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WORLD'S LARGE RIVERS INITIATIVE (WLRI) REPORT

Sub-item 6.9 of the provisional agenda

Summary

This document presents the World´s Large River Initiative (WLRI) report that includes the activities, proposed methodology of the initiative, outcomes of the working group meetings, publications and research, as well as an outlook of the initiave and a concept paper for further activities.

WORLD'S LARGE RIVERS INITIATIVE (WLRI) REPORT

Title of the Initiative:	World's Large Rivers Initiative (WLRI)
Host Institution:	UNESCO Chair on "Integrated River Research and Management" at the University of Natural Resources and Life Sciences, Vienna, Austria (BOKU)
Date of establishment:	June 2014 (IHP-IC-21)
Report established by:	Prof. Dr. Helmut Habersack (UNESCO Chairholder) Dr. Doris Gangl (Senior Scientist)

Executive Summary

The World's Large Rivers Initiative (WLRI) is of scientific nature and aims to create the knowledge base required for a holistic scientific assessment of the status and possible future of the world's large rivers. Furthermore, it aims to develop innovative strategies based on best practices for their sustainable management. The WLRI serves as a scientific platform for peer learning that will ultimately compile global data in a comprehensive format, as accessible reference for innovation and development. Rivers are complex, dynamic and diverse ecosystems with major ecological, social, economic and cultural significance for their communities and the world at large.
The WLRI was established as an IHP initiative at the 21st session of the Intergovernmental Council of the International Hydrological Programme (IHP-Council) in 2014 (Resolution XXI-3). It supports the achievement of internationally agreed commitments such as the Agenda 2030, in particular SDG 6, the United Nations Framework Convention on Climate Change, the Paris Agreement and the Convention on Biological Diversity. It further supports an integrated approach across UNESCO programmes such as the IHP, World Water Assessment Programme (WWAP), the Man and the Biosphere (MAB) Programme and the International Geoscience Programme. The WLRI directly contributes to MLA 3, Expected Result 7 of 39 C/5, strengthening Member States' response to water security challenges, towards the achievement of water-related Sustainable Development Goals (SDGs) and targets, and other targets from relevant international water agendas.

The WLRI is hosted by the UNESCO Chair on Integrated River Research and Management based at the University of Natural Resources and Life Sciences, Vienna, Austria who will continue to function as a secretariat of the WLRI at no cost to UNESCO.
In accordance with Resolution XXI-3 adopted at the 21st session of the Intergovernmental Council of IHP a Working Group of member states of the IHP was established and met three times on 25 and 26 June 2015, 27 and 28 June 2016 and on 17 and 18 May 2018 to elaborate the scope, activities and desired outputs of the initiative. All delegations, international experts and all regions were invited, and representatives from over 30 Member States participated in the Working Group Meetings. The Working Group has fulfilled its mandate by clarifying the scientific scope of the initiative (definition of large rivers) as well as a common methodology, activities and desired outputs.
After a testing phase of the methodology (Phase I) on three rivers (Danube, Mekong, Niger) on the basis of a harmonized and commonly agreed upon method for assessing the status of large rivers, up to 300 rivers will be assessed on a voluntary basis (Phase II). As a result, the first ever Global Status Report on WLRs will be produced. It will contribute to promoting an integrated and sustainable river management by providing comparable baseline information for decision makers, funding bodies, researchers, civil society and river managers. The WLRI was presented at a side event during the 23rd session of the IHP Intergovernmental Council.
Other activities of the WLRI included the organization of World's Large Rivers Conferences every three years e.g. in Manaus, Brazil in 2014 and in New Delhi, India in 2017, as well as numerous research and educational activities. The planning for the next World's Large Rivers Conference in 2020 is ongoing. The scientific output of the previous conferences has led to publication of ten special issues in top SCI (Scientific Citation Index) journals (further three are in preparation).

Background and Aims

Rivers are complex, dynamic and diverse ecosystems with major ecological, social, economic and cultural significance. They are fundamental to life, water security and possess major cultural significance. Rivers provide people with multiple goods and services, such as drinking water, food, hydropower, navigation, irrigation and recreation. At the same time large rivers are among the most modified systems worldwide. Their basins are threatened by increasing human pressures and more frequent and severe floods and droughts driven by climate change and land-use alteration, which jointly alter morphology, increase pollution, degrade aquatic habitats and rapidly decrease biological diversity.

The WLRI is of scientific nature and aims to create the knowledge base required for a holistic scientific assessment of the status and possible future of the world's large rivers. Furthermore, it aims to develop innovative strategies based on best practices for their sustainable management. The WLRI will, as a scientific platform for peer learning, ultimately compile global data in a comprehensive format creating an accessible reference for innovation and development. After a testing phase of the methodology (Phase I) on three rivers (Danube, Mekong, Niger) on the basis of a harmonized and commonly agreed upon method for assessing the status of large rivers, up to 300 rivers will be assessed on a voluntary basis (Phase II). As a result, the first ever Global Status Report on WLRs will be produced. It will contribute to promoting an integrated and sustainable river management by providing comparable baseline information for decision makers, funding bodies, researchers, civil society and river managers. Every three years, the WLRI organizes the World's Large Rivers Conferences, aiming to gather scientists, discuss novel research and to publish articles in high-ranking scientific journals. Promoting and organising a variety of educational activities are also part of the initiative's objectives.

The WLRI supports the achievement of internationally agreed commitments such as the Agenda 2030, in particular SDG 6, the United Nations Framework Convention on Climate Change and the Paris Agreement as well as the Convention on Biological Diversity. It further supports an integrated approach across UNESCO programmes such as the IHP, World Water Assessment Programme (WWAP), the Man and the Biosphere (MAB) Programme and the International Geoscience Programme. It directly contributes to MLA 3, Expected Result 7 of 39 C/5, strengthening Member States' response to water security challenges, towards the achievement of water-related Sustainable Development Goals (SDGs) and targets, and other targets from relevant international water agendas.

Activities

Activity 1: Create a global overview of the present and future status of WLRs

On the basis of a common methodology for a holistic, scientific assessment of the status and possible future of WLRs – with member states participating on a voluntary basis –, the first ever Global Status Report on WLRs will be produced . (see *Methodology* and *Research and Publications*).

Activity 2: Close knowledge gaps, foster knowledge transfer

Several activities have been successfully implemented by the WLRI including student exchanges, outreach activities (e.g. Children University programme), the supervision of Master and PhD theses and the organisation of guest seminars (see *Education*). A website for information and data exchange has been set up (http://unesco-chair.boku.ac.at/). A separate website is maintained for the WLR Conferences (http://worldslargerivers.boku.ac.at/wlr/).

Activity 3: Formulate a collaborative International Research Action Plan on WLRs

A Working Group of member states of the IHP in fulfilment of its mandate in accordance with Resolution XXI-3 adopted at the 21st session of the Intergovernmental Council of IHP elaborated the scope, activities and desired outputs of the initiative (see *Working Group Meetings*).

Activity 4: Establish a World River Forum, World Rivers Day and WLRs Commission Meetings

Collaborations with several River Commissions were initiated at the three WLR Conferences (Vienna, Manaus, New Delhi) and the International Summit "Water and Climate – Meeting of the Great Rivers of the World" in Rome, Italy in October 2017 (see *Interuniversity Exchanges / Partnerships*).

Activity 5: Organise future Conferences on the World's Large Rivers

Three International World's Large Rivers Conferences have been organised in Vienna/Austria (2011), Manaus/Brazil (2014) and New Delhi/India (2017). The fourth conference will take place in 2020 and planning is currently underway (see *International Conferences organized by the WLRI*).

Methodology

The methodology of the WLRI was elaborated in a Working Group (WG) of member states of the IHP. It is summarised in a Concept Paper (see Annex to this Reference Document) and also includes the background, aims and activities of the initiative. This Concept Paper was drafted in the follow-up of the first WG meeting, further developed during the 2nd WG meeting and finalized in the 3rd WG meeting.

Common Methodology for Activity 1 as defined in the Concept Paper:

The structural working plan for the global overview of the status and future of WLRs is divided into three stages:

Concept Paper/(Pre-)Feasibility-Study:

The Concept Paper describes the common methodology and includes a set of parameters as well as a list of three rivers (Danube, Mekong and Niger) for the first assessment.

Phase I:

Phase I is the testing phase of the methodology on three rivers. The outcome of this phase will be a harmonized and commonly agreed method for assessing the status of WLRs as well as the status report of these rivers.

Phase II:

Phase II will involve the assessment of up to 300 rivers. The end product will be a status report of the WLRs in order to support member states, upon their request, with strategies for sustainable river management regarding technical, economic, and ecological needs and to provide comparable baseline information for decision makers, funding bodies, researcher, civil society and river managers. This will be the first global status report on large rivers using a common methodology. The main outcomes will be presented in a similar way for all 300 rivers and compiled in a summary report (including the description of the methodology).

Selection of rivers:

The first step of the methodological approach was based on (a) an evaluation of expert suggestions, questionnaires and existing project information, (b) a database of the 100 largest rivers (according to river length, discharge, catchment size) in order to (c) select three large rivers for the testing phase (Phase I). The Working Group agreed that in order to facilitate an inclusive process other criteria like cultural and economic significance could be taken into account as well when moving into Phase II of the project. The comprehensive project data research ("data mining") comprised existing World Bank and other projects of UN organisations on large rivers dealing with issues of the 4 thematic fields hydrology & hydraulics, sediment transport & morphodynamics, water quality & ecology and river management & socioeconomics. In particular, it was investigated how many research projects (incl. the project budget and the thematic focus) on large rivers had been conducted, especially in the recent past. Based on this evaluation, useful information on the regional / river basin-related research focus of the World Bank, UNDP and UNEP / GEF could be gathered.

To ensure a broad involvement and expert input of participating countries the attendees of the 1st Working Group Meeting of the WLRI were encouraged to send a preliminary list of ten large rivers (including brief reasons for their suggestions). Moreover, a questionnaire was drafted to additionally involve experts of the World Bank, UNEP, UNDP, GEF, ADB and WWF in the decision making process by asking for a list of ten economically, environmentally and socially relevant rivers from their organizations' point of view.

Based on the priorities assigned to the list of preselected rivers by internal and external experts and discussions at the 2nd WG meeting, the three rivers Danube, Mekong and Niger were selected for Phase I. These rivers will serve as a proof of concept to test the methodology. Representatives responsible for supporting the WLRI team with data and contacts for those three rivers were chosen at the same meeting. These are Helmut Habersack (Danube), Gil Mahé (Niger) and Siegfried Demuth (Mekong).

On successful completion of Phase I, assessments will be completed for up to 300 large rivers in Phase II, whereby the maximum number will depend on the available financial means, provided data, participating countries etc. and thus could be much smaller.

Definition and Selection of Parameters

In the course of the 1st Working Group Meeting of the WLRI in 2015 in Vienna, a set of parameters was elaborated by the thematic coordinators of the WLRI. Based on the outcomes of the WG discussions, individual suggestions by experts and a web-based data research of existing online-

databases related to large rivers, a first draft set of parameters was decided upon. The parameters were categorized according to the thematic fields hydrology & hydraulics, sediment transport & morphodynamics, water quality & ecology and river management & socioeconomics.

After the 2nd Working Group Meeting questionnaires were distributed among all participants of the WLRI in order to select the parameters of highest importance for Phase I. Based on the feedback a refined list of parameters was determined. The chosen representatives for the rivers Danube, Mekong and Niger will assist the collection of data with regards to these parameters.

Analysis of three Rivers

With the aim to create a neutral, evidence-based status report of large rivers several standardized analytical approaches have to be derived dealing, for example, with the following aspects (extract):

- Temporal / downstream development of parameters and derivation of standardized diagrams
- Interrelation between parameters (e.g. mean annual discharge – suspended load; land use – river morphology / ecological status)
- Spatial and temporal heterogeneity of parameters
- Extreme values

Working Group Meetings

Hosted by the UNESCO Chair on Integrated River Research and Management at the University of Natural Resources and Life Sciences, Vienna in Austria, a Working Group of member states of the IHP met three times in Vienna and defined the scope, including the definition of large rivers and a common methodology, as well as the activities and desired outputs of the initiative. All delegations, international experts and all regions were invited, and representatives from over 30 Member States participated in the Working Group meetings.

The 1st WLRI Working Group meeting took place from 24 to 25 June 2015 in Vienna and provided a forum for wide-ranging discussions on the scope of the WLRI and possible approaches for an integrated, international project for the assessment of the status and the future of WLRs. The methodology was defined, the scientific scope clarified and the development of a concept paper suggested. The definition of large rivers was discussed and agreed. For the purpose of the WLRI, the WMO definition of large rivers will be used (according to mean annual discharge), but can be extended during further development of the WLRI. In order to facilitate an inclusive process other quantitative and qualitative criteria can be taken into account (e.g. the natural, cultural and economic significance of rivers).

The 2nd WLRI Working Group meeting took place from 27 to 28 June 2016 in Vienna and further developed the international and interdisciplinary project. The concept paper/pre-feasibility study was presented and discussed. The parameters for the assessment of rivers in Phase I and II were reviewed and debated. In addition, three rivers were selected for Phase I (Danube, Niger, Mekong).

The 3rd WLRI Working Group meeting took place from 17 to 18 May 2018. The concept paper was finalised and first results of the project were presented. The next steps with regard to the project funding (e.g. World Bank) were discussed.

International Conferences organized by the WLRI every three years

International Conferences on the Status and Future of the World´s Large Rivers (co-sponsored by UNESCO, IAHR, IAHS, WASER and IAG)

1st international WLR Conference in Vienna, Austria from 11 to 14 April 2011

- First public discussion of the WLRI
- Recommendation of a collaborative, multidisciplinary and international initiative

2nd international WLR Conference in Manaus, Brazil from 21 to 24 July 2014

- Scientific presentations on all aspects of WLRs
- Discussion on the scope of the WLRI, scale definitions, WLRI activities and next WLR conference venue

3rd international WLR Conference in New Delhi, India from 18 to 21 April 2017.

- Scientific presentations on all aspects of WLRs
- Discussion of the publication of further special issues SCI journals

4th international WLR Conference: planned for 2020

- Currently in the planning phase
- More information announced in 2018

Other meetings:

- Besides organising the above mentioned meetings and conferences, the WLRI was presented at more than 13 events by the UNESCO Chairholder and colleagues.

Research and Publications

Publications within WLRI:

The WLRI has **published ten special issues with 143 articles and 554 authors** following the International Conferences in top SCI journals. An additional three special issues are in preparation [see also Annex I].

In preparation:

- ***International Journal of River Basin Management*** (ed. Habersack, Eder, Tritthart, Liedermann (in prep.)): **Major Issues in Large Rivers' Basin Management**.
- ***Hydrological Processes*** (ed. Habersack, Eder, Tritthart, Liedermann (in prep.)): **Hydrological Challenges for the Status and Future of World's Large Rivers**.
- ***Journal of Hydraulic Engineering*** (ed. Habersack, Eder, Tritthart, Liedermann (in prep.)): **Hydraulic Engineering in Large Rivers**.

Published:

- ***Hydrobiologia*** 814, 1-246 (ed. Habersack, Samek, Eder (2018)): **Multifunctionality of Large Rivers**.
- ***Environmental Science and Pollution Research*** 23, 11393-12490 (ed. Habersack, Samek (2016)): **Water quality issues and management of large rivers**.
- ***Natural Hazards*** 75, 1-105 (ed. Habersack, Haspel, Schober (2015)): **Flood prevention and mitigation at large rivers**.
- ***Water Resources Research*** 50, 3641-4544 (ed. Habersack, Haspel, Kondolf (2014)): **Large Rivers in the Anthropocene: Insights and tools for understanding climatic, land use, and reservoir influences**.
- ***Hydrobiologia***. 729, 1-259 (ed. Habersack, Haspel, Muhar, Waidbacher (2014)): **Impact of human activities on biodiversity of large rivers**.
- ***Geomorphology***, 215, 1-106 (ed. Habersack, Haspel, Schober (2014)): **Morphological characterization and fluvial processes of large rivers at different time scales**.

- ***River Systems***, 20, 145-287, (ed. Habersack, Hein (2013)): **Integrating landscape, catchment perspectives, ecology, management**.

- ***International Journal of River Basin Management***. 11, 137-236 (ed. Habersack, Haspel, Campell (2013)): **Integrated management of large river systems**.

- ***Hydrological Processes***. 27, 2103-2224 (ed. Habersack, Walling (2013)): **The Hydrology of Large Rivers**.

- ***International Journal of Sediment Research***. 28, 431-598 (ed. Habersack, Haspel (2013)): **Sediment loads and processes in large rivers**.

Publication of the WLR Conference Abstract Books:

- Habersack, Filizola, Schober (Eds.) (2014): World's Large Rivers Conference 2014 Manaus, Brazil, Conference Abstract Book.
- National Institute of Hydrology India, University of Natural Resources and Life Sciences Vienna (Eds.) (2017), Proceedings of the 3rd International Conference on the Status and Future of the World's Large Rivers, Conference Abstract Book.

Concept paper:

A concept paper was drafted in the follow-up of the first WLRI Working Group (WG) meeting of member states of the IHP. It was further developed at the 2nd WG meeting and finalized at the 3rd WG meeting. The concept paper includes a common methodology to assess large rivers on a voluntary basis and further clarifies the scope, activities and desired outputs of the initiative.

Questionnaires:

A questionnaire to determine the rivers for phase I of the global project was drafted and distributed among WLRI members and experts of the World Bank, UNEP, UNDP, GEF, ADB, WWF, UNESCO and WMO. A second questionnaire was distributed after the 2nd Working Group meeting to select relevant parameters for Phase I.

Phase I:

In Phase I of the project the common methodology designed within the WLRI will be tested on the three rivers Danube, Mekong and Niger. Representatives acting as contact persons for these rivers have been assigned.

