Sustainable Water Future Programme

Initial Design Report

SWFP
Sustainable Water Future Programme

futureearth

Imprint

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A Scientific, Policy Relevant, and Solution Oriented Global Water Research Programme for Sustainable Development

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Executive Summary

For a decade, the Global Water System Project (GWSP) has been administered under the Earth System Science Partnership (ESSP) and the four Global Environmental Change Programmes (IGBP, IHDP, DIVESITAS and WCRP). GWSP coordinated and supported a broad research agenda to study the complex global water system, including the interactions between natural and human components, and their feedback processes.

GWSP has now transitioned into the Sustainable Water Future Programme (SWFP) of Future Earth, building upon more than a decade of its global water-related studies. With clear emphasis on solutions, the Sustainable Water Future Programme has an objective of promoting the adoption of science-based evidence into the implementation and monitoring of goals for sustainable development, and it will develop into a center of excellence for interdisciplinary global water research to support sustainable development trajectories.

SWFP will maximize the value of water research in the stewardship domain, co-balancing the needs of humankind and nature through the protection of ecosystems and their services provided, offering solutions based on interdisciplinary science with the involvement of all relevant stakeholders for a sustainable "Water World".

The integrative, inter- and transdisciplinary water programme will address science, engineering, governance and management issues, enhancing the knowledge base of a science–policy dialogue. This broadens the scope of the programme to serve as an incubator, network hub and translator of different projects' scientific findings for science-policy dialogues. For instance, the SWFP will serve as a "testbed" for developing, testing and monitoring experience with integrated methodologies and will establish a future oriented knowledge synthesis and assessment process on the state of global water resources, the Global Water System Assessment. The process will have tangible outputs, organized as a series of Sustainable Water Future Reports and Topical Reports, the content of which will be co-designed by knowledge generators and knowledge implementers. Another product will be a dedicated, state-of-the-art science and technology assets component from the Earth System Science and technology communities. This pillar will be built on the successful GWSP Global Water Atlas (www.atlas.gwsp.org) uniting high resolution geospatial data and information systems. The integrated information system will provide for: queryable meta-data; baseline spatial mapping; derived indicators organized in meaningful geophysical space (i.e., river networks, basins) and administrative units for management (i.e., provinces, nation-states); affiliated information resources (i.e., economic statistics, legal frameworks, governance indicators); scenario design; and, tradeoff assessment tools.

Preface

The transition process of the Global Water System Project (GWSP) into the Sustainable Water Future Programme (SWFP) started two years back in response to a call to the global water research community to expand the focus on fundamental global water system research to one that co-produces actionable scientific knowledge with the environmental planning, policy and management community.

Research carried out by GWSP and its partners over the last decade has produced several important results that inform a better global understanding of fresh water today, particularly on how countless millions of individual local human actions add up and reverberate into larger regional, continental and global changes that have drastically changed water flows and storage, impaired water quality, and damaged aquatic ecosystems. These realities had motivated the global water community to assemble in Bonn in May 2013 for the GWSP open science conference "Water in the Anthropocene". As an outcome of the conference, a set of core recommendations in the form of the Bonn Water Declaration on Global Water Security was made to institutions and individuals focused on science, governance, and management of water. The Declaration urged them to form a strategic partnership in order to develop a community-consensus blueprint for a reality-based and multi-scale knowledge-to-action water agenda. This initial design document for the establishment of the The Sustainable Water Future Programmes is based on the recommendations of the Bonn Water Declaration. It provides a synoptic blue print for a Sustainable Water Future Programme on the basis of a prospective and forward looking synthesis paper written by Claudia Pahl-Wostl, Charles Vörösmarty, Anik Bhaduri, Janos Bogardi, Johan Rockström and Joseph Alcamo (Pahl- Wostl et al 2013).

