secretariat	None (updates made through Convention budget)									
		f. Rotterdam Convention Secretariat	None (updates made through Convention budget)									
			Indicator processing (UNEP-DHI)				30 000					
			Sub-total	**180 000**	**0**	**150 000**	**30 000**	**Sub-total**	**0**	**0**	**0**	**0**
ECOSYSTEMS	**6. Biodiversity and habitat loss**	a. Kassel/Frankfurt, GLWD[7] [2000?, 2004]	Update by Kassel/Frankfurt Universities required				XXX					
		b. IUCN, Red List Index [updated yearly with 2 yr lag, pub. yearly]	Re-aggregation required to basin level + updates for regional (e.g. Pan-African) or taxa-specific (e.g. Amphibians) assessments			615 000	75 000				615 000	140 000
			Indicator processing (IUCN)				35.000					
			Sub-total	**725 000**	**0**	**615 000**	**110 000**	**Sub-total**	**755 000**	**0**	**615 000**	**140 000**
	7. Ecosystem degradation	a. CUNY, river fragmentation, flow disruption, dam density [ca. 2000; Vörösmarty, *et al.*, 2010]	Derived from 7b, 7c			400 000					400 000	
		b. GWSP, global reservoir & dam database [near contemporary, expected pub. 2011]	None: use existing			150 000		Expansion to next 5,000 dams/ reservoirs			150 000	150 000
		c. CUNY, small reservoir dataset [near contemporary; Vörösmarty, *et al.*, 2010, based on Vörösmarty, *et al.*, 2003]	None: use existing					Enhance, check with remote sensing data				75 000
		d. CUNY integrated threat maps of ecosystem loss; coupled to ecosystem services decrement	None: use existing					Update to 2010				75 000

CLUSTER	TWAP INDICATOR	EXISTING DATASET	CORE					OPTIONS FOR ADDING VALUE				
			Core Additional activities required for TWAP [1]	Total cost	Partner Co-financing: Cash [2]	Partner Co-financing: In-kind [3]	Requested GEF contribution	Optional activities required for TWAP	Total cost US$	Co-financing : Cash US$	Partner Co-financing : In-kind US$	Requested GEF [4] contribution US$
		e. Core data and indicator toolkit development									400 000	300 000
			Indicator processing (CUNY)				35 000					
			Sub-total	**585 000**	**0**	**550 000**	**35 000**	**Sub-total**	**1 550 000**	**0**	**950 000**	**600 000**
	8. Fish threat	a. CUNY, gridded fish catch, potential fish production, proportion of non-native fishes, primary productivity, fish catch [2001?, pub. 2010]	None			45 000		Updating to 2010			45 000	15 000
		b. FAO, FishStat Plus, fish catch										
			Indicator processing (CUNY)				30 000					
			Sub-total	**75 000**	**0**	**45 000**	**30 000**	**Sub-total**	**60 000**	**0**	**45 000**	**15 000**
GOVERNANCE	**9. Governance architecture**	a. OSU, Country-Basin Unit database [2007?, pub. 2010]										
		b. UNEP-DHI Centre/SIWI, Rio+20 status report on IWRM (in progress) (exp. Pub. 2012), Regional Water Governance Benchmarking Project 2008-2011 (SIWI)	Questionnaires prepared, distributed to basin/regional experts (UNEP-DHI/SIWI)		25 000	600 000	100 000				550 000	100 000
			Indicator processing (UNEP-DHI)				30 000					
			Sub-total	**755 000**	**25 000**	**600 000**	**130 000**	**Sub-total**	**650 000**	**0**	**550 000**	**100 000**
	10. River basin resilience	a. OSU, Transboundary Freshwater Dispute Database [2009, publication under preparation]	None: Use existing					Incorporating the GW component of instit. Resil. & Indicat. proc. (OSU)			175 000	70 000
		b. OSU Mapping the Resilience of International River Basins to Future Climate Change-Induced Water Variability [2009, pub. 2010]										