Further Research Activities:

The WLRI was the driving force behind the **DREAM (Danube River Research and Management) project** which aims at creating an international research network along the Danube River. It consists of a partnership of universities and research institutions and will be completed by the establishment of two large-scale hydraulic laboratories and the operation of research vessels. The laboratory associated with BOKU university is in its final planning phase. The construction will begin in 2018.

The WLRI supported the establishment of the **Christian Doppler Laboratory for Sediment Research and Management** and supports one of the work packages by linking it to the WLRI Phase II assessment of 300 large rivers.

Education

Theses:

2 Doctoral theses and 9 Master theses have been completed within the scope of the WLRI.

Further events:

- Exchange of two students (MSc/PhD) and one scholar within the CEEPUS (Central European Exchange Program for University Studies) project.

- Participation at the Children University 2015, 2016 and 2017 with the topic River ecological and morphological issues at the Danube River. The Children University programme brings together 7-12-year-old children and researchers from university. The aim is to foster scientific curiosity and make scientific research topics more accessible to the general public.

Guest seminars:

7 guest seminars were organised by the WLRI at which internationally renowned experts presented their research and which offered an opportunity for scientific discussions.

- Prof. Gjetaj (University of Zagreb, Croatia)
- Prof. Fotis Sotiropoulos (University of Minnesota, USA)
- Prof. Koen Blanckaert (University of Hong Kong, China)
- Dr. Arvind Singh (University of Central Florida, USA)
- Prof. Paul Carling (University of Southampton, UK)
- Prof. Vladimir Kukurin (University of Architecture, Civil Engineering and Geodesy, Bulgaria)
- Dr. Graeme Smart (NIWA, New Zealand)

Interuniversity Exchanges / Partnerships

The WLRI started an interaction/partnership with several UNESCO Chairs, Cat. II Centers and other IHP Programmes (e.g. ISI, IDI, FRIEND participated in the 2nd Working Group Meeting) and the Transboundary Water Assessment Programme TWAP (letter of cooperation, M. MacDevette, UNEP, GEF).

As work package leaders for the sectoral themes of the project, the following institutions/persons have agreed to participate in the WLRI:

- Hydrology & Hydraulics: Francis Chiew (Australia)
- Sediment Transport & Morphodynamics: Edgardo Latrubesse (USA)
- Water Quality & Ecology: Marnik Vanclooster (Belgium)
- River Management & Socioeconomics: Luna Bharati (Nepal)

At the 2nd Working Group meeting the three rivers Danube, Mekong and Niger were chosen based on expert discussions and feedback questionnaires. Members of the following institutions have agreed to act as representatives responsible for supporting the WLRI team with data and contacts for those three rivers:

- University of Natural Resources and Life Sciences (Austria): Helmut Habersack
- IRD (France): Gil Mahé
- International Centre for Water Resources and Global Change (Germany): Siegfried Demuth

The WLRI idea was presented at numerous conferences/meetings, e.g.:

- 9 - 19 February 2015: UNESCO Inception Meeting “Addressing Water Security: Climate Impacts and Adaptation responses in Africa, the Americas, Asia and Europe”, Paris, France.
- 19 February 2015: Presentation of the WLRI at the World Bank, UNEP, Washington DC, UNDP, New York, USA.
- 21 - 22 October 2015: WLRI meeting with UNESCO Liaison Office, Brussels, Belgium.
- 26 - 30 October 2015: International Conference on African Large River Basins Hydrology, Hammamet, Tunisia [supported by WLR].
- 24 - 25 May 2016: Participation IHP Region I Meeting in Koblenz, Germany
- 13 - 17 June 2016: Participation at the 22nd session of the IHP Intergovernmental Council. Paris, France
- 25 - 27 October 2016: Cooperation between WLRI and G-WADI in the course of the Global G-WADI Conference in Bejing, China
- 30 November 2016: Presentation at the Western Balkans Sustainable Hydropower Conference in Palais Ferstel, Vienna, Austria
- 15 - 16 June 2017: UNESCO IHP Region I Meeting in Perugia, Italy
- 19 June 2017: Meeting at UNESCO headquarters to discuss possible next steps for the WLRI. Paris, France

- 20 - 22 June 2017: UNESCO IHP Bureau Meeting in Paris, France: Prof. Habersack in the function of Vice-Chair of the IHP for Region I
- 5 - 7 July 2017: Helmut Habersack attended the UNESCO Chair Conference “Mobilising UNESCO Chairs in Natural Science for Policy Action towards the 2030 Agenda” in Geneva, Switzerland and presented a poster on the WLRI
- 23 - 25 October 2017: Participation at the International Summit “Water and Climate – Meeting of the Great Rivers of the World”, future contribution of WLRI, in Rome, Italy

Further exchanges/partnerships include:

- WASER – World Association for Sedimentation and Erosion Research
- International Water Management Institute (IWMI), Sri Lanka / Nepal
- International Commission for the Protection of the Danube River (ICPDR)
- Institute for the Danube Region and Central Europe
- UFAM Universidade Federal do Amazonas, Manaus, Brazil
- Moscow State University, Russia
- UNESCO Khartoum Office / University of Khartoum, Sudan
- Rhodes University, South Africa
- Technical University of Bucharest, Romania
- Czech University of Life Sciences Prague, Czech Republic
- University of Novi Sad, Serbia
- Tsinghua University / ISI / ITRCS Peking UNESCO Cat. II Center, China
- UNESCO Cat. II Centers (e.g. IRTCES, WRGC at BfG), China, Germany
- University of California, Berkeley, USA
- University of Exeter, UK
- Collaboration with the proposed UNESCO Chair on Ecology and Ecohydrology for Water (Security & Scarcity) of Prof. Pradeep Shrivastava at Barkatullah University, Department of Environmental Science & Limnology, Bhopal, India
- Prof. Habersack was elected President of the International Commission for the Hydrology of the Rhine basin (CHR) in 2018

Outlook

The methodology for the global assessment of WLRs in the status report will be updated, if necessary, based on the results of Phase I and implemented in Phase II (applying the methodology up to approx. 300 rivers on a voluntary basis). Funding for the WLRI by the World Bank is currently being discussed. Regarding the WLR Conferences, the venue for the next conference will be selected in 2018. The preparations for the 4th conference in 2020 have started in January 2018. Those countries which have not been selected this time, will be invited to apply again for the 5th conference in 2023 (most likely this conference will take place in Africa). A cooperation with the International Network of Basin Organizations will be started. In interaction with the UNESCO Water Family, the closing of knowledge gaps, knowledge transfer to next generation scientists, stakeholders, decision makers, children (education) and the general public is envisaged. A strong emphasis will be given to achieving a gender balance in all activities related to the WLRI.

Annex I
List of Publications (only papers in SCI journals, published in Special Issues coordinated by the WLRI)

Hydrobiologia, Vol. 814, Issue 1, June 2018

Habersack, H., Eder, M., Samek, R.: Preface: Multifunctionality of large rivers. P. 1-3.

Arias, M.E., Wittmann, F., Parolin, P., Murray-Hudson, M., Cochrane, T.A.: Interactions between flooding and upland disturbance drivers species diversity in large river floodplains. P. 5-17.

Lopes, A., Ferreira, A.B., Pantoja, P.O., Parolin, P., Piedade, M.T.F.: Combined effect of elevated CO_2 level and temperature on germination and initial growth of *Montrichardia arborescens* (L.) Schott (Araceae): a microcosm experiment. P. 19-30.

Li, T., Huang, X., Jiang, X., Wang, X.: Assessment of ecosystem health of the Yellow River with fish index of biotic integrity. P. 31-43.

Schletterer, M., Kuzovlev, V.V., Zhenikov, Y.N., Tuhtan, J.A., Haidvogl, G., Friedrich, T., Górski, K., Füreder, L.: Fish fauna and fisheries of large European rivers: examples from the Volga and the Danube. P. 45-60.

Górski, K., Habit, E.M., Pingram, M.A., Manosalva, A.J.: Variation of the use of marine resources by *Galaxias maculatus* in large Chilean rivers. P. 61-73.

Cron, N., Quick, I., Zumbroich, T.: Assessing and predicting the hydromorphological and ecological quality of federal waterways in Germany: development of a methodological framework. P. 75-87

Haimann, M., Hauer, C., Tritthart, M., Prenner, D., Leitner, P., Moog, O., Habersack, H.: Monitoring and modelling concept for ecological optimized harbour dredging and fine sediment disposal in large rivers. P. 89-107.

Moog, O., Stubauer, I., Haimann, M., Habersack, H., Leitner, P.: Effects of harbour excavating and dredged sediment disposal on the benthic invertebrate fauna of River Danube (Austria). P. 109-120.

Environmental Science and Pollution Research , Vol. 23, Issue 12, June 2016

Habersack, H., Samek, R.: Water quality issues and management of large rivers. P. 11393-11394.

Pantoja, N.G.P., Castro, L.M., Rocha, S.D., Silva, J.A., Ribeiro, J.S.P., Donald, A.R., Silva, L.M., Oliveira, T.C.S.: Quality of the Solimões River water for domestic use by the riverine community situated in Manacapuru-Amazonas-Brazil. P. 11395-11404.

Moquet, J.S., Guyot, J.L., Crave, A., Viers, J., Filizola, N., Martinez, J.M., Oliveira, T.C., Sánchez, L.S.H., Lagane, C., Casimiro, W.S.L., Noriega, L., Pombos, R.: Amazon River dissolved load: temporal dynamics and annual budget from the Andes to the ocean. P. 11405-11429.

Puig, A., Olguín Salinas, H.F., Borús, J.A.: Relevance of the Paraná River hydrology on the fluvial water quality of the Delta Biosphere Reserve. P. 11430-11447.

Yang, H., Wang, G., Wang, L., Zheng, B.: Impact of land use changes on water quality in headwaters oft he Three Gorges Reservoir. P. 11448-11460.

de Paula, J., Luizao, F.J., Piedade, M.T.F.: The size distribution of organic carbon in headwater streams in the Amazon basin. P. 11461-11470.

Puig, A., Olguín Salinas, H.F., Borús, J.A.: Recent changes (1973-2014 versus 1903-1972) in the flow regime of the Lower Paraná River and current fluvial pollution warnings in its Delta Biosphere Reserve. P. 11471-11492.

Yılmaz, E., Koç, C.: Organic pollution of the Büyük Menderes River, Turkey and effects on aquaculture. P. 11493-11506.

Natural Hazards, Vol. 75, Issue 1, February 2015

Habersack, H., Haspel, D., Schober, B.: Flood prevention and mitigation at large rivers. P. 1-3.

Habersack, H., Schober, B., Hauer, C.: Floodplain evaluation matrix (FEM): An interdisciplinary method for evaluating river floodplains in the context of integrated flood risk management. P. 5-32.

Schober, B., Hauer, C., Habersack, H.: A novel assessment of the role of Danube floodplains in flood hazard reduction (FEM method). P. 33-50.

Skublics, D., Rutschmann, P.: Progress in natural flood retention at the Bavarian Danube. P. 51-67.

Ionuş O., Licurici, M., Pătroescu, M., Boengiu, S.: Assessment of flood-prone stripes within the Danube drainage area in the South-West Oltenia Development Region, Romania. P. 69-88.

Teodosiu, C., Robu, B., Cojocariu, C., Barjoveanu, G.: Environmental impact and risk quantification based on selected water quality indicators. P. 89-105.

Geomorphology, Vol. 215, 15 June 2014

Habersack, H., Haspel, D., Schober, B.: Morphological characterization and fluvial processes of large rivers at different time scales. P. 1-2.

Hohensinner, S., Jungwirth, M., Muhar, S., Schmutz, S.: Importance of multi-dimensional morphodynamics for habitat evolution: Danube River 1715–2006. Original research article. P. 3-19.

Klasz, G., Reckendorfer, W., Gabriel, H., Baumgartner, C., Schmalfuss, R., Gutknecht, D.: Natural levee formation along a large and regulated river: The Danube in the National Park Donau-Auen, Austria. Original research article. P. 20-33.

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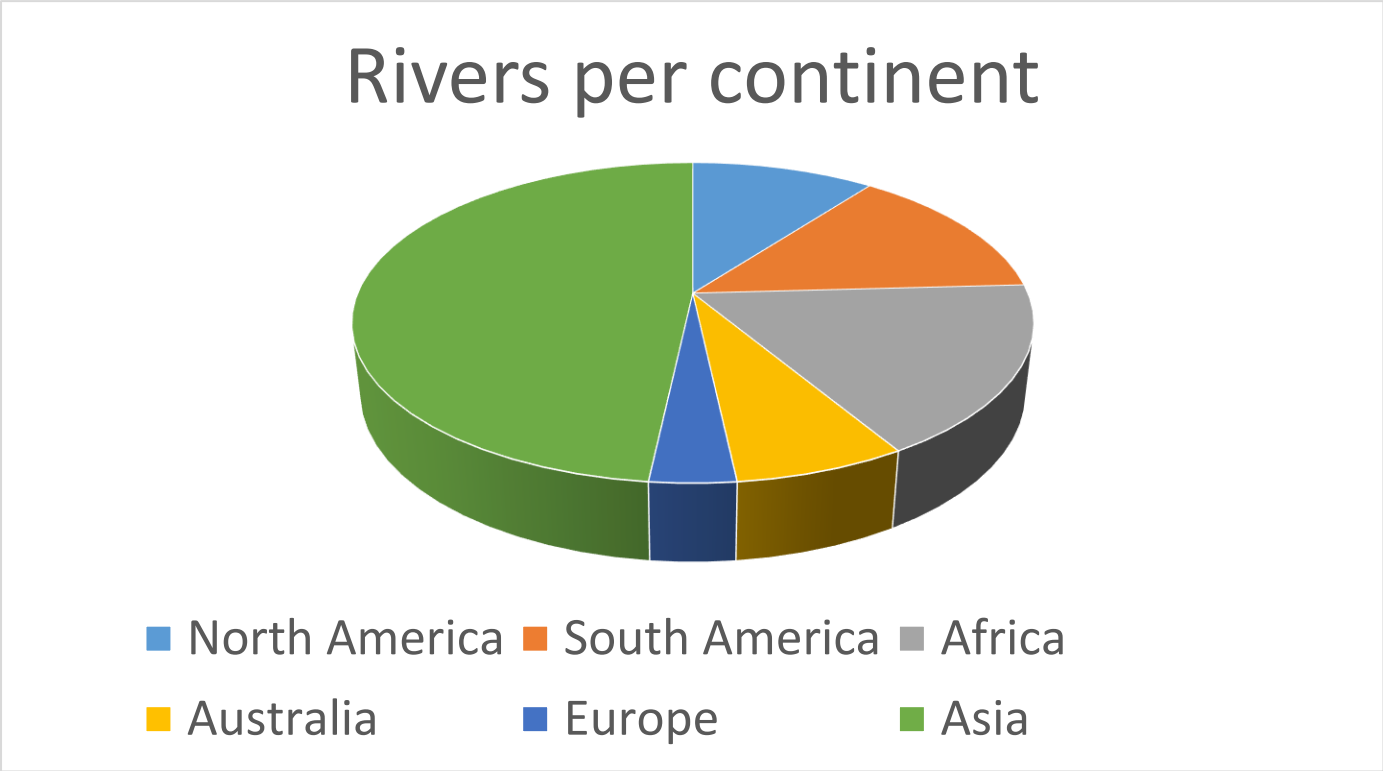

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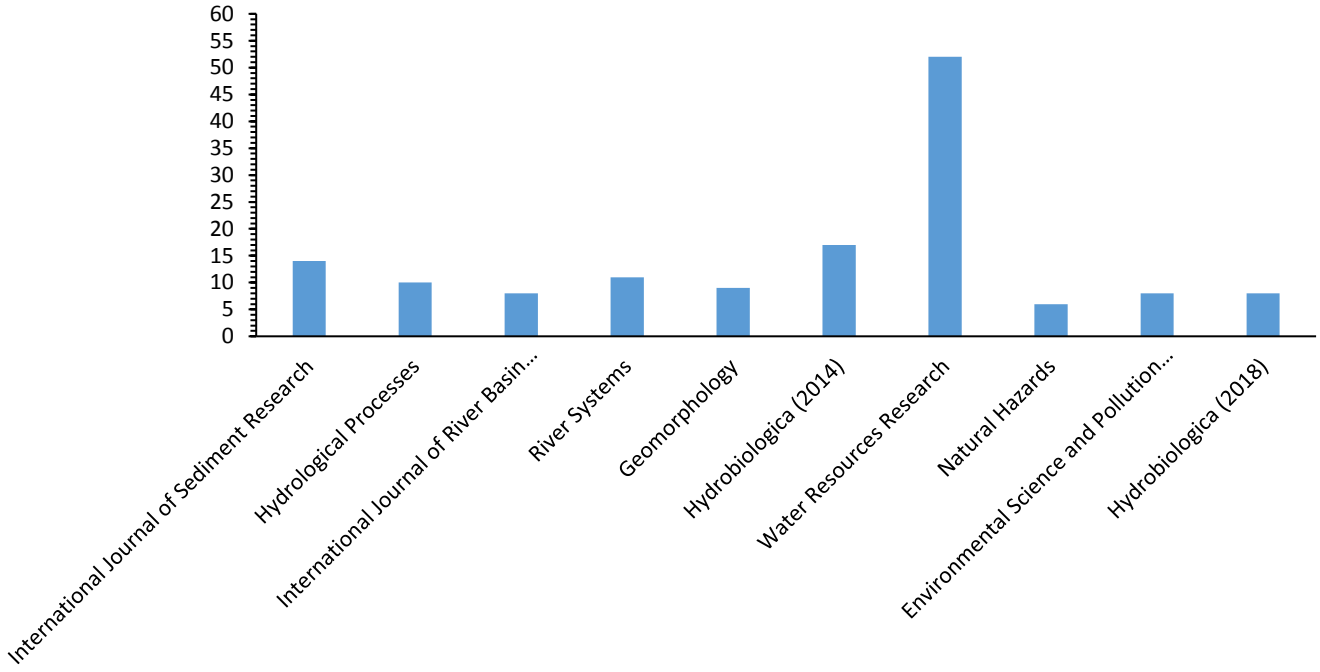