In this endeavor, we would like thank other members of the Scientific Steering Committee of GWSP, Hong Yang, Stuart Bunn, Joyeeta Gupta, Richard Lawford , Jun Xia , Sharad Jain, Felino Lansigan , Claudia Ringler, David Dudgeon and members of Future Earth and Global Environmental Change community for their valuable comments on this document, and on related Future Earth transition documents.
We also would like to thank members of the GWSP International Project Office, Sina Marx, Eva Flinkerbusch and Anna Schürkmann as well as Ninad Bondre from IGBP secretariat for their contribution in the synthesis process and in editing this document. Finally, we thank the German Federal Ministry of Education and Research (BMBF), the German Research Foundation (DFG) and the US National Science Foundation (NSF) for their financial support of organizing conferences and workshops to prepare the blueprint for the freshwater research agenda of this new water programme.

Charles Vörösmarty and Claudia Pahl-Wostl
Co-Chairs of the Global Water System Project

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1. Introduction

1.1 Global Water Research: Towards Solution-Oriented Approaches

In the face of global change, sustainable water management represents a major challenge for humanity in a highly interconnected and rapidly changing world. Water is an absolute requirement for life and human well-being, yet humankind modifies - often irreversibly and unwittingly - the pathways and processes through which the global water cycle operates. The last decade of global water research has provided clear evidence and understanding of these modifications and identified the key problems associated with human management - and mismanagement - of water. Trends in many variables indicate that human-water interactions are intensifying and indicate a worsening global situation and looming water crises manifest at regional and local scales. Insights from science seem not to have been translated to path-breaking action to reverse these trends. This can also be attributed to the fact that research in the past has emphasized the identification of problems rather than the identification of solutions. In order to move towards sustainable use of our water resource, we need an approach that deals with the increased demand for scarce water resources under environmental and socio-economic constraints, identify unrealized co-benefits of economic development and environmental protection; and make a major contribution towards these end by focusing on integrated solutions to some of the key challenges that global change poses to the Earth system and humanity as a whole.

For a decade, the Global Water System Project (GWSP)[1] has been administered under the Earth System Science Partnership (ESSP) and its four Global Environmental Change Programmes[2].

GWSP coordinated and supported a broad research agenda to study the complex global water system, including the interactions between natural and human components, and their feedback processes. GWSP has transitioned into a long term Sustainable Water Future Programme (SWFP) of Future Earth[3], and will work closely together with global initiatives like UNESCO, UNEP, UNU, and CGIAR.

The GWSP conference on "Water in the Anthropocene" held in Bonn during May 2013 elaborated upon the current state-of-the-art in interdisciplinary water research, setting the stage for the next step in the evolution of the global water research agenda, namely to more formally connect research to improved decision making. As an output from this international event, the water community made a set of core recommendations in the form of a declaration called "The Bonn Declaration on Global Water Security", addressing institutions and individuals focused on science, governance, management and decision-making relevant to water resources on Earth. The declaration calls for joint global action to develop a broad community consensus blueprint for a reality-based, multi-perspective and multi-scale knowledge-to-action water agenda based on these recommendations. This design document for the establishment of the "Sustainable Water Future Programme" (SWFP) is conceived based on the recommendations of the Bonn Water Declaration, with a clear objective of promoting the adoption of science-based evidence into the implementation and monitoring of goals for sustainable development.

SWFP will maximize the value of water research in the stewardship domain, co-balancing the needs of humankind and nature through the protection of ecosystems and their services provided, offering solutions based on interdisciplinary science with the involvement of all relevant stakeholders for a sustainable "Water World".

While there have been many scientific and conceptual breakthroughs, our capacity to understand the evolving water system has still remained limited.

[1] www.gwsp.org

[2] DIVERSITAS, the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme (IHDP) and the World Climate Research Programme (WCRP).

[3] http://www.futureearth.org

There are still gaps in the integrated knowledge of change in the global water system concerning the following

- How do we support the economies and societies to move on a trajectory that ensures water resource-efficiency, sustainability and wellbeing?
- How could we measure risk to humans and the global water system through quantifying the bio geophysical goods and services conveyed by the Earth System?
- In an interconnected world, how can we govern and minimize the negative impacts of systemic and emerging risk to attain sustainability?
- How do humans perceive of, economically value, and manage planetary and fresh water ecosystems as assets?
- How could societies invest in renewing and sustaining such assets to guarantee future well-being of social-ecological systems?