CLUSTER	TWAP INDICATOR	EXISTING DATASET	CORE					OPTIONS FOR ADDING VALUE				
			Core Additional activities required for TWAP [1]	Total cost	Partner Co-financing: Cash [2]	Partner Co-financing: In-kind [3]	Requested GEF contribution	Optional activities required for TWAP	Total cost US$	Co-financing : Cash US$	Partner Co-financing : In-kind US$	Requested GEF [4] contribution US$
		c. ISARM worldwide atlas [pub. 2009]										
			Indicator processing (OSU)				30 000					
			Sub-total	**30 000**	**0**	**0**	**30 000**	**Sub-total**	**245 000**	**0**	**175 000**	**70 000**
	11. Water legislation	a. UNEP-DHI Centre, Rio+20 status report on IWRM (in progress) (exp. Pub. 2012), see 9b	See 9b									
			Indicator processing (SIWI/UNEP-DHI)				40 000					
			Sub-total	**40 000**	**0**	**0**	**40 000**	**Sub-total**	**0**	**0**	**0**	**0**
SOCIOECONOMIC	**12. Economic dependence**	a. CIESIN, Gridded Population of the World, see 2b	See 2b									
		b. CIESIN, GDP per unit area [yr?, pub 2005]	None									
		c. World Bank, World Development Indicators, GDP, agricultural GDP, GDP per unit energy use [updated yearly, with a few years lag, depending on the indicator, pub. yearly]	None (updates made through World Bank budget)									
		d. WaterGAP, water withdrawals, see 1b	See 1b									
		e. Kassel/Frankfurt, agricultural area										
		f. FAO, FishStat Plus, total inland fish catch	None (updates made through FAO budget)									
		g. World Bank/FAO/WorldFish Centre, GDP from fish catch				?					?	
		h. CUNY, gridded fish catch [2001, pub. 2010]	see 8a								?	

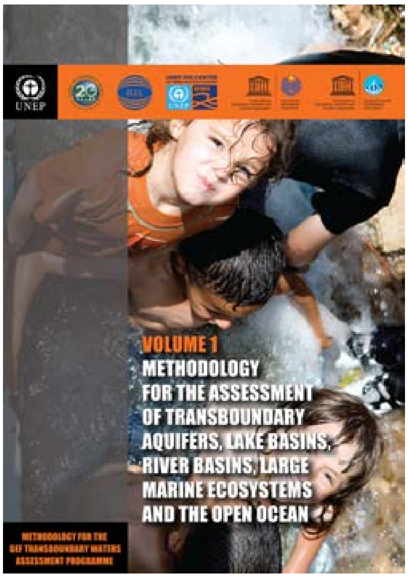
CLUSTER	TWAP INDICATOR	EXISTING DATASET	CORE					OPTIONS FOR ADDING VALUE				
			Core Additional activities required for TWAP [1]	Total cost	Partner Co-financing: Cash [2]	Partner Co-financing: In-kind [3]	Requested GEF contribution	Optional activities required for TWAP	Total cost US$	Co-financing : Cash US$	Partner Co-financing : In-kind US$	Requested GEF [4] contribution US$
SOCIOECONOMIC (cont.)		i. US EIA, energy consumption per capita [updated yearly with 2 yr lag, pub. yearly]	none									
			Indicator processing (UNEP-DHI/SIWI)				60 000					
			Sub-total	**60 000**	**0**	**0**	**60 000**	**Sub-total**	**0**	**0**	**0**	**0**
	13. Societal well-being	a. CIESIN, Gridded Population of the World, see 2b	See 2b					See 2b				
		b. WHO/UNICEF JMP, access to improved water supply										
		c. WHO/UNICEF JMP, access to improved sanitat., see 5d	See 5d					See 5d				
		d. UNDP Human Development Report, Adult literacy & life expectancy [updated yearly with 2 yr. lag, pub. yearly]										
		e. UNDP, GINI coefficient										
			Indicator processing (UNEP-DHI/SIWI)			50 000	50 000					
			Sub-total	**100 000**	**50 000**		**50 000**		**0**	**0**	**0**	**0**
	14. Vulnerability	a. CIESIN, Gridded Population of the World, see 2b	See 2b									
		b. CIESIN, GDP per unit area [pub 2005], see 12b	See 12b			100 000	10 000					
		c. CIESIN, Drought hazard, flood hazard, mortality and economic-loss related vulnerability coefficients [pub 2005].				100 000	20 000	inputs from UNEP-GRID Europe		XXX	XXX	XXX
			Indicator processing (CIESIN)				20 000	Indicator processing (CIESIN/GRID?)				
			Sub-total	**250 000**	**0**	**200 000**	**50 000**	**Sub-total**	**0**	**0**	**0**	**0**