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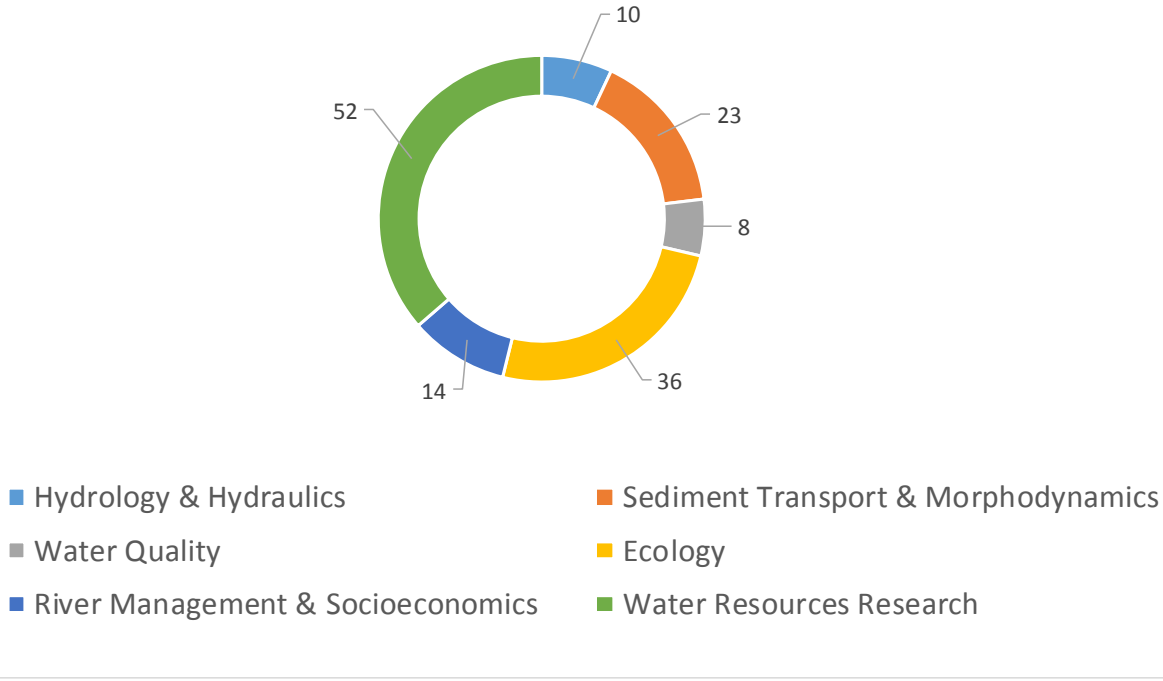

Annex II
(Currently under review)

Concept Paper

Roadmap of the World's Large Rivers Initiative (WLRI)

Vienna, Austria

United Nations Educational, Scientific and Cultural Organization

UNESCO Chair on Integrated River Research and Management Vienna, Austria

IHP – International Hydrological Programme of UNESCO

UNESCO Chair on Integrated River Research and Management, Vienna, Austria

1. Background and Aims

Rivers are complex, dynamic and diverse ecosystems with major ecological, social, economic and cultural significance. They are fundamental to life, water security and possess major cultural significance. Rivers provide people with multiple goods and services, such as drinking water, food, hydropower, navigation, irrigation and recreation. At the same time large rivers are among the most modified systems worldwide. Their basins are threatened by increasing human pressures, more frequent and severe floods and droughts driven by climate change and land-use alteration, which jointly alter morphology, increase pollution, degrade aquatic habitats and rapidly decrease biological diversity.

The WLRI is of scientific nature and aims to create the knowledge base required for a holistic scientific assessment of the status and possible future of the World's Large Rivers. Furthermore, it aims to develop innovative strategies based on best practices for their sustainable management. The WLRI will, as a scientific platform for peer learning, ultimately compile global data in a comprehensive format creating an accessible reference for innovation and development. After a testing phase of the methodology (Phase I) on three rivers (Danube, Mekong, Niger) on the basis of a harmonised and commonly agreed upon method for assessing the status of large rivers, up to 300 rivers will be assessed on a voluntary basis (Phase II). As a result, the first ever global status report on WLRs will be produced. It will contribute to promoting an integrated and sustainable river management by providing comparable baseline information for decision makers, funding bodies, researchers, civil society and river managers. Every three years, the WLRI organises the World's Large Rivers Conferences, aiming to gather scientists, discuss novel research and to publish articles in high-ranking scientific journals. Promoting and organising a variety of educational activities are also part of the initiative's objectives.

The WLRI supports the achievement of internationally agreed commitments such as the Agenda 2030 (in particular SDG 6, but also SDG 1, 2, 3, 13 and 15), the United Nations Framework Convention on Climate Change and the Paris Agreement, the Sendai Framework as well as the Convention on Biological Diversity. It further supports an integrated approach across UNESCO programmes such as the IHP, World Water Assessment Programme (WWAP), the Man and the Biosphere (MAB) Programme and the International Geoscience Programme. It directly contributes to Main Line of Action (MLA) 3, Expected Result 7 of 39 C/5, strengthening Member States' response to water security challenges, towards the achievement of water-related Sustainable Development Goals (SDGs) and targets, and other goals from relevant international water agendas.

2. Objective of the WLRI

The collaborative and interdisciplinary World's Large Rivers Initiative (WLRI) will, as a scientific platform for peer learning, ultimately compile global data in a comprehensive format creating an accessible reference for innovation and development for sustainable management of large rivers.

The specific objectives are:

- To analyse the current state and the future development of the WLRs.
- To establish a platform to build, facilitate, and harvest hydrological science synergies between countries and to provide education and training at technical and tertiary level.
- To develop innovative strategies for the sustainable management of the WLRs for the benefit of both humans and nature, while recognising the individuality of rivers.
- To collaborate with River Commissions.
- To organise future Conferences on the World's Large Rivers.

3. Activities

Act. 1: Create a global overview of the present and future status of WLRs

Act. 2: Close knowledge gaps and foster knowledge transfer

Act. 3: Formulate a collaborative International Research Action Plan on WLRs

Act. 4: Establish a World River Forum, World Rivers Day and WLRs Commission Meetings

Act. 5: Organise future Conferences on the World's Large Rivers

4. Scope of the WLRI

Within the WLRI „large" is defined as a river with a mean annual discharge exceeding 2000 m^3/s at the mouth or with a drainage basin exceeding 500.000 km^2 or a river length exceeding 1000 km (measured at the main stem). In order to facilitate an inclusive process other quantitative and qualitative criteria can be taken into account (e.g. the natural, cultural and economic significance of rivers). The Working Group of member states of the IHP agreed that each member state is welcome to nominate large rivers on a voluntary basis.

5. Structural Working Plan of the WLRI

5.1. Work plan for Activity 1 – Create a global overview of the present and future status of WLRs

To achieve the initiative's objectives, *Activity 1* of the WLRI proposes to create a global overview of the present and future status of WLRs.

The present Concept Paper is embedded in the overall action plan of the WLRI, which was elaborated in a Working Group of member states of the IHP in accordance with Resolution XXI-3 adopted at the 21st session of the Intergovernmental Council of IHP. Figure 1 gives an overview of the general working steps.

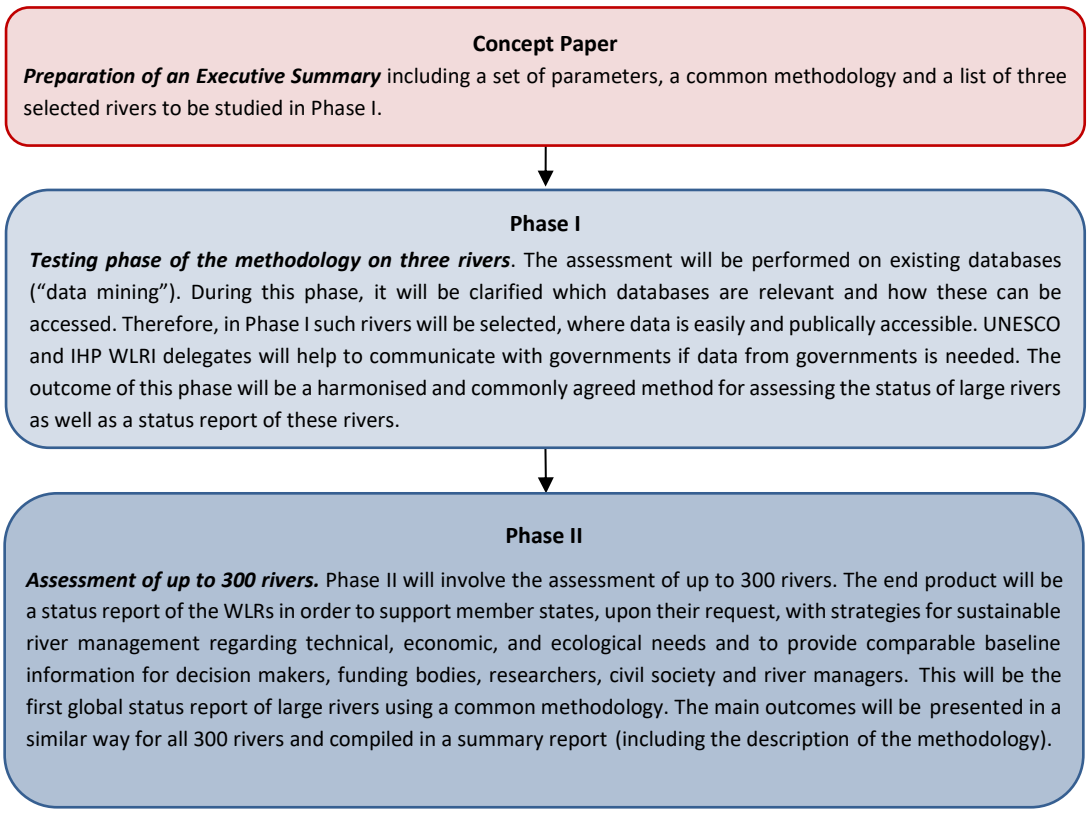

Figure 1: Working plan including the main steps for Activity 1.

5.1.1. Common Methodology

5.1.1.1. Determination of three Rivers for Phase I

The first step of the methodological approach was based on (a) an evaluation of experts suggestions, questionnaires and existing project information, (b) a database of the 100 largest rivers (according to river length, discharge, catchment size) in order to (c) select three rivers for the testing phase (Phase I). A short overview of the methodological steps is given in Figure 2.

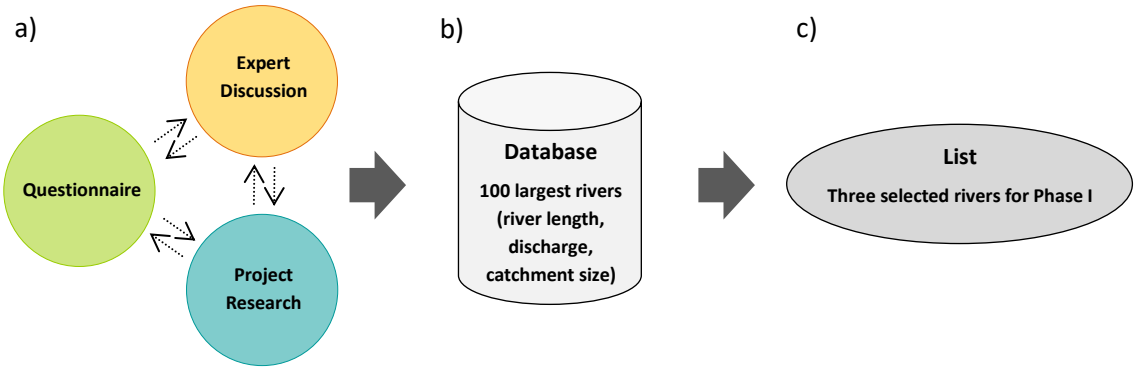

Figure 2: Methodological approach for the determination of three rivers.

The comprehensive project data research ("data mining") comprised existing projects of the World Bank and UNDP on large rivers dealing with issues of the 4 thematic fields *Hydrology & Hydraulics*, *Sediment Transport & Morphodynamics*, *Water Quality & Ecology* and *River Management & Socioeconomics* (period of data collection: 1.12.2015 - 15.1.2016). In particular, it was investigated how many research projects (incl. the project budget and the thematic focus) on large rivers have been conducted, especially

in the recent past. Based on this evaluation, useful information on the regional / river basin-related research focus of the World Bank, UNDP and UNEP / GEF could be gathered.

To ensure a broad involvement and expert input from participating countries the attendees of the 1st Working Group Meeting of the WLRI were encouraged to send a preliminary list of 10 large rivers (including brief reasons for their suggestions). Moreover, a questionnaire has been drafted to additionally involve experts of the World Bank, UNEP, UNDP, GEF, ADB and WWF in the decision making process by asking for a list of 10 economically, environmentally and socially relevant rivers from their organisations' point of view (see Appendix I).

In order to select only large rivers, the suggested rivers (with local researcher support) were synchronised with a database of the 100 largest rivers (according to river length, discharge, catchment size). Based on this step, a matrix of 100 rivers illustrating the results of the previously observed surveys could be developed (see Appendix II).

Based on the priorities assigned to the list of preselected rivers by internal and external experts and the discussions at the 2nd WLRI WG meeting, the three rivers Danube, Mekong and Niger were selected for Phase I. These rivers will serve as a proof of concept to test the methodology. Representatives responsible for supporting the WLRI team with data and contacts for those three rivers were chosen at the same meeting. These are Helmut Habersack (Danube), Gil Mahé (Niger) and Siegfried Demuth (Mekong).

On successful completion of Phase I, assessments will be completed for up to 300 large rivers in Phase II, whereby the maximum number will depend on the available financial means, provided data, participating countries etc. and thus could be much smaller.

5.1.1.2. Definition and Selection of Parameters

In the course of the 1st Working Group Meeting of the WLRI in 2015 a set of parameters has been suggested and elaborated by the thematic coordinators of the WLRI. Based on the outcomes of the WGs, individual suggestions by experts and a web-based data research of existing Online-Databases related to large rivers (see Appendix III), a first draft set of parameters was decided upon. The parameters have been categorised according to the thematic fields *Hydrology & Hydraulics*, *Sediment Transport & Morphodynamics*, *Water Quality & Ecology* and *River Management & Socioeconomics* (Table 1).

In the follow-up of the 2nd Working Group Meeting of the WLRI a questionnaire was distributed among the members to support the selection of the parameters (see Appendix IV). Based on the feedback obtained a refined list of parameters was established (Table 1). The proposed parameters were subsequently re-assessed using SMART (specific, measurable, achievable, relevant, time-bound) indicator criteria. Based on this analysis, a core list of parameters was decided upon in the course of the 3rd Working Group Meeting in 2018. The selected parameters will provide a common basis to analyse and compare WLRs.

The list of selected parameters is not exhaustive and will serve as a common basis to analyse and compare rivers in Phase I. It will also provide the opportunity to test their feasibility on the three selected rivers Danube, Mekong and Niger. The studies can lead to a reduction or increase in the number of parameters, their specification and calculation. If data is not available for selected parameters at specific rivers, the results obtained at other rivers can serve as an example for monitoring and modelling the missing parameters in the future. Within Phase I a definition and glossary of the chosen parameters will be elaborated. The study will use parameters for which data is available using existing monitoring (for example at selected, representative points along the length of the river including the relevant temporal resolution) and modelling results.

Table 1: Parameters defined in the course of the 1st Working Group Meeting for the thematic fields *Hydrology & Hydraulics, Sediment Transport & Morphodynamics, Water Quality & Ecology and River Management & Socioeconomics*. Selected parameters based on the results of the questionnaires and discussions at the 3rd Working Group meeting are highlighted in bold.

Hydrology & Hydraulics

Hydrology
Mean annual runoff
Natural low and high flows
Mean monthly / seasonal runoff
Coefficient of Variation of annual flow
Flow regime
Ground water parameter (BFI)
Environmental flows
Trend in flows
Flow duration curves (for hydrology & meteorology)
Spatial variability (at different locations in the river basin)
Temporal variability (hydrographs)
Instream water capacity
Flow velocity
Natural surface water storage

Catchment
Drainage basins
Watershed boundaries
Flow direction
Flow accumulations
River networks

Sediment Transport & Morphodynamics

Sediments
Sediment source (spatial, temporal)
Sediment fluxes, in the river and the mouth
Sediment trends (statistical values)
Grain size of the sediments, change of grain size over time
Ratio of bedload and suspended sediments, fractions
Ratio on Sed_Discharge max vs Sed_Discharge min
Spatio temporal variability of sediment transport
Sediment budget (source, sink)
Types of clay, fines
Atmospheric input of sediment (by dust, desert, airal)
Sediment quality
Trap efficiency
Future trends

Morphodynamics
Floodplain and dimensions, surface
Channel patterns, forms (e.g. meandering)
Sinuosity, Braiding Index etc.
River metamorphosis
Migration rates, bank erosion
River bed level changes, including trends
Base level changes
Bathymetry, river and delta, bloom of sediments
Incision, cutoff sediments
Aggradation
Contaminants and sediments and morphodynamics
Coastal morphodynamics-fluxes
Future trends (depending on data availability)

Human impacts and effects on sediment transport and morphodynamics
Hydropower plants
Dredging
River engineering
Measures for floodrisk management
Land cover changes
Erosion protection works

Table 1 continued: Parameters defined in the course of the 1st Working Group Meeting for the thematic fields *Hydrology & Hydraulics, Sediment Transport & Morphodynamics, Water Quality & Ecology and River Management & Socioeconomics*. Selected parameters based on the results of the questionnaires and discussions at the 3rd Working Group meeting are highlighted in bold.