A future solution-oriented research, knowledge synthesis and assessment process under the leadership of the scientific community within the framework of the SWFP offers a high legitimacy, with the aim of facilitating a knowledge flow between science, policy and application. With successfully integrated models, an improved quantitative, geospatial, and institutional analysis depicting the biophysical and human dimensions of freshwater, the rapidly expanding knowledge base will be productively applied at scales important to managers, integrating it with situated knowledge and experience on the ground to produce robust solutions to complex problems. Close exchange between research, policymaking and practice will increase the practical relevance of knowledge produced within the SWFP.
SWFP will address the water related scientific, policy and fundamental societal questions regarding global environmental change and pathways toward sustainable futures with the following knowledge to action agenda as mentioned in the Bonn Water Declaration on Global Water Security:

- Understanding the complex and interlinked nature of the global water system and current and future changes through adopting a multi scale and interdisciplinary approach.
- Implementation of the state-of-the-art synthesis studies of knowledge about water system that can inform risk assessments and be used to develop strategies to better promote the protection of water systems.
- Capacity building of the next generation of water scientists and practitioners in water research, making use of cross-scale analysis and integrated system design.
- Expanded monitoring, through traditional land-based environmental observation networks and state-of-the-art earth-observation satellite systems, to provide detailed observations of state of global water system.
- Explore ecosystem-based alternatives to costly structural solutions for climate proofing, such that the design of the built environment in future includes both traditional and green infrastructure.
- Stimulating innovation in water institutions, with a balance of technical- and governance-based solutions and taking heed of value systems and equity.

1.2 Elements of the Sustainable Water Future Programme

Water is and will remain a crucial factor of adaptation to the multifold challenges that humankind faces in the light of global change, including climate change, environmental hazards, population growth, health risks, economic development, technological innovations, pollution, land use change and ecosystem protection and restoration. If water does not gain the necessary attention despite its cross-cutting and integrating functions in dealing with all of these issues, it will be impossible to deal sustainably with global change.

Furthermore, water remains an important interdisciplinary research area, centrally positioned at the interface of social and natural (water) sciences; given that neither water governance problems nor technical issues can be successfully addressed without accounting for value systems, social aspirations, beliefs and culture.

Further, despite a decade of research outcomes, we have no formal synthesis of water research generated by the global water community to date. Therefore, we see the timely need for a process to systematically harvest and subsequently test the value of this vast and continuously growing store of information within policy and management domains, leading to sustainable solutions for water problems.

Given the intrinsic character of water and the challenges involved in dealing with the need to upscale (findings), integrate (over sectors and disciplines) and communicate (with policy, practice and public), the Sustainable Water Future Programme (SWFP) will be a broader water programme in global change research.

As to be seen in Fig.1, the integral components of SWFP will be:

1. Cutting Edge Research and Knowledge Synthesis on Multiple Scales
2. Solutions through Co-Design with Stakeholders
3. Scientific Assessments of the Impacts of Institutions and Policy Instruments on the Earth system and Human Well-being (on basis of 1 and 2)
4. Capacity Building and Outreach

This integrative, inter- and transdisciplinary water programme will address science, engineering, governance and management issues, enhancing the knowledge base of a science–policy dialogue. In fact, the water programme could be conceived as a breeding place, network hub and translator of different projects' scientific findings for science- policy dialogues and demonstrate how new approaches to research and capacity building can create a tangible move toward sustainability. In the spirit of the Sustainable Water Future framework, such demonstration projects should not address sustainability solely from the water perspective, but rather in a manner that avoids traditional fragmented approaches. Such projects should involve:

- Shared problem identification: a structured phase of pre-project deliberation involving researchers, funders and stakeholders.