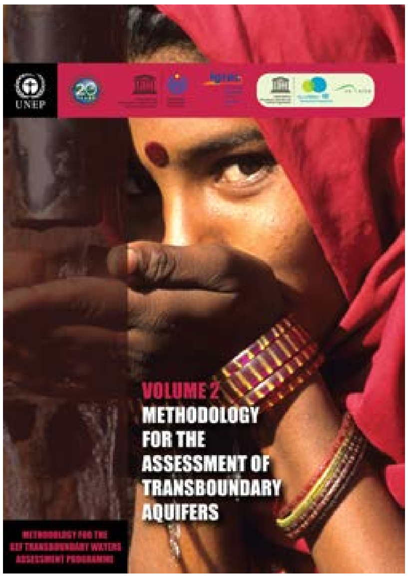
CLUSTER	TWAP INDICATOR	EXISTING DATASET	CORE					OPTIONS FOR ADDING VALUE				
			Core Additional activities required for TWAP [1]	Total cost	Partner Co-financing: Cash [2]	Partner Co-financing: In-kind [3]	Requested GEF contribution	Optional activities required for TWAP	Total cost US$	Co-financing : Cash US$	Partner Co-financing : In-kind US$	Requested GEF [4] contribution US$
PROJECTED TRANS-BOUNDARY STRESS (2030/2050)	1. Environmental water stress	a. See 1	Make projections (Kassel/Frankfurt)	40 000			40 000					
	2. Human water stress	a. See 2	Make projections (CUNY)	40 000			40 000					
	3. Nutrient pollution	a. See 4	Make projections (IGBP)	20 000			20 000					
	4. Population density	a. CIESIN, Gridded Population of the World, see 2b	Make projections (CIESIN)	20 000			20 000					
	5. River basin resilience	a. OSU, Basin At Risk Database, [2000, Wolf, *et al.*, 2003]	Mapping of factors influencing future hydropolitical tensions	307 000		227 000	80 000					
		b. OSU, International Water Events Database, period 1948-2008 [updated in 2008, De Stefano, *et al.*, 2009]		0								
		c. OSU, Transboundary Freshwater Dispute Database [2009; Giordano, *et al.*, under preparation] see 10a		0								
		d. Hydropower and Dams World Atlas [pub 2010].		0								

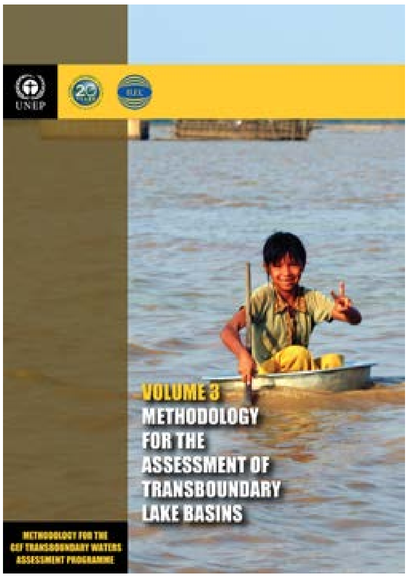
CLUSTER	TWAP INDICATOR	EXISTING DATASET	CORE					OPTIONS FOR ADDING VALUE				
			Core Additional activities required for TWAP [1]	Total cost	Partner Co-financing: Cash [2]	Partner Co-financing: In-kind [3]	Requested GEF contribution	Optional activities required for TWAP	Total cost US$	Co-financing : Cash US$	Partner Co-financing : In-kind US$	Requested GEF [4] contribution US$
			Indicator processing (OSU)	20 000			20 000					
			Sub-total	**447 000**	**0**	**227 000**	**220 000**	**Sub-total**	**0**	**0**	**0**	**0**
LEVEL 2		Building on existing work (e.g. TDA) from selected basins			20 000	200 000	200 000					
			Sub-total	**420 000**	**20 000**	**200 000**	**200 000**	**Sub-total**	**0**	**0**	**0**	**0**
Cross-cutting groups & issues			NA	300 000	75 000	75 000	150 000	NA	0			
Assessment analysis & reporting			NA	300 000	75 000	75 000	150 000	NA	0			
Sustainability & outreach			NA	70 000		35 000	35 000	NA				
PROJECT MANAGEMENT		Contract management of consortium partners (contracts, financial reporting, Auditing including dispersal of funds)			60 000		30 000					
		Progress/financial reporting to secretariat			60 000		37 500					
		Arrangement of meetings/workshops with consortium partners			40 000		15 000					
		Internal information flows to/between partners			40 000		15 000					
			Sub-total	**297 500**	**200 000**	**0**	**97 500**	**Sub-total**	**0**	**0**	**0**	**0**
Contingency		In-kind co-financing, e.g. staff time	NA	200 000	0	100 000	100 000	NA	0	0		
TOTAL				**6 097 500**	**445 000**	**3 755 000**	**1 897 500**		**4 762 000**	**0**	**2 985 000**	**1 777 000**