Water Quality & Ecology

Ecosystems and Biodiversity
Wetland disconnectivity
Ecosystem impacts from anthropogenic influences
Freshwater Species
Species richness
Livestock density
Fish diversity
Rare and endangered species and biotic communities
Number of endemic species
Number of non-native fishes
Impervious surfaces

Threats and Human Pressures
Threats to fish
Threats to other species (birds, mammals, amphibians and crocodiles)
WWF living plant index for freshwater
Human footprint
Extinction risk
Fishing pressure
Aquaculture pressure
Climate change induced changes species and biotic communities

Water Quality and Pollution
Ecological status
Thermal pollution
Nutrient pollution
Wastewater pollution
Mercury accumulation
Biological oxygen demand
Freshwater alkalinity
Anthropogenic nitrogen loading
Anthropogenic phosphorus loading
Pesticide loading
Organic loading
Soil salinization
Potential acidification
Areas of high loadings / pollution
Poorest water quality
Water salinity
Emerging pollutants (e.g microplastics, antibiotics, EDCs)
Heavy metals

River Management & Socioeconomics

Water Use
Hydropower (installed capacity, generation density)
Irrigation
Navigation
Recreation
Fishing
Mining
Industrial water use
Total freshwater withdrawal

Socioeconomics
Water Economics / Economic dependence on water resources
Societal wellbeing
Exposure to floods
Exposure to droughts
Water and health (e.g. spread of cholera)
Pricing water
Environmental awareness
Disasters (biological, climatological, geophysical, hydrological, meteorological and technological)
Religious and cultural practices

Water Stress and Water Resource Development
Environmental water stress
Human water stress
Agricultural water stress
Water exploitation index
Water scarcity index
Water management in urban areas
Dam density
Level of river fragmentation
Level of flow regulation
Consumptive water loss
Water storage capacity (existing and potential)

Governance
Legal framework (e.g. regional standards)
Level of cooperation
Enabling environment

5.1.1.3. Analysis of 3 Rivers

With the aim to create a neutral, science based status report on large rivers, several standardised analytical approaches have to be derived dealing, for example, with the following aspects (*extract*):

- Temporal / downstream development of parameters and derivation of standardised diagrams (Figure 3)
- Interrelation of parameters (e.g. mean annual discharge – suspended load; land use – river morphology / ecological status)
- Spatial and temporal heterogeneity of parameters
- Extreme values

The basis for this step is a revised and harmonised set of parameters. Both, the list of parameters and suggestions of analytical approaches were discussed in the course of the 2nd and 3rd WLRI Working Group Meeting in June 2016 and May 2018 and selected based on distributed questionnaires and expert discussions.

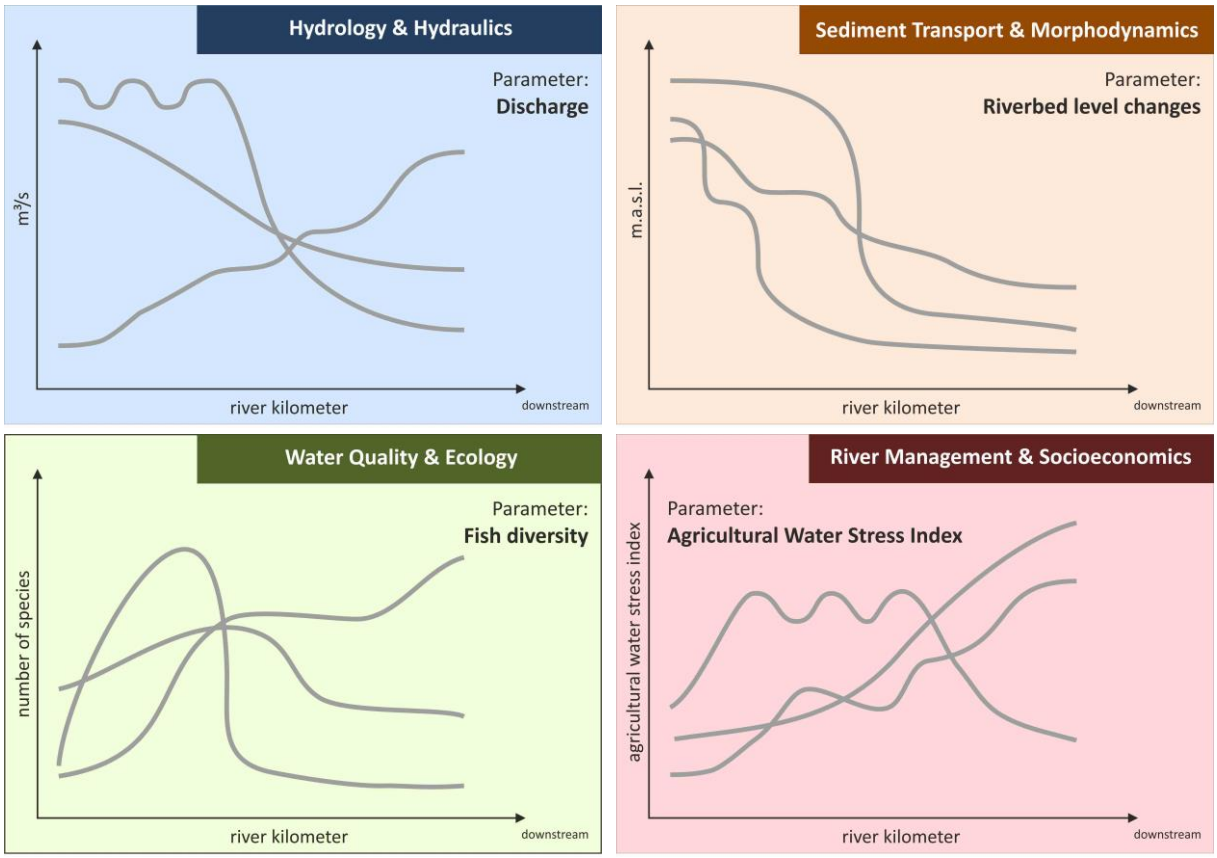

Figure 3: Derivation of diagrams in order to illustrate the downstream development of parameters.

5.2. Work Plan of Activity 2 – Close knowledge gaps and foster knowledge transfer

In a concerted action, the research required to close knowledge gaps relating to WLRs will be identified and promoted. Particular attention should be given to knowledge transfer to next generation scientists, stakeholders, decision makers, children (education) and the general public. Training of experts should therefore be a key element. A training course was organised at each of the three African Large Rivers Hydrology Conferences. There are plans to develop online resources to support the training of future river experts (including cooperation with other existing initiatives such as MOOCs for Africa).

5.3. Work Plan of Activity 3 – Formulate a collaborative International Research Action Plan on WLRs

An action plan on WLRs research will be jointly developed with international scientific bodies and associations (e.g. UNESCO, IAHR, IAHS, WASER, IAG etc.) which will also co-sponsor future WLR conferences. The WLRI links to the Water Family (Category II Centres and Chairs) and other UNESCO programmes and initiatives by providing specific thematic knowledge and transferring it to individual rivers. These programmes include among others ISI, IFI, FRIEND-Water, HELP, G-WADI, IDI, PCCP, ISARM, UWMP, IIWQ and the Ecohydrology Programme (Figure 4).

The Working Group was concluded with the 3rd Working Group meeting as it fulfilled its mandate. After the 23rd session of the IGC a formal setting for the operationalisation of the Initiative will be established.

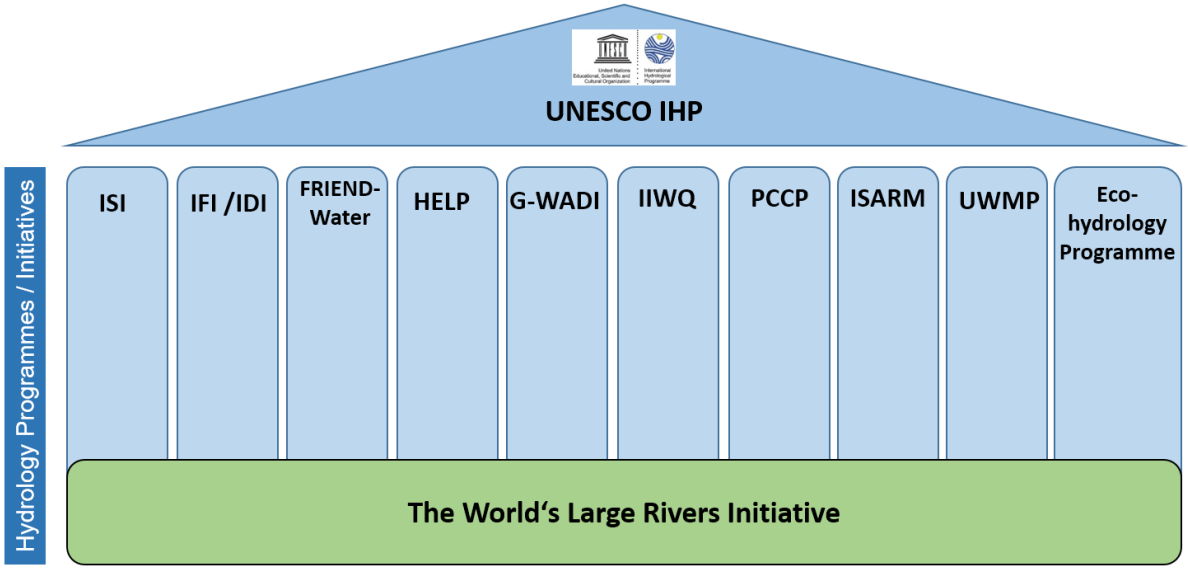

Figure 4: Interlinkages to other programmes and initiatives.

A key activity of the WLRI is the publication of research papers in SCI journals. To date, the WLRI has published ten special issues with 143 articles and 554 authors following the International Conferences in top SCI journals. An additional three special issues are currently in preparation.

5.4. Work Plan of Activity 4 – Establish a World River Forum, World River Day and WLRs Commission Meetings

A World River Forum will be established in collaboration with other organisations (e.g. River Commissions) which aims to bring together scientists, stakeholders and decision makers in order to promote and improve

the integrated management of WLRs. The UN World Rivers Day will be scientifically supported. Collaborations with several River Commissions have been initiated and representatives will meet regularly to exchange experiences, discuss best practices on integrated management and debate future needs.

In particular, a cooperation with the International Network of Basin Organizations INBO and regional related networks (e.g. African Network of River Basin Organization, Asian Network of River Basin Organization) is planned

5.5. Work Plan of Activity 5 – Organise future Conferences on the World's Large Rivers

A Conference on the Status and Future of WLRs will be held every three years with the aim of expanding and disseminating scientific knowledge on the WLRs and their integrated and sustainable management.

Three International World's Large Rivers Conferences have been organised in Vienna/Austria (2011), Manaus/Brazil (2014) and New Delhi/India (2017) (Figure 5). The next WLR Conference will take place in 2020.

Figure 5: Impressions from the three World's Large Rivers Conferences in Vienna, Austria (top), Manaus, Brazil (middle) and New Delhi, India (bottom).

In addition to the World's Large Rivers Conferences African Large Rivers Hydrology Conferences have already been organised by the FRIEND-Water initiative in 2015 (Tunisia), 2016 (Senegal) and 2018 (Algeria). The fourth Conference is planned for 2020 (Benin).

6. Outcomes of the World's Large Rivers Initiative

The following list refers to the expected outcomes of the WLRI.

Outcome 1: First global status report on the world's large rivers.
The report will include the thematic areas Hydrology & Hydraulics, Sediment Transport & Morphodynamics, Water Quality & Ecology and River Management & Socioeconomics.

Outcome 2: Closed knowledge gaps and trained experts.
Manual for integrated river research and management including examples for best practices.

Outcome 3: Collaborative International Action Plan.
Cutting-edge research articles will be published and compiled in special issues in top SCI journals.

Outcome 4: World River Forum, World River Days and WLRs Commission Meetings.
Cooperation strategy with INBO and individual river commissions.

Outcome 5: Series of International Conferences on the World's Large Rivers.
A conference on the status and future of WLRs is successfully implemented every three years. Additionally, regional conferences are organised.

7. Roadmap and Outlook

The working plan of the WLRI comprises the following further working steps:

- **17th – 18th May 2018**: 3rd Working Group Meeting of the WLRI in Vienna. The concept paper will be finalised and first results presented.
- **11th – 15th of June 2018**: UNESCO IHP Intergovernmental Council (IGC). The 23rd session of the IHP IGC will review the performance of the initiative and decide to continue the WLRI as part of IHP's workplan, beyond the 23rd session of the IHP Intergovernmental Council. A side event will take place on 11th June 2018 at 13:30 in Room IX at the UNESCO Headquarters in Paris to present the WLRI and its activities.
- **July 2018**: Phase I of the WLRI will be started after having finalised the contracts concerning extrabudgetary funds.
- **July 2018:** After the 23rd session of the IGC a formal setting for the operationalisation of the Initiative will be established.
- **2020**: 4th World's Large Rivers Conference.

List of Acronyms

ADB	Asian Development Bank
FAO	Food and Agriculture Organization (UN)
GEF	Global Environmental Facility
IGC	Intergovernmental Council
IHP	International Hydrological Programme (UNESCO)
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNDP	United Nations Development Programme
WHO	World Health Organization
WLR	World's Large Rivers
WLRI	World's Large Rivers Initiative
WWF	World Wide Fund for Nature

APPENDIX I

Questionnaire
on the Determination of 10 Large Rivers

APPENDIX I:

Questionnaire on the Determination of 10 Large Rivers

for further developing World´s Large Rivers Initiative (WLRI)

Please nominate in Table 1 the **10 most interesting large rivers** (i.e. economically, environmentally or socially relevant) of your organizations point of view and/or those actually covered e.g. by your projects. Additionally in Table 2 we provide the 100 largest rivers (according to the river length) in alphabetical order as an alternative possibility for your choice.

Kindly send the list of your selected rivers by e-mail, no later than **29th of January 2016** to **worldslargerivers@boku.ac.at**.

Please fill in rivers of high interest according to your point of view (or select rivers from Table 2).

Table 1: Suggestion of rivers that should be analyzed in Phase 1 of the WLRI project.

River	Country

Or please mark the rivers of high interest according to your point of view.

Table 2: Selection of rivers based on a list of 100 large rivers (by length; alphabetical order).

River	Country	
Aldan	Russia	☐
Amazon – Ucayali – Apurímac	Brazil, Peru, Bolivia, Colombia, Ecuador, Venezuela, Guyana	☐
Amu Darya -- Panj	Uzbekistan, Turkmenistan, Tajikistan, Afghanistan	☐
Amur–Argun (Heilong Jiang)	Russia, China, Mongolia	☐
Araguaia	Brazil	☐
Arkansas	United States	☐
Ayeyarwady (Irrawaddy)	Myanmar	☐
Belaya	Russia	☐
Beni	Bolivia	☐
Benue	Cameroon, Nigeria	☐
Blue Nile	Ethiopia, Sudan	☐
Brahmaputra–Tsangpo	India (58.0%), China (19.7%), Nepal (9.0%), Bangladesh (6.6%), Disputed India/China (4.2%), Bhutan (2.4%)	☐
Churchill	Canada	☐
Colorado (Texas)	United States	☐
Colorado (western U.S.)	United States, Mexico	☐
Columbia	United States, Canada	☐
Congo–Chambeshi (Zaïre)	Democratic Republic of the Congo, Central African Republic, Angola, Republic of the Congo, Tanzania, Cameroon, Zambia, Burundi, Rwanda	☐
Cooper–Barcoo	Australia	☐

University of Natural Resources and Life Sciences, Vienna
Department of Water, Atmosphere and Environment
E-mail: worldslargerivers@boku.ac.at

Danube–Breg (Duna)	Romania (28.9%), Hungary (11.7%), Austria (10.3%), Serbia (10.3%), Germany (7.5%), Slovakia (5.8%), Bulgaria (5.2%), Croatia (4.5%),…	☐
Dnieper	Russia, Belarus, Ukraine	☐
Dniester	Ukraine, Moldova	☐
Don	Russia, Ukraine	☐
Ganges–Hooghly–Padma (Ganga)	India, Bangladesh, Nepal, China	☐
Godavari	India	☐
Guaporé (Itenez)	Brazil, Bolivia	☐
Han	P. R. China	☐
Içá (Putumayo)	Brazil, Peru, Colombia, Ecuador	☐
Ili (Yili)	P. R. China, Kazakhstan	☐
Indigirka	Russia	☐
Indus	Pakistan (93%), India, China	☐
Ishim	Kazakhstan, Russia	☐
Japurá (Rio Yapurá)	Brazil, Colombia	☐
Jubba–Shebelle	Ethiopia, Somalia	☐
Juruá	Peru, Brazil	☐
Kama	Russia	☐
Kasai	Angola, Democratic Republic of the Congo	☐
Khatanga	Russia	☐
Kolyma	Russia	☐
Lena	Russia	☐
Limpopo	Mozambique, Zimbabwe, South Africa, Botswana	☐

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Department of Water, Atmosphere and Environment
E-mail: worldslargerivers@boku.ac.at

Lower Tunguska	Russia	☐
Mackenzie–Slave–Peace–Finlay	Canada	☐
Madeira–Mamoré–Grande–Caine–Rocha	Brazil, Bolivia, Peru	☐
Magdalena	Colombia	☐
Marañón	Peru	☐
Mekong (Lancang Jiang)	China, Myanmar, Laos, Thailand, Cambodia, Vietnam	☐
Mississippi–Missouri–Jefferson	United States (98.5%), Canada (1.5%)	☐
Murray–Darling	Australia	☐
Murrumbidgee River	Australia	☐
Negro	Brazil, Venezuela, Colombia	☐
Nelson–Saskatchewan	Canada, United States	☐
Niger	Nigeria (26.6%), Mali (25.6%), Niger (23.6%), Algeria (7.6%), Guinea (4.5%), Cameroon (4.2%), Burkina Faso (3.9%), Côte d'Ivoire, Benin, Chad	☐
Nile – Kagera	Ethiopia, Eritrea, Sudan, Uganda, Tanzania, Kenya, Rwanda, Burundi, Egypt, Democratic Republic of the Congo, South Sudan	☐
Northern Salado	Argentina	☐
Ob–Irtysh	Russia, Kazakhstan, China, Mongolia	☐
Ohio–Allegheny	United States	☐
Oka	Russia	☐
Okavango	Namibia, Angola, Botswana	☐
Olenyok	Russia	☐
Orange	South Africa, Namibia, Botswana, Lesotho	☐
Orinoco	Venezuela, Colombia, Guyana	☐