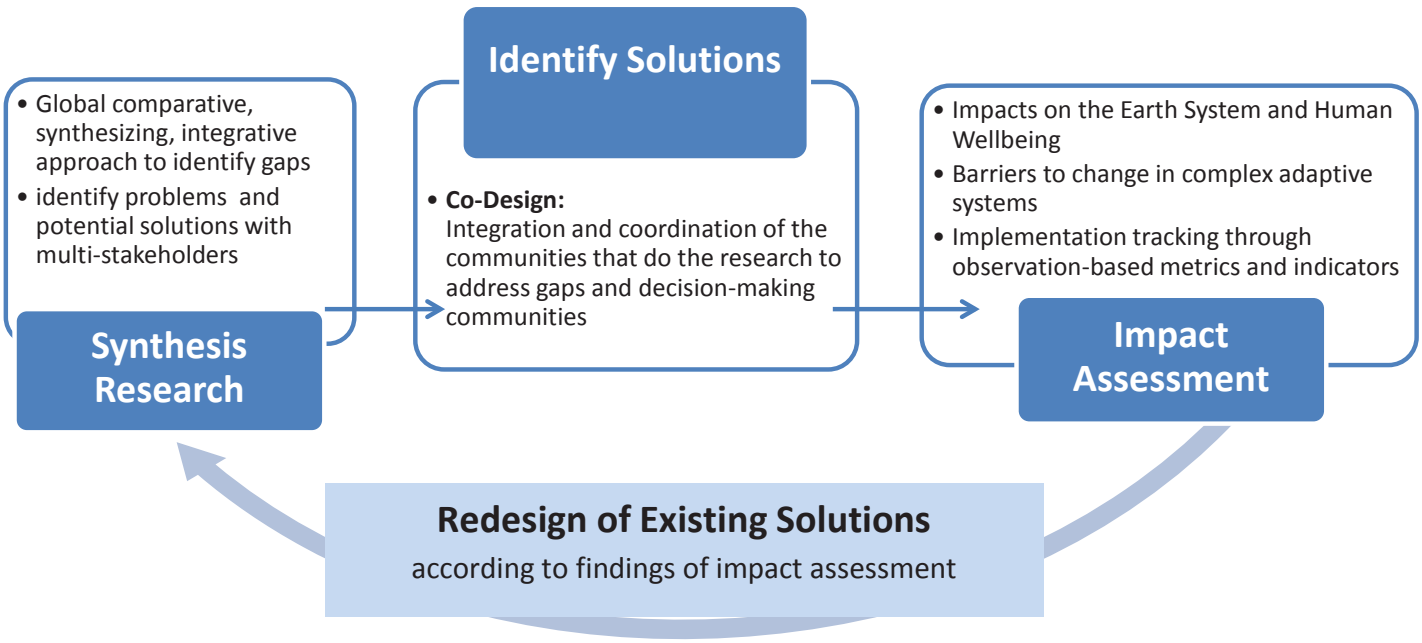

Figure 1: Integral components of the Sustainable Water Future Programme

- Establishing and then supporting "testbeds" for developing, testing and monitoring experience with integrated methodologies, whereby experimentation with different approaches is encouraged. Viable methodologies that generate interdisciplinary and transdisciplinary knowledge and integrate different knowledge cultures are not developed here in the abstract, but in practice.
- Integrating education and exchange programmes for academia, policy and practitioners.
- A shared vision: developed between all stakeholders within all projects to guide research and implementation, regularly updated based on the results of the Programme.
- Creating an institutional space to develop epistemology, methodologies and influence of transdisciplinary research and practice.
- Time for thought and integration: synthesis is an essential phase (or part of the cycle) – 'knowing what is known' in transdisciplinary research is not the same as in separate scientific disciplines, and will need to reflect a crucial part of the programme.

A global network of such projects could be realized in a stepwise and flexible approach through the following:

- Funding long-term initiatives that analyze and build the capacity of regions to deal with global environmental change.
- Organizing a project network around a core module coordinating the development of shared conceptual and methodological frameworks, establishing shared data and knowledge bases and monitoring the progress of the initiatives in order to allow cross-initiative learning and knowledge integration.
- Implementing an open global sustainability learning platform to connect projects funded under the umbrella of long-term initiatives. Such a platform should be open for further transdisciplinary projects of differing natures and operating at different levels that meet certain access criteria.

Based on experience from a decade of research under the umbrella of GWSP (Bogardi 2012, Vörösmarty et al 2013, Gupta and Pahl-Wostl 2013, Pahl-Wostl et al 2012, 2013a, 2013b, Bhaduri et al 2014) and the objective to transit towards a new era of solution-oriented research, it is considered that a next phase of water research encompasses the following four guiding principles that cut across all activities:

- **Generate robust knowledge.** Water is featured as a key agent of planetary cycles, a medium inherent in several sectors and transitions and as a basic ingredient to