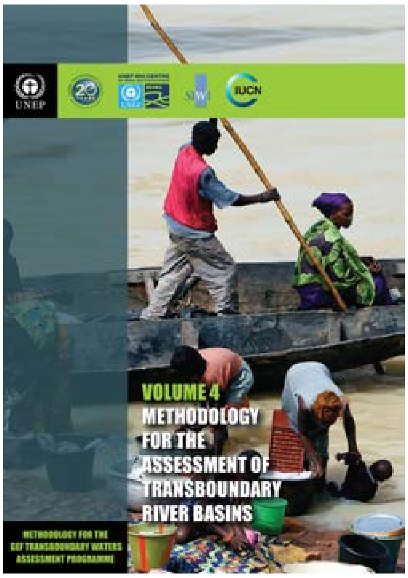
METHODOLOGY FOR THE GEF TRANSBOUNDARY WATERS ASSESSMENT PROGRAMME

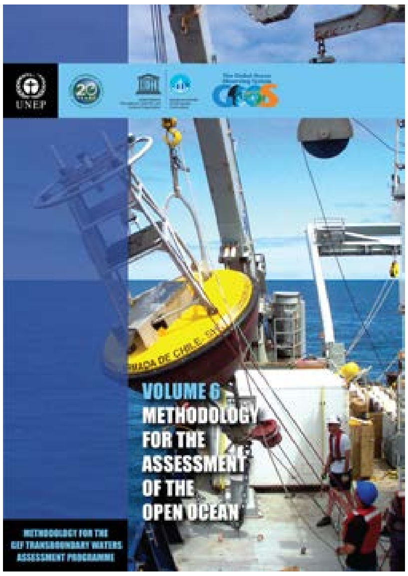
Volumes 1-6











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The water systems of the world - aquifers, lakes, rivers, large marine ecosystems, and open ocean - support the socioeconomic development and wellbeing of the world's population. Many of these systems are shared by two or more nations and these transboundary resources are interlinked by a complex web of environmental, political, economic and security interdependencies. In order to address this challenge UNEP, under the auspices of the GEF, coordinated over a 2 years period from 2009 to 2011 the implementation of the Medium Size Project (MSP) entitled "Development of the Methodology and Arrangements for the GEF Transboundary Waters Assessment Programme (TWAP)".

This Project produced methodologies for transboundary water systems. The final results of this Project are presented in the following six volumes:

Volume 1 - Methodology for the Assessment of Transboundary Aquifers, Lake Basins, River Basins, Large Marine Ecosystems and the Open Ocean;
Volume 2 - Methodology for the Assessment of Transboundary Aquifers;
Volume 3 - Methodology for the Assessment of Transboundary Lake Basins;
Volume 4 - Methodology for the Assessment of Transboundary River Basins;
Volume 5 - Methodology for the Assessment of Large Marine Ecosystems; and
Volume 6 - Methodology for the Assessment of the Open Ocean.

This Project has been implemented by UNEP in partnership with the following lead agencies for each of the water systems: the International Hydrological Programme (IHP) of the United Nations Educational, Scientific and Cultural Organization (UNESCO) for transboundary aquifers including aquifers in small island developing states (SIDS); the International Lake Environment Committee (ILEC) for lake basins; UNEP-DHI Centre for Water and Environment (UNEP-DHI) for river basins; and Intergovernmental Oceanographic Commission (IOC) of UNESCO for large marine ecosystems and the open ocean.

ISBN: 978-92-807-3118-7
DEW/1323/NA