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Department of Water, Atmosphere and Environment
E-mail: worldslargerivers@boku.ac.at

Paraguay (Rio Paraguay)	Brazil, Paraguay, Bolivia, Argentina	☐
Paraná – Río de la Plata	Brazil (46.7%), Argentina (27.7%), Paraguay (13.5%), Bolivia (8.3%), Uruguay (3.8%)	☐
Pearl – Zhu Jiang	China (98.5%), Vietnam (1.5%)	☐
Pechora	Russia	☐
Pecos	United States	☐
Pilcomayo	Paraguay, Argentina, Bolivia	☐
Platte	United States	☐
Purús	Brazil, Peru	☐
Red (USA)	United States	☐
Rio Grande	United States (52.1%), Mexico (47.9%)	☐
Río Grande (Guapay)	Bolivia	☐
Saint Lawrence – Niagara – Detroit – Saint Clair – Saint Marys – Saint Louis	Canada (52.1%), United States (47.9%)	☐
Salween (Nu Jiang)	China (52.4%), Myanmar (43.9%), Thailand (3.7%)	☐
São Francisco	Brazil	☐
Senegal	Guinea, Senegal, Mali, Mauritania	☐
Shatt al-Arab – Euphrates	Iraq (60.5%), Turkey (24.8%), Syria (14.7%)	☐
Snake	United States	☐
Songhua	P. R. China	☐
Stony Tunguska	Russia	☐
Syr Darya – Naryn	Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan	☐
Tapajós	Brazil	☐
Tarim	P. R. China	☐

University of Natural Resources and Life Sciences, Vienna
Department of Water, Atmosphere and Environment
E-mail: worldslargerivers@boku.ac.at

Tigris	Turkey, Iraq, Syria	☐
Tobol	Kazakhstan, Russia	☐
Tocantins–Araguaia	Brazil	☐
Ubangi–Uele	Democratic Republic of the Congo, Central African Republic, Republic of Congo	☐
Upper Ob -- Katun	Russia	☐
Upper Yenisei -- Little Yenisei (Kaa-Hem)	Russia, Mongolia	☐
Ural	Russia, Kazakhstan	☐
Uruguay	Uruguay, Argentina, Brazil	☐
Vilyuy	Russia	☐
Vitim	Russia	☐
Volga	Russia	☐
Volta	Ghana, Burkina Faso, Togo, Côte d'Ivoire, Benin	☐
Warburton–Georgina	Australia	☐
Xingu	Brazil	☐
Yangtze (Chang Jiang)	China	☐
Yellow River (Huang He)	China	☐
Yenisei–Angara–Selenge	Russia (97%), Mongolia (2.9%)	☐
Yukon	United States (59.8%), Canada (40.2%)	☐
Zambezi (Zambesi)	Zambia (41.6%), Angola (18.4%), Zimbabwe (15.6%), Mozambique (11.8%), Malawi (8.0%), Tanzania (2.0%), Namibia, Botswana	☐

University of Natural Resources and Life Sciences, Vienna
Department of Water, Atmosphere and Environment
E-mail: worldslargerivers@boku.ac.at

APPENDIX II

Matrix illustrating the 100 Largest Rivers (according to river length) related to the Expert and Project-based Analysis

River	km	ES	Q	PR	River	km	ES	Q	PR
Aldan	2.273				Niger	4.200	xx	x	xxx
Amazon - Ucayali	6.400	xx		x	Nile – Kagera	6.650	xx	x	xxx
Amu Darya- Panj	2.620				Northern Salado	2.010			
Amur - Argun (Heilong Jiang)	4.444			x	Ob–Irtysh	5.410			
Araguaia	2.627				Ohio–Allegheny	2.102			
Arkansas	2.348				Oka	1.500			
Ayeyarwady (Irrawaddy)	2.170			x	Okavango	1.600		x	x
Belaya	1.420				Olenyok	2.292			
Beni	1.599				Orange	2.092	x	x	xx
Benue	1.400				Orinoco	2.101			
Blue Nile	1.600			x	Paraguay (Rio Paraguay)	2.549			x
Brahmaputra–Tsangpo	2.948				Paraná – Río de la Plata	4.880	x		x
Churchill	1.600				Pearl – Zhu Jiang	2.200			
Colorado (Texas)	1.438				Pechora	1.809			
Colorado (western U.S.)	2.333				Pecos	1.490			
Columbia	2.250				Pilcomayo	2.500			
Congo–Chambeshi (Zaïre)	4.700	xx	x		Platte	1.594			
Cooper–Barcoo	1.420				Purús	3.211			
Danube–Breg (Duna)	2.888	xx		xx	Red (USA)	2.188			x
Dnieper	2.287				Rio Grande	3.057			x
Dniester	1.411		x		Río Grande (Guapay)	1.438			x
Don	1.870				Saint Lawrence – Niagara	3.058	x		
Ganges–Hooghly	2.620	xx		x	Salween (Nu Jiang)	3.060			
Godavari	1.465				São Francisco	3.180			xx
Guaporé (Itenez)	1.749				Senegal	1.641	x		xxx
Han	1.532				Shatt al-Arab – Euphrates	3.596			
Içá (Putumayo)	1.575				Snake	1.670			
Indigirka	1.726				Songhua	1.927			
Indus	3.180			x	Stony Tunguska	1.865			
Ishim	2.450				Syr Darya – Naryn	3.078			x
Japurá (Rio Yapurá)	2.615				Tapajós	1.900			
Jubba–Shebelle	1.580				Tarim	2.100			x
Juruá	2.410				Tigris	1.950			
Kama	1.805				Tobol	1.591			
Kasai	2.153				Tocantins–Araguaia	3.650			
Khatanga	1.600				Ubangi–Uele	2.270			
Kolyma	2.513			x	Upper Ob -- Katun	2.490			
Lena	4.400				Upper Yenisei - Little Yenisei	1.480			
Limpopo	1.800			x	Ural	2.428			
Lower Tunguska	2.989				Uruguay	1.610			
Mackenzie–Slave	4.241				Vilyuy	2.650			
Madeira–Mamoré	3.380				Vitim	1.978			
Magdalena	1.550				Volga	3.645	xx		
Marañón	1.415				Volta	1.600	x		xx
Mekong (Lancang Jiang)	4.350	xx		xxx	Xingu	2.100			
Mississippi–Missouri	6.275	xx			Yangtze (Chang Jiang)	6.300	xx		x
Murray–Darling	3.672	xxx			Yellow River (Huang He)	5.464	x		
Murrumbidgee River	1.600				Yenisei–Angara	5.539			
Negro	2.250				Yukon	3.185			
Nelson–Saskatchewan	2.570				Zambezi (Zambesi)	2.693	x		xx

Legend:

	Africa
	Asia
	Australia
	Europe
	North America
	South America

ES	Experts Suggestions
Q	Questionnaire
PR	Project Research

APPENDIX III

Overview of existing Online-Databases on Large Rivers

APPENDIX III: Overview of existing Online-Databases on Large Rivers

Hydrology and Hydraulics:

- Joint Research Center (JRC)
- The State of the World's Rivers (Mapping the Health of the World's Fifty Major River Basins)
- Major River Basins of the World (Global Runoff Data Centre)
- Transboundary Waters Assessment Programme (TWAP)
- HydroSHEDS (Hydrological data and maps based on Shuttle Elevation Derivatives at multiple Scales)
- World Atlas (The Rivers of the World)
- Global Rivers Observatory (Woods Hole Research Center & Woods Hole Oceanographic Institution)
- Vital Water Graphics (An Overview of the World's Fresh and Marine Waters – 2nd Edition)
- Geographically Referenced Global River Discharge Database (RivDIS v1.1)
- World Resources Institute (Maps & Data)
- Global Water System Project (GWSP Digital Water Atlas Project)

Sediment Transport & Morphodynamics:

- Global River Sediment Yields Database (AQUASTAT Programme)
- AQUASTAT Databases
- Global Rivers Observatory (Woods Hole Research Center & Woods Hole Oceanographic Institution)
- The State of the World's Rivers (Mapping the Health of the World's Fifty Major River Basins)
- Vital Water Graphics (An Overview of the World's Fresh and Marine Waters – 2nd Edition)

Water Quality & Ecology:

- Joint Research Center (JRC)
- The State of the World's Rivers (Mapping the Health of the World's Fifty Major River Basins)
- World Water Quality Assessment – WWQA (UNEP, GEMS / Water)
- Transboundary Waters Assessment Programme (TWAP)
- Global Rivers Observatory (Woods Hole Research Center & Woods Hole Oceanographic Institution)
- Freshwater Ecoregions of the World – FEOW (Interactive Map)
- Vital Water Graphics (An Overview of the World's Fresh and Marine Waters – 2nd Edition)
- Rivers in Crises (Mapping dual threats to water security for biodiversity and humans)
- World Resources Institute (Maps & Data)
- Global Water System Project (GWSP Digital Water Atlas Project)

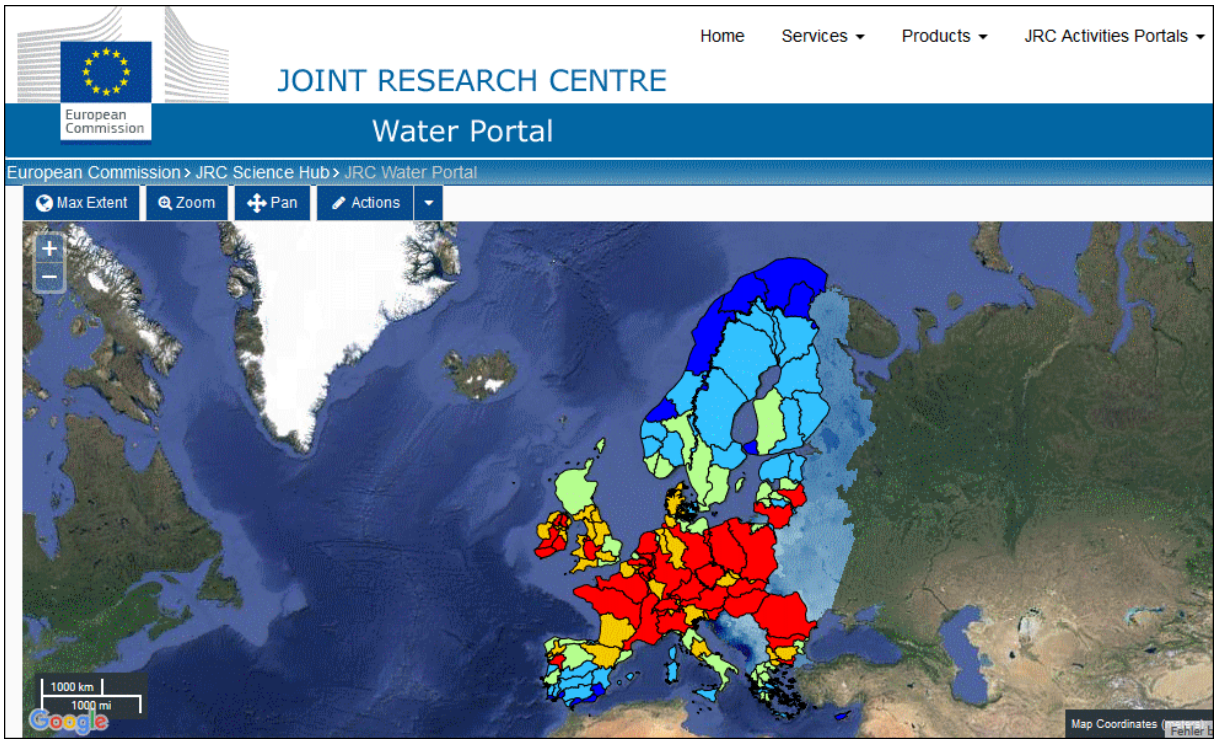
River Management & Socioeconomics:

- Joint Research Center (JRC)
- AQUASTAT Databases
- Transboundary Waters Assessment Programme (TWAP)
- The International Disaster Database (EM-DAT Database)
- International Hydropower Association – IHA (Hydropower Maps)
- The European Small Hydropower Association – ESHA (Small Hydropower Map)
- Vital Water Graphics (An Overview of the World's Fresh and Marine Waters – 2nd Edition)
- Rivers in Crises (Mapping dual threats to water security for biodiversity and humans)
- World Resources Institute (Maps & Data)
- Global Water System Project (GWSP Digital Water Atlas Project)

Joint Research Centre (JRC)

JRC Water Portal

Organization / Program: **European Commission, JRC Science Hub, JRC Water Portal**



Source: http://water.jrc.ec.europa.eu/

Dataset description: **Database** serving as a gateway to **JRC's products on freshwater and marine water resources**, providing access to **water data (incl. statistical tools), publications and maps** as well as to projects and events

URL: http://water.jrc.ec.europa.eu/

River basins: European river basins

Content:

- Water Economics
- Water Indicators
- Water Quality
- Water Quantity
- Water Use
- Water Exploitation Index
- Global streamflow characteristics
- Irrigation
- High Resolution Precipitation Datasets
- JRC assessment of water pressures

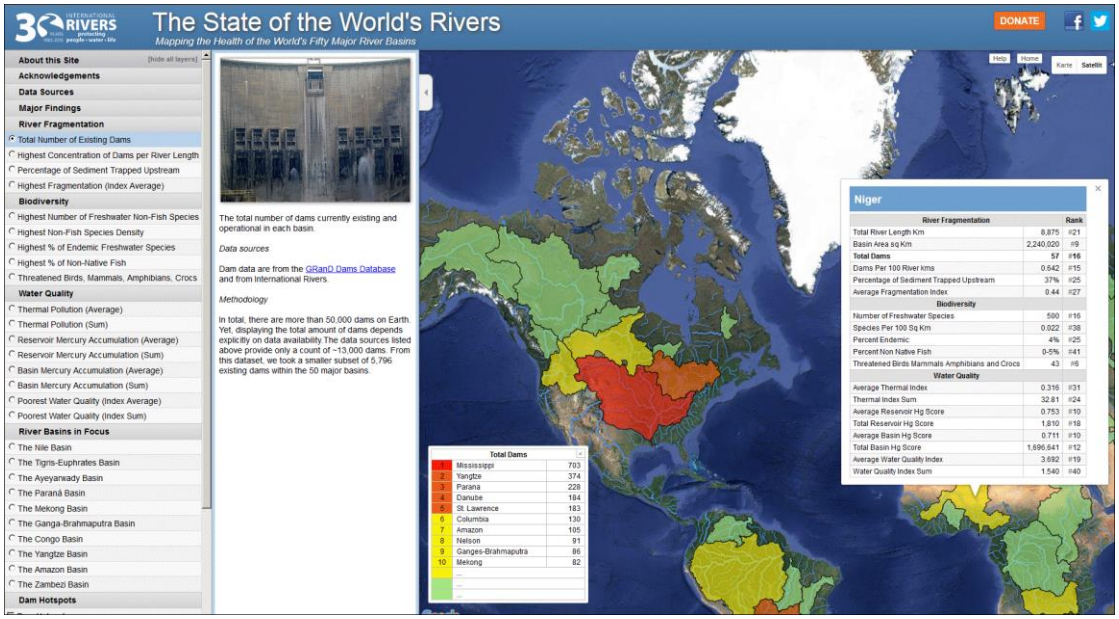
Data origin: variable

Status of the data: 4.11.2015 (last update)

The State of the World's Rivers

Mapping the Health of the World's Fifty Major River Basins

Organization / Program: **International Rivers, 2054 University Ave, Suite 300, Berkeley, CA 94704-2644, USA**



Source: http://www.internationalrivers.org/worldsrivers/

Dataset description: Interactive **web database** illustrating **data on ecological health in the World's 50 major river basins** including the Congo, the Amazon and the Mekong basins

URL: http://www.internationalrivers.org/worldsrivers/

River basins: Albany, Amazon, Amu-Darya, Amur, Anadyr, Baker, Chubut, Churchill (Hudson Bay), Columbia, Congo, Danube, Dnepr, Dvina, Fraser, Ganges-Brahmaputra, Godavari, Hai Ho, Indigirka, Indus, Ayeyarwaddy, Khatanga, Koksoak, Kolyma, Lena, Mackenzie, Mekong, Mississippi, Nelson, Neva, Niger, Nile, Ob, Orinoco, Parana, Pechora, Pyasina, São Francisco, St. Lawrence, Tigris-Euphrates, Tocantins, Uruguay, Volga, Volta, Wisla, Yana, Yangtze, Yellow Yenisei, Yukon, Zambezi

Content:

- River fragmentation (dams)
- Biodiversity (freshwater species, threatened birds, mammals, amphibians and crocodile species)
- Water Quality (thermal pollution, mercury accumulation, poorest water quality)

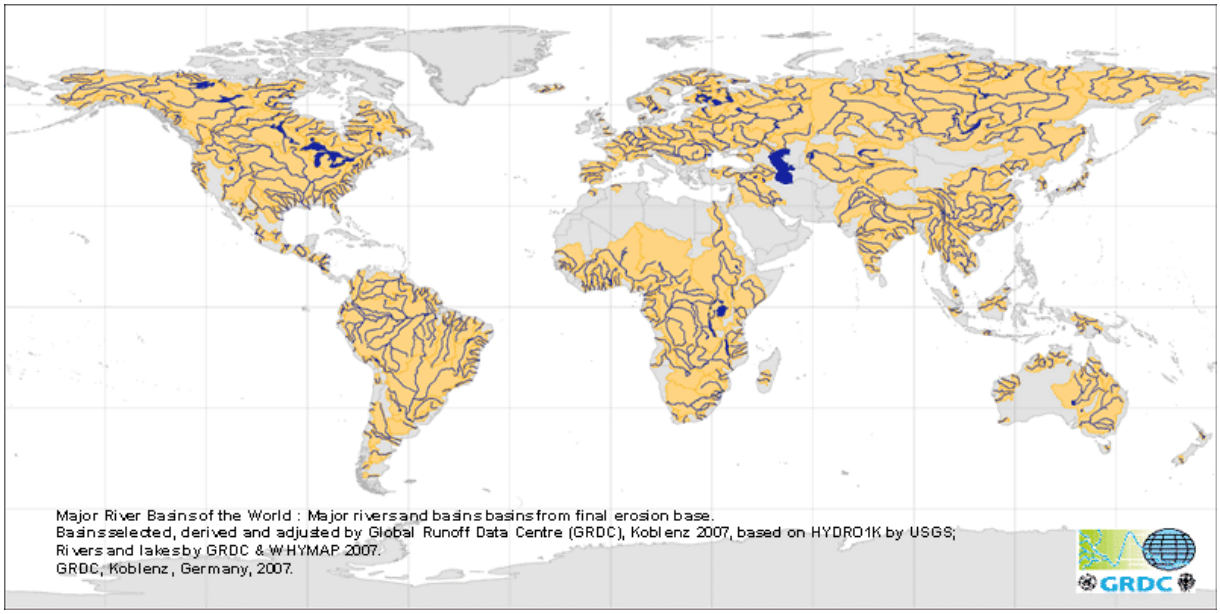
Data origin: *river basin boundaries*: Global Runoff Data Centre – GRDC (2007); flow direction data sets for Africa, Asia, North and South America and Europe: HYDRO1k Elevation Derivative Database; *additional basin data*: Fekete, Vörösmarty and Lammers (2010); *dams*: Global Reservoir and Dam (GRanD) Database, Consultative Group on International Agricultural Research (CGIAR) Challenge Program on Water and Food – Mekong, United States National Inventory of Dams (NID), other government dam inventories and original data collection by International Rivers

Status of the data: 2014 (last update)

Major River Basins of the World

Global Runoff Data Centre (GRDC)

Organization / Program: ***Global Runoff Data Centre (2007) - Major River Basins of the World / Global Runoff Data Centre, Koblenz, Germany: Federal Institute of Hydrology (BfG)***



http://www.bafg.de/SharedDocs/Bilder/Bilder_GRDC/major_rivers_and_basins.gif?__blob=poster

Dataset description: **GIS project** that aims to provide a **set of shape files of major river basins** for the use with Geographic Information Systems

URL:
http://www.bafg.de/GRDC/EN/02_srvcs/22_gslrs/221_MRB/riverbasins_node.html#doc201778bodyText2

River basins: 405 river basins (and 687 associated rivers)

Content:

- River basins from the river mouths at the erosion base level (polygons)
- Rivers, associated to the basins from the river mouths (polylines)
- Rivers, classified by discharge (polylines)

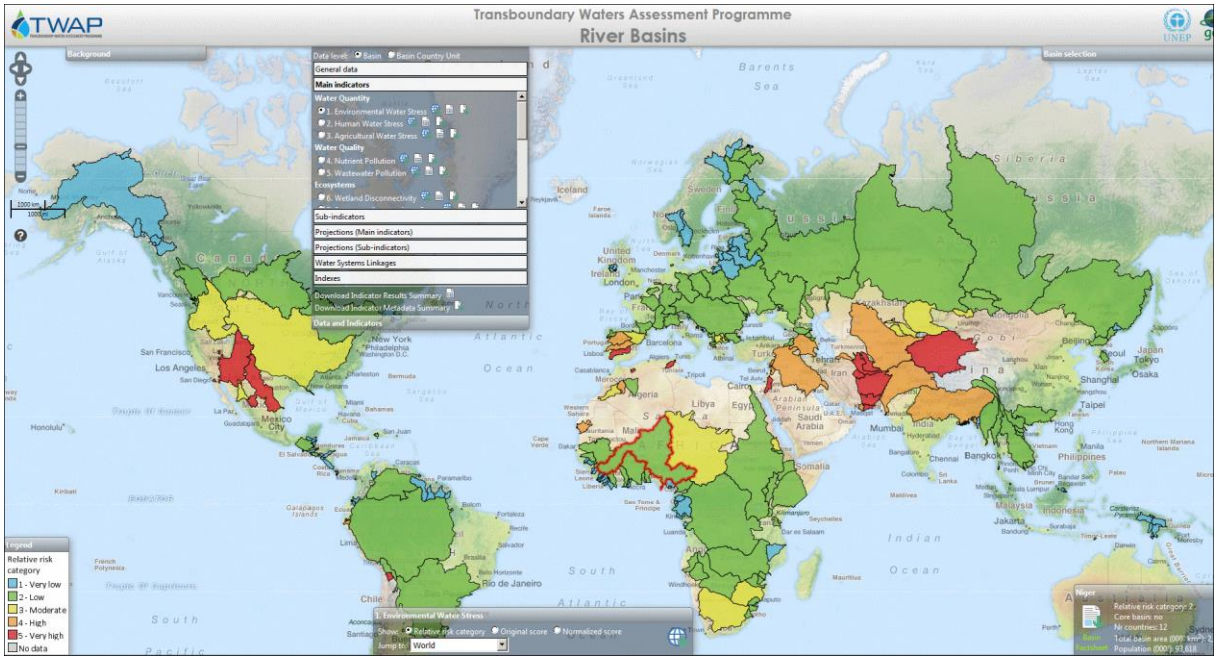
Data origin: *drainage basins*: flow direction data set of the HYDRO1k Elevation Derivative Database; *river network*: Major Riverbasins of the BGR; *mean river discharge values*: WaterGAP 2.1 (Universities of Frankfurt and Kassel, 2007)

Status of the data: 2007

Transboundary Waters Assessment Programme (TWAP)

River Basins Component

Organization / Program: **GEF TWAP Project Coordination Unit (PCU), United Nations Environment Programme (UNEP), P.O. Box 30552 (00100), Nairobi, Kenya**



Source: http://twap-rivers.org/indicators/

Dataset description: **Baseline assessment of the World's transboundary water resources** including an interactive **web database** (TWAP RB Data Portal) illustrating **indicator risk maps, result sheets (incl. metadata) and river basin**

URL: http://twap-rivers.org/

River basins: 286 global transboundary river basins

Content:

- Water Quantity (environmental water stress, human water stress, agricultural water stress)
- Water Quality (nutrient pollution, wastewater pollution)
- Ecosystems (wetland disconnectivity, ecosystem impacts from dams, threat to fish, extinction risk)
- Governance (legal framework, hydropolitical tension, enabling environment)
- Socioeconomics (economic dependence on water resources, societal wellbeing, exposure to floods and droughts)

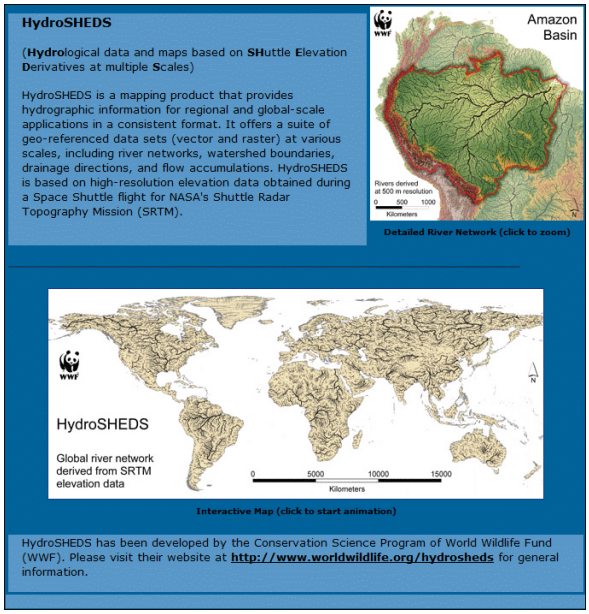
Data origin: *country delineations*: FAO GAUL (Global Administrative Unit Layers, 2014) using the International Boundary dataset of the UNCS (UN Cartographic Section); *indicator data*: variable

Status of the data: variable

HydroSHEDS

Hydrol. data and maps based on Shuttle Elevation Derivatives at multiple Scales

Organization / Program: **WWF Conservation Science Program in partnership with the U.S. Geological Survey, the International Centre for Tropical Agriculture, The Nature Conservancy and the Center for Environmental Systems Research of the University of Kassel, Germany**



http://hydrosheds.cr.usgs.gov/dataavail.php

Dataset description: **Mapping product** providing **hydrographic information for regional and global-scale applications** (geo-referenced data set at various scales) based on high-resolution elevation data obtained during a Space Shuttle flight for NASA's Shuttle Radar Topography Mission (SRTM)

URL: http://hydrosheds.cr.usgs.gov/index.php

River basins: worldwide

Content:

- River networks
- Watershed boundaries
- Drainage basins
- Flow direction
- Flow accumulations

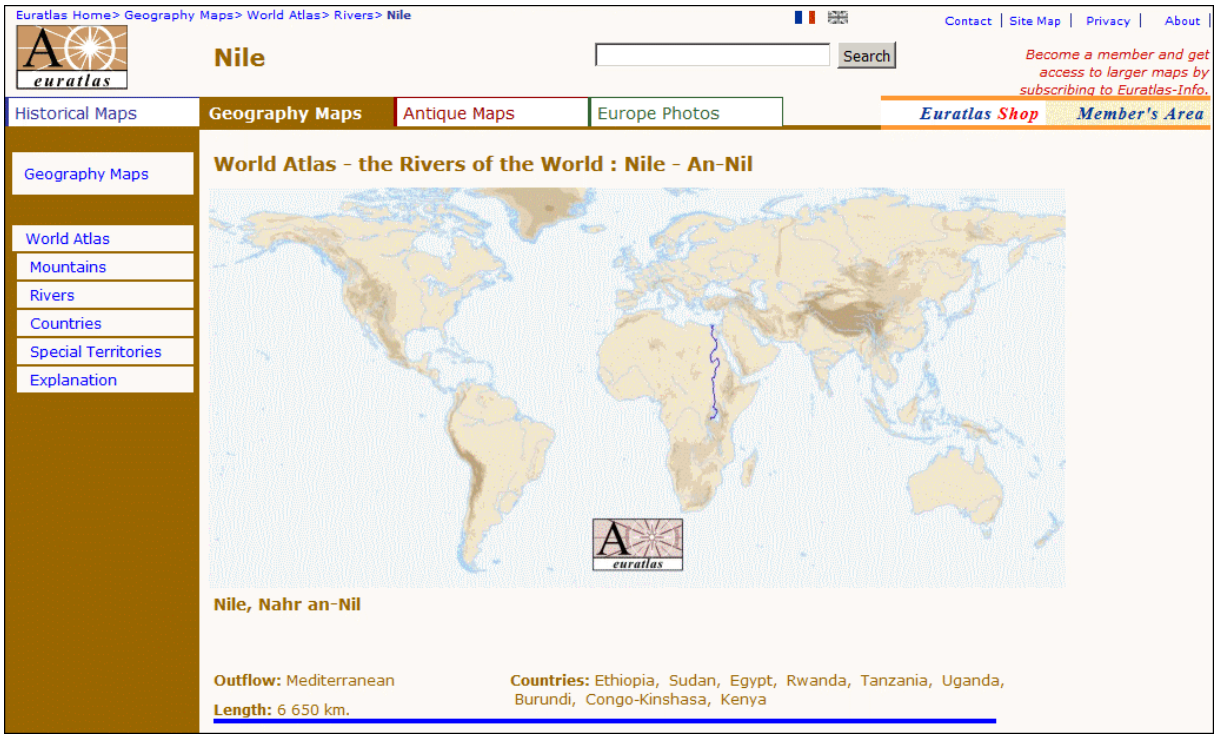
Data origin: Shuttle Radar Topography Mission (2000); SRTM elevation data, Version 1 (2005); SRTM elevation data, Version 2 (2005); SRTM tiling format and data availability (2005); SRTM Water Body Data (1998, 2003); Digital Chart of the World (DCW) global vectorized river network (1993, 1995); ArcWorld global vectorized river network (1992); Global Lakes and Wetlands Database (GLWD) (2004)

Status of the data: *South America*: May 2006; *Asia*: March 2007; *Central America*: March 2007; *Africa*: October 2007; *Australia*: March 2008; *Europe*: October 2008; *North America*: January 2009

World Atlas

The Rivers of the World

Organization / Program: **Euratlas-Nüssli, rue du Milieu 30, 1400 Yverdon-les-Bains, Switzerland**



http://www.euratlas.net/geography/world/rivers/nile.html

Dataset description: Interactive **web database** illustrating the location and describing the mouth, crossed countries and length of the **major rivers of the World**

URL: http://www.euratlas.net/geography/world/rivers/index.html

River basins: 119 rivers

Content:

- River name
- Outflow
- Crossed countries
- Length

Data origin: n.s.

Status of the data: 2001-2011 (last update)

Global Rivers Observatory

Woods Hole Research Center & Woods Hole Oceanographic Institution

Organization / Program: **National Science Foundation; additional funding from the Woods Hole Oceanographic Institution (360 Woods Hole Road, MS 25 Woods Hole, MA 02543-1541, USA) and the Woods Hole Research Center (149 Woods Hole Road Falmouth, MA 02540-1644, USA)**

Source: http://www.globalrivers.org/

Dataset description: **Project** investigating **river chemistry in Earth's most significant river systems** in order to understand how climate change, deforestation and other disturbances are impacting river chemistry and land-ocean linkages

URL: http://www.globalrivers.org/

River basins: currently 18 river basins (incl. Amazon, Congo, Danube, Fraser, Ganges-Brahmaputra, Kolyma, Lena, Mackenzie, Ob', Yangtze, Yenisey, Yukon)

Content:

- River basin data (country, large-scale drainage area, drainage, population density, large cities, cropland, developed, loss of original forest, large dams, suspended sediment, sediment trapping efficiency)
- Chemical composition of rivers near their mouths where they empty into the ocean

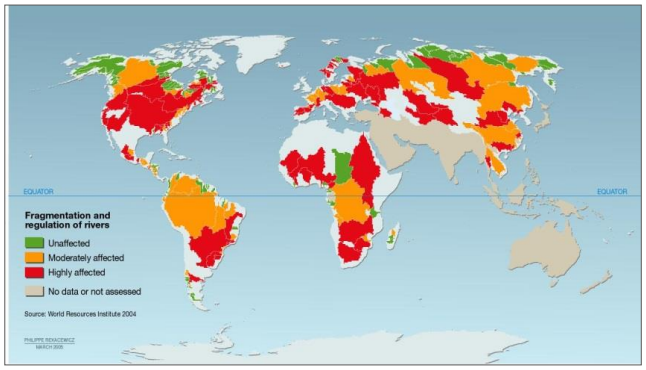
Data origin: variable

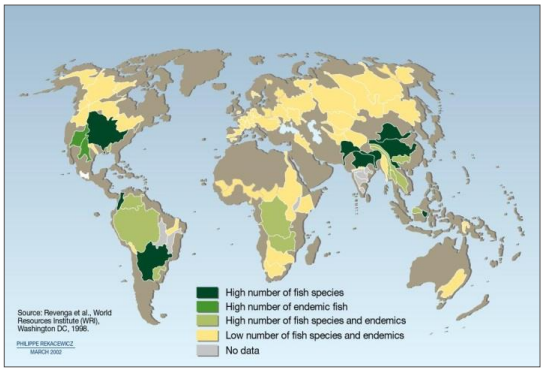
Status of the data: 2015 (last update)

Vital Water Graphics

An Overview of the State of the World's Fresh and Marine Waters (2nd Edition)

Organization / Program: **UNEP GRID-Arendal – A Centre Collaborating with United Nations Environment Programme (UNEP), Teaterplassen 3, 4836 Arendal, Norway**





Source: http://www.unep.org/dewa/vitalwater/rubrique7.html

Dataset description: **Report** providing an overview, through a set of **graphics, maps** and other **illustrations**, of the **current state of the world's fresh, coastal and marine waters** (also illustrating the causes and effects of trends that threaten the water resources)

URL: http://www.unep.org/dewa/vitalwater/rubrique7.html

River basins: worldwide (no specific reference to river basins)

Content:

- Storage, distribution and circulation (freshwater resources, suspended sediment discharge, river runoff throughout the 20th century, main world's river basins etc.)
- Water use and management (trends in global water use, freshwater use by sector, freshwater use – country profiles, total population – access to an improved water source etc.)
- A scarce and competitive resource (water supply per river basin, global waterstress and scarcity, Water Scarcity Index, dependency ratio in renewable water etc.)
- Water management in urban area (water competition between cities and agriculture etc.)
- River's fragmentation (level of river fragmentation and flow regulation, damming the world, water storage capacity for selected countries etc.)
- Pollution (biological oxygen demand, freshwater alkalinity, nitrate levels etc.)
- Biodiversity in freshwater (fish diversity in freshwater systems, the WWF living plant index for freshwater)
- Water and political conflicts (disappearance of the Aral Sea, the Mekong River – survival for millions etc.)
- Water and health (the spread of cholera)
- Pricing Water (increasing price with volume etc.)

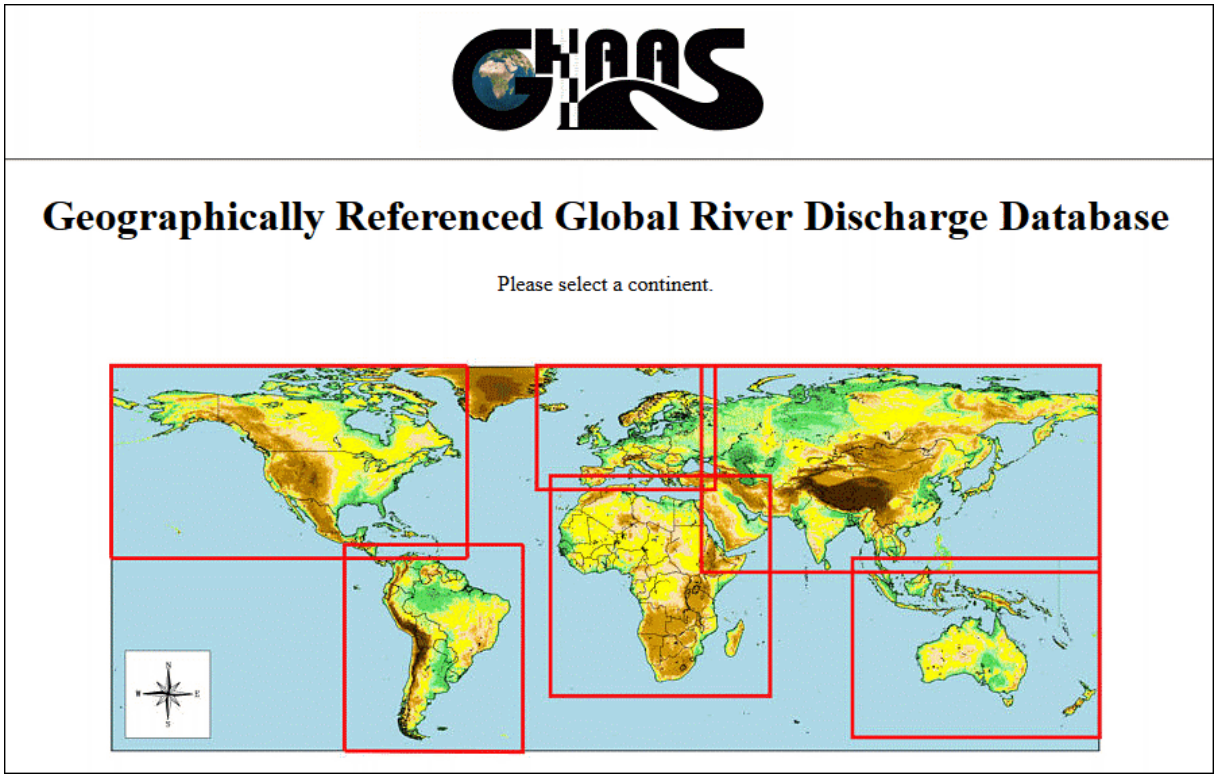
Data origin: variable

Status of the data: 2008 (last update)

The Global River Discharge Database

RivDIS v1.1

Organization / Program: **Institute for the Study of Earth, Oceans, and Space / University of New Hampshire, Durham NH (USA)**



Source: http://www.rivdis.sr.unh.edu/maps/

Dataset description: **worldwide compilation** of **river discharge information**

URL: http://www.rivdis.sr.unh.edu/

River basins: worldwide

Content:

- River Discharge Information (at worldwide station sites):
  - Geographically referenced data
  - Tabular data (information available by continent or country)

Data origin: *river discharge*: UNESCO river archives, series of publications entitled "The Discharge of Selected Rivers of the World" (1969-1984)

Status of the data: 4.8.1998 (last update)

World Resources Institute

Maps & Data

Organization / Program: **World Resources Institute, 10 G Street NE Suite 800, Washington, DC 20002, USA**

http://www.wri.org/resources/maps/water-stress-most-populous-river-basins

Dataset description: **Global research organization** focusing on six critical issues at the intersection of environment and development (**climate, energy, food, forests, water, and cities and transport**) producing **maps, charts, data sets, infographics** and **other visual resources**

URL: http://www.wri.org/

River basins: worldwide

Content:

- Country and River Basin Rankings
- Watersheds
- Water Stress
- Flood Risk
- Forest Atlas
- Mining and Critical Ecosystems

Data origin: various

Status of the data: various

Global Water System Project (GWSP)

GWSP Digital Water Atlas Project

Organization / Program: **GWSP International Project Office, Walter-Flex-Str. 3, Bonn, 53113 Germany**

Source: http://atlas.gwsp.org/index.php?option=com_content&task=view&id=97&Itemid=63

Dataset description: **project** including a **Digital Water Atlas** describing the **basic elements of the Global Water System**, the interlinkages of the elements and changes in the state of the Global Water System by creating a consistent set of annotated maps

URL: http://atlas.gwsp.org/index.php

River basins: worldwide

Content:

- **Natural environmental, anthropic environment:** anthroposphere (built environment, human settlements, land setup), atmosphere (air, climate), biosphere (organisms, ecosystems), environment (natural environment, anthropic environment), hydrosphere (freshwater, marine water, waters), land (landscape, geography), lithosphere (soil, geological processes), space, time (chronology)
- **Social aspects, environmental policy measures:** administration, management, policy, politics, institutions, planning, economics, finance, environmental policy, health, nutrition, information, education, culture, environmental awareness, legislation, norms, conventions, research, sciences, risks, safety, society
- **Human activities and products, effects on the environment:** agriculture, forestry, animal husbandry, fishery, chemistry, substances, processes, effects, impacts, energy, industry, crafts, technology, equipments, physical aspects, noise, vibrations, radiations, products, materials, recreation, tourism, resources (utilisation of resources), trade, services, traffic, transportation, wastes, pollutants, pollution

Data origin: variable

Status of the data: variable

Global River Sediment Yields Database

AQUASTAT Programme

Organization / Program: **Food and Agriculture Organization of the United Nations (FAO), AQUASTAT Programme**

	A	B	P	Q	R	S	T	U	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
1			Database of world rivers and their sediment yields																
2																			
3												Unknown	Pre -Dam	Post-Dam					
4										R	Ro	Condition	Conditions	Conditions	Y		Initial	Final	
5		River	Continent	Lat	Long	Area	Monitoring	Monitoring	H/L	Rainfall	Runoff	Load	Load	Load	Yield	Reservoir	Volume	Volume	
6				deg N	deg E	km^2	Start Date	End Date	m/km	mm/yr	(mm/yr)	(10^6 t/yr)	(10^6 t/yr)	(10^6 t/yr)	(t/km^2/yr)	?	Mn^3	Mn^3	Ref.
7	(1)	(2)	(13)	(14)	(15)		(17)	(18)		(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
8		river	cont	lat_n	long_e		start	end	rainfall	rainfall	runoff	unknown	pre-dam	post-dam	yield	resvoir	vol_ini	vol_fin	ref
9																			
836	827	Ruamahanga	Pacific			640						0,23			360				2
837	828	Tongariro	Pacific		48	772	1960	1963	19,7	2 633					420				1
838	829	Tukituki	Pacific			2 400						1,10			440				2
839	830	Tutaekuri	Pacific			790						0,33			420				2
840	831	Waiapu	Pacific			1 400						28,00			20 000				2
841	832	Waiapu	Pacific			1 378									19 970				18
842	833	Waiau	Pacific			2 000					1400	2,60			1 300				2
843	834	Waimakariri	Pacific			3 200					1200	5,30			1 700				2
844	835	Waingaromia	Pacific			175									17 340				18
845	836	Waioeka	Pacific			640						0,38			590				2
846	837	Waipaoa	Pacific			1 600						9,30			5 800				2
847	838	Waipaoa	Pacific	28	51	1 580	1960	1964	10,3	1 990					6 983				1
848	839	Wanganui	Pacific			6 600						2,20			330				2
849	840	Whakapapa	Pacific	7	28	176	1960	1963	89,6						929				1
850	841	Whakatane	Pacific			1 600						0,38			2 400				2
851	842	Colorado	South America	50	50	22 300	1938	1964							309				1
852	843	Colorado	South America			23 000					190	6,90			300				2
853	844	Negro	South America	26	40	95 000	1935	1965							142				1
854	845	Negro	South America			100 000					300	13,00			140				2
855	846	Parana	South America			2 600 000					165	79,00			30				2
856	847	Parana	South America			2 305 100									38				1
857	848	Parana	South America			2 304 121			0,8	1 750	204	89,86			39				7
858	849	Uraguay	South America			388 500									38				1
859	850	Uraguay	South America			388 335			2	1 500	322	15,15			39				7
860	851	Amazon	South America			6 133 120									65				1
861	852	Amazon	South America			6 130 515			1	2 000	932	404,61			66				7
862	853	Amazon	South America			6 100 000					100	1200,00			190				2
863	854	Sao Francisco	South America			640 000					150	6,00			9				2
864	855	Sao Francisco	South America			630 000						6,00			10				2
865	856	Aconcagua	South America	50	34	2 060	1962	1966	48,9	471					237				1
866	857	Cachapoal	South America	17	21	6 481	1958	1966	14,9	755					186				1
867	858	Tingiririca	South America	30	23	3 089	1957	1966	16,9	572					165				1
868	859	Magdalena	South America			240 000					990	220,00			916				2, 11
869	860		South America			8 500	1972								1 539	Reservoir			1
870	861	Rio Lempa	South America			8 584	1971	1975							1 185				1
871	862	Chira	South America			20 000					250	20,00			1 000				2
872	863	Grande	South America			230						0,42			1 800				2
873	864	Gurabo	South America			160						0,26			1 700				2
874	865	Uruguay	South America			240 000						11,00			45				2
875	866	Neveri	South America			980						0,29			300				2
876	867	Manzanares	South America			830						0,20			250				2
877	868	Maticora	South America			2 500						5,40			2 200				2
878	869	Orinoco	South America			990 000					1100	150,00			150				2
879	870	Orinoco	South America			949 350			1,5	1 750	753	94,94			100				7
880	871	Tuy	South America			6 600						12,00			1 800				2
881	872	Tuy	South America			6 610			19	1 250	224	1,57			238				7
882	873	Urama	South America			430						0,02			47				2

Source: FAO (Database of World's rivers and their sediment yields)

Dataset description: **database** containing **data on annual sediment yields in worldwide rivers and reservoirs** (searchable by river, country and continent)

URL: http://www.fao.org/nr/water/aquastat/sediment/index.stm

River basins: over 800 sediment data entries (worldwide)

Content:

- River (name, number, order, notes, country, continent)
- Sediment measurement (location of measurement, measurement site number, monitoring start date and end date, unknown condition load, pre-dam conditions load, post-dam conditions load, yield, reservoir, initial volume, final volume)

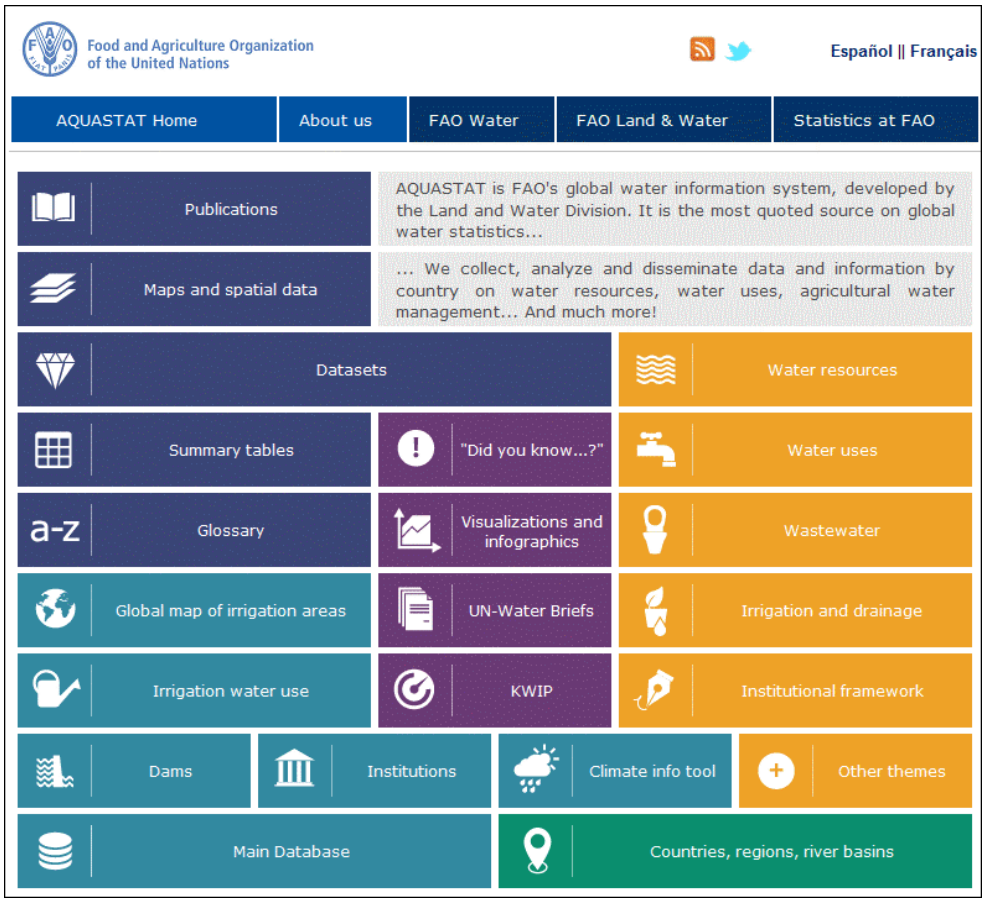
Data origin: *sediment data:* different sources by HR Wallingford, United Kingdom on behalf of the FAO Land and Water Division

Status of the data: 2000 (last update)

AQUASTAT

Databases

Organization / Program: **Food and Agriculture Organization of the United Nations (FAO)**



Source: http://www.fao.org/nr/water/aquastat/main/index.stm

Dataset description: **Global water information system**, developed by the Land and Water Division incl. **datasets, global maps and publications** on global water resources, water uses, water management etc.

URL: http://www.fao.org/nr/water/aquastat/main/index.stm

River basins: worldwide

Content:

- Dams database (~ 14000 dams in 156 countries)
- River sediment yields (~ 850 points on ~ 560 rivers in 78 countries)
- Others (e.g. freshwater withdrawal, institutions database, irrigation)

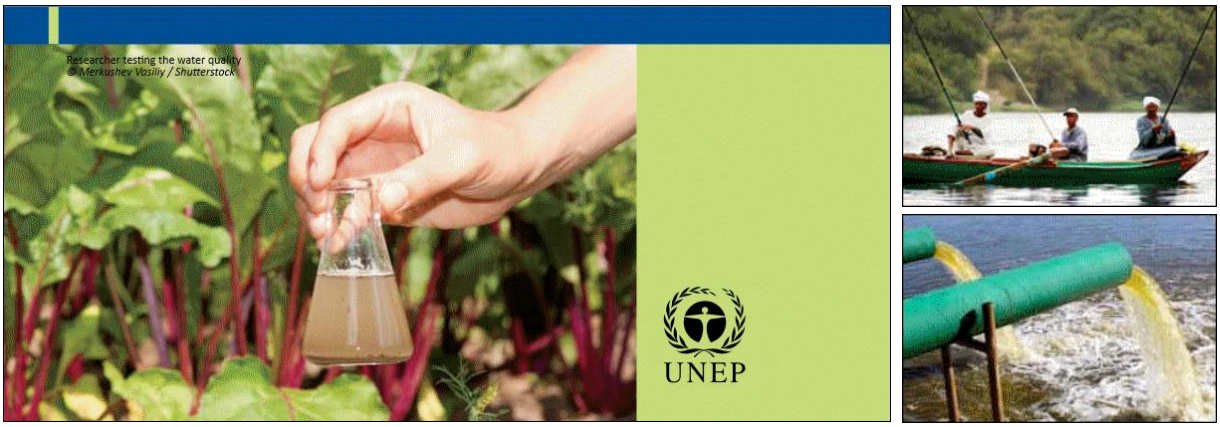
Data origin: variable

Status of the data: *water data*: variable (e.g. *dams database*: continuous; *river sediment yields*: 2000)

World Water Quality Assessment (WWQA)

UNEP (GEMS/Water)

Organization / Program: **International Centre on Water Resources and Global Change (hosted by the Federal Institute of Hydrology, Germany / Initiative of the UN-Water Group led by the United Nations Environment Programme UNEP with the Global Environment Monitoring System for Water (GEMS/Water)**



Source:http://www.unep.org/esm/Portals/50159/WWQA%20Report.pdf

Dataset description: **ongoing project** identifying current and future **freshwater quality problem areas in surface waters** (especially in developing countries), evaluating policy options for addressing water pollution and **establishing a water-quality database** to track the progress of surface water protection

URL:
http://www.unep.org/esm/Waterecosystems/WaterQuality/WorldWaterQualityAssessmentReport/tabid/ 131715/Default.aspx

River basins: worldwide (especially developing countries)

Content:

- Water Quality
- Areas of high loadings / pollution
- Sources of pollution
- Policy options

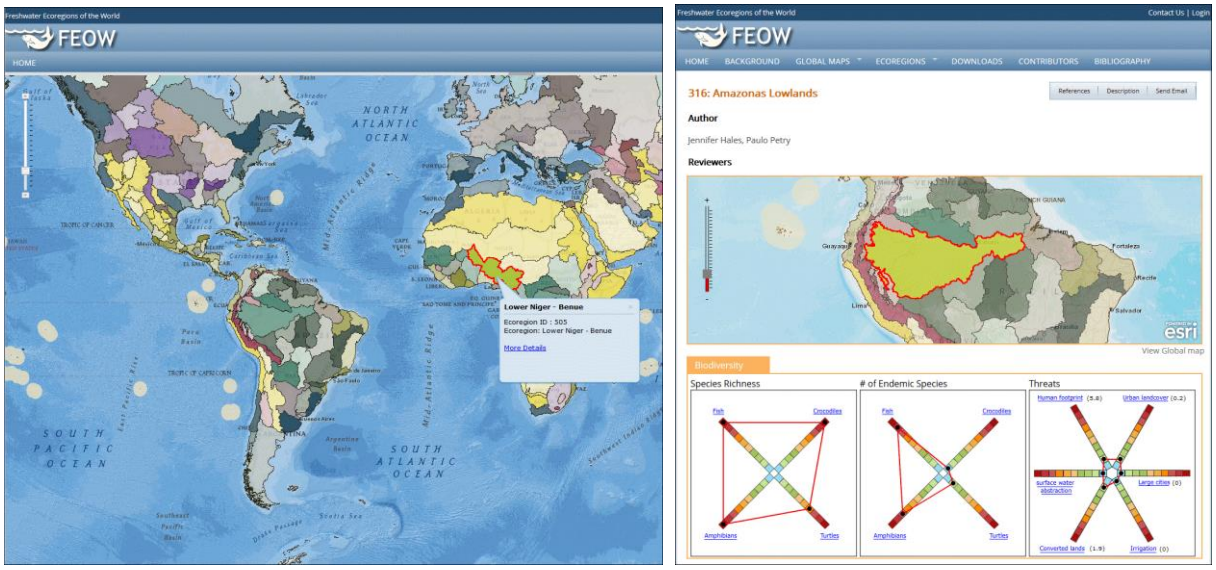
Data origin: variable

Status of the data: variable

Freshwater Ecoregions of the World (FEOW)

Interactive Map

Organization / Program: **The Nature Conservancy (TNC) and World Wildlife Fund (WWF)**



Source: http://www.feow.org/globalmap

Dataset description: collaborative project including an interactive **web database** providing a **global biogeographic regionalization of the Earth's freshwater biodiversity** and **synthesizing biodiversity and threat data** for the resulting **ecoregions**

URL: http://www.feow.org/

River basins: 426 units (whose boundaries generally correspond with those of watersheds)

Content:

- Species richness (fish, amphibians, turtles, crocodiles)
- Number of endemic species (fish, amphibians, turtles, crocodiles)
- Threats (human footprint, urban landcover, large cities, irrigation, converted lands, surface water abstraction)

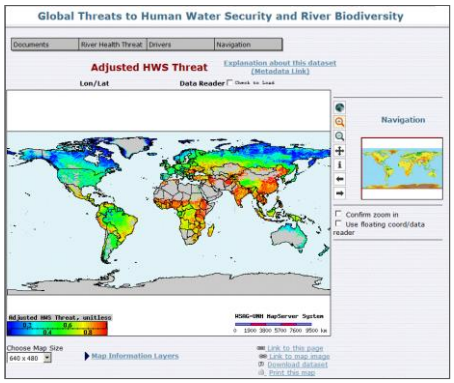
Data origin: *ecoregional data*: variable experts (contributors to FEOW are individuals who have either delineated ecoregions, reviewed ecoregion delineations, contributed or reviewed species lists, or authored or reviewed ecoregion descriptions

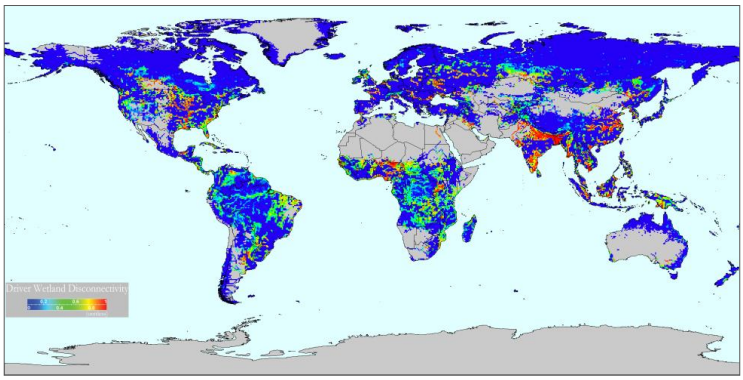
Status of the data: 2.10.2015 (last update); *ecoregional data*: variable

Rivers in Crisis

Mapping dual threats to water security for biodiversity and humans

Organization / Program: **City College of New York, USA & University of Wisconsin, Madison, Wisconsin, USA & International Media Outreach, Toronto, Canada**





http://www.riverthreat.net/maps/

Dataset description: **global-scale initiative** to quantify the **impact of human-induced stressors on human water security and riverine biodiversity** (incl. an **interactive mapping tool**, pre-defined maps and a Nature Article)

URL: http://www.riverthreat.net/index.html

River basins: worldwide

Content:

- Catchment disturbance (cropland, impervious surfaces, livestock density, wetland disconnectivity)
- Pollution (soil salinization, anthropogenic nitrogen loading, anthropogenic phosphorus loading, anthropogenic mercury deposition, pesticide loading, sediment loading, organic loading, potential acidification, thermal alteration)
- Water resource development (dam density, river fragmentation, consumptive water loss, human water stress, agricultural water stress, change in residence time)
- Biotic factors (Number and percent of non-Native Fishes, fishing pressure, aquaculture pressure)

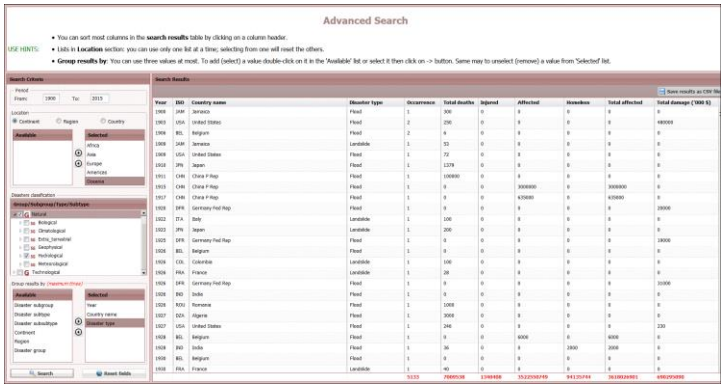
Data origin: variable (see also Nature Article "Global threats to human water security and river biodiversity")

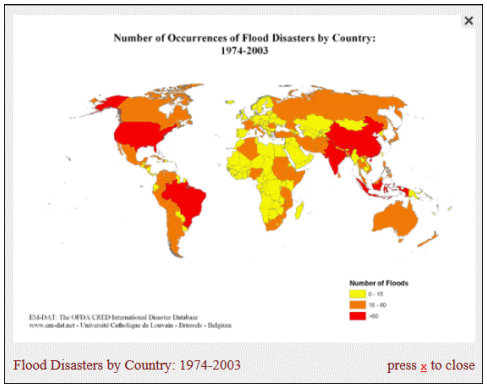
Status of the data: variable

The International Disaster Database

EM-DAT Database

Organization / Program: **Centre for Research on the Epidemiology of Disasters (CRED), School of Public Health of the Université catholique de Louvain, Brussels, Belgium**





Source: http://www.emdat.be/

Dataset description: **global database on natural and technological disasters** that contains essential core data on the occurrence and effects of more than 21000 disasters in the world from 1900 to present and includes **4 dynamic search tools** (countries, disaster profiles, disaster list, advanced search) and pre-made **disaster reference maps**

URL: http://www.emdat.be/

River basins: worldwide (no specific reference to river basins)

Content:

- Natural disasters (biological, climatological, extra-terrestrial, geophysical, hydrological, meteorological)
- Technological disasters
- Complex disasters

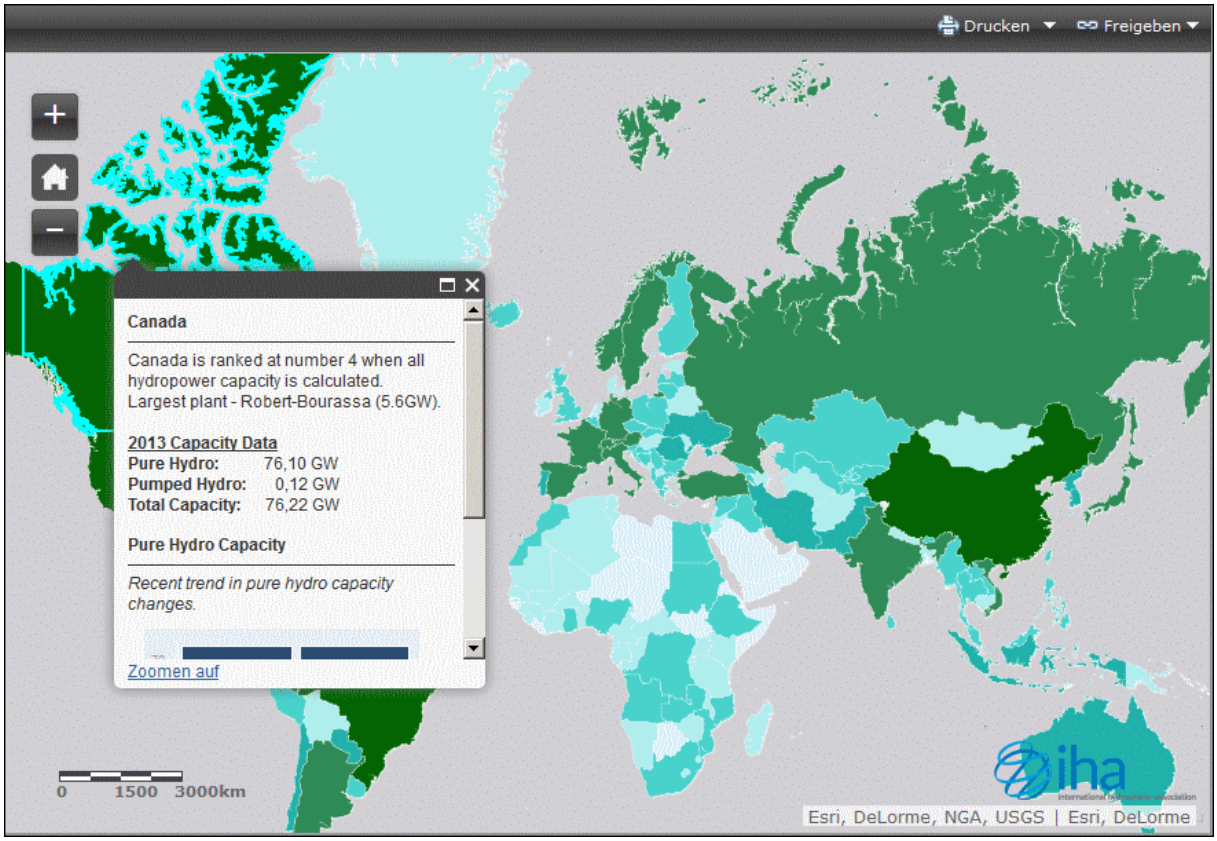
Data origin: *disaster data*: various sources, including UN agencies, non-governmental organizations, insurance companies, research institutes and press agencies (Priority is given to data from UN agencies, governments and the International Federation of Red Cross and Red Crescent Societies.)

Status of the data: 2009 (last update); *disaster data*: variable

International Hydropower Association (IHA)

Hydropower Maps

Organization / Program: **International Hydropower Association (IHA), Chancery House, St Nicholas Way, Sutton, London SM1 1JB, United Kingdom**



Source: https://www.hydropower.org/world-installed-hydropower-capacity

Dataset description: Interactive **web database** illustrating **data on hydropower installed capacities**, **World generation density** and **intensity by population**

URL: https://www.hydropower.org/maps

River basins: worldwide (no specific reference to river basins)

Content:

- Installed hydropower capacity
- Hydropower generation density
- Hydropower generation intensity by population

Data origin: *hydropower data*: various sources (regulators, ministries, electricity associations, World's station owners and operators)

Status of the data: n.s.

The European Small Hydropower Association (ESHA)

Small Hydropower Map

Organization / Program: **ESHA Secretariat, Renewable Energy House, Rue d'Arlon 67, Brussels, Belgium**

Source: http://www.esha.be/projects/projects/hydropower-map.html

Dataset description: Interactive **web database** illustrating **data on small hydropower plants mainly in Europe**

URL: http://www.esha.be/projects/projects/hydropower-map.html

River basins: mainly in Europe (no specific reference to river basins)

Content:

- Installed hydropower plant (type, power, planning, installation year, details)

Data origin: *small hydropower data*: various sources (broad network of organizations, regions, local authorities, companies and other energy actors within the framework of the *repowermap.org initiative*, which is a non-profit initiative supported by the European Union)

Status of the data: n.s.

APPENDIX IV

Questionnaire on the Determination of the Parameters

Questionnaire on the Determination of the Parameters

for further developing the World´s Large Rivers Initiative (WLRI)

Please nominate in the following table the **3-4 most important parameters** (column: "high importance") from your point of view in each category. The categories are "Hydrology and Hydraulics", "Sediment Transport and Morphodynamics", "Water Quality and Ecology", "River Management & Socioeconomics".

Further you can also mark the remaining parameters with a cross, either if you consider them of medium or low importance.

Additionally we ask you to mark if you think these parameters should be determined on river OR catchment level.

Based on your input we will select those parameters which will be used for the development of the methodology in Phase I (including analysis of the existing situation, historic developments, future trends, variability, etc.).

Please send the list of your selected parameters by e-mail, no later than **16th of September 2016** to **worldslargerivers@boku.ac.at**.

Please mark the parameters according to your point of view.

Parameters	Importance for Phase I			To be determined on		Further remarks e.g.: comments regarding necessary time series, accuracy, etc.
	high	medium	low	river level	catchment level	
Hydrology & Hydraulics						
Hydrology						
Mean annual runoff						
Low and high flows						
Mean monthly / seasonal runoff						
CV of annual flow						
Flow regime						
Ground water parameter (BFI)						
Minimum flow (e.g. Q95)						
Trend in flows						
Flow duration curves (for hydrology & meteorology)						
Spatial variability (at different locations in the river basin)						
Temporal variability (hydrographs)						
Additional Data in regard to the whole Catchment						
Drainage basins						
Watershed boundaries						
Flow direction						
Flow accumulations						
River networks						
…						
…						

Parameters	Importance for Phase I			To be determined on		Further remarks e.g.: comments regarding necessary time series, accuracy, etc.
	high	medium	low	river level	catchment level	
Sediment Transport & Morphodynamics						
Sediments						
Sediment source (spatial, temporal)						
Sediment fluxes, in the river and the mouth						
Sediment trends (statistical values)						
Grain size of the sediments, change of grain size over time						
Ratio of bedload and suspended sediments, fractions						
Ratio on Sed_Discharge max vs Sed_Discharge min						
Spatio temporal variability of sediment transport						
Sediment budget (source, sink)						
Types of clay, fines						
Atmospheric input of sediment (by dust, desert, aeolianl)						
Sediment quality						
Trap efficiency						
Future trends						
Morphodynamics						
Floodplain and dimensions, surface						
Channel patterns, forms						
River metamorphosis						
Migration rates, bank erosion						
River bed level changes, including trends						
Base level changes						
Bathymetry, river and delta, bloom of sediments						

Parameters	Importance for Phase I			To be determined on		Further remarks e.g.: comments regarding necessary time series, accuracy, etc.
	high	medium	low	river level	catchment level	
Incision, cutoff sediments						
Contaminants and sediments and morphodynamics						
Coastal morphodynamics-fluxes						
Future trends						
Human impacts and effects on sediment transport and morphodynamics						
Hydropower plants						
Dredging						
River engineering						
Measures for floodrisk management						
Land cover changes						
Erosion protection works						
…						
…						
…						

Parameters	Importance for Phase I			To be determined on		Further remarks e.g.: comments regarding necessary time series, accuracy, etc.
	high	medium	low	river level	catchment level	
Water Quality & Ecology						
Ecosystems and Biodiversity						
Wetland disconnectivity						
Ecosystem impacts from dams						
Freshwater Species						
Species richness						
Livestock density						
Fish diversity						
Rare and endangered species and biotic communities						
Number of endemic species						
Number of non-native fishes						
Impervious surfaces						
Threats and Human Pressures						
Threats to fish						
Threats to other species (birds, mammals, amphibians and reptiles)						
WWF living plant index for freshwater						
Human footprint						
Extinction risk						
Fishing pressure						
Aquaculture pressure						
Climate change induced changes species and biotic communities						

Parameters	Importance for Phase I			To be determined on		Further remarks e.g.: comments regarding necessary time series, accuracy, etc.
	high	medium	low	river level	catchment level	
Water Quality and Pollution						
Ecological status						
Thermal pollution						
Nutrient pollution						
Wastewater pollution						
Mercury accumulation						
Biological oxygen demand						
Freshwater alkalinity						
Anthropogenic nitrogen loading						
Anthropogenic phosphorus loading						
Pesticide loading						
Organic loading						
Soil salinization						
Potential acidification						
Areas of high loadings / pollution						
Poorest water quality						
Other aspects						
Nutrients / minerals / OM / particles / aquatic life (species, fish …)						
Need to define basin specific parameters						
Quid biosensors /sediments and remote sensing						
Need for SMART parameters and assessment methodologies (integrated in space and time)						

Parameters	Importance for Phase I			To be determined on		Further remarks e.g.: comments regarding necessary time series, accuracy, etc.
	high	medium	low	river level	catchment level	
River Management & Socioeconomics						
Water Use						
Hydropower (installed capacity, generation density)						
Irrigation						
Navigation						
Recreation						
Nutrition						
Fishing						
Mining						
Freshwater withdrawal						
Water Stress and Water Resource Development						
Environmental water stress						
Human water stress						
Agricultural water stress						
Water exploitation index						
Water scarcity index						
Water management in urban areas						
Dam density						
Level of river fragmentation						
Level of flow regulation						
Consumptive water loss						
World storage capacity						
…						

Parameters	Importance for Phase I			To be determined on		Further remarks e.g.: comments regarding necessary time series, accuracy, etc.
	high	medium	low	river level	catchment level	
River Management & Socioeconomics						
Socioeconomics						
Water Economics / dependence on water resources						
Societal wellbeing						
Exposure to floods						
Exposure to droughts						
Water and health (e.g. spread of cholera)						
Pricing water						
Environmental awareness						
Disasters (biological, climatological, geophysical, hydrological, meteorological and technological)						
Governance						
Legal framework						
Hydropolitical tensions / conflicts						
Enabling environment						
…						
…						
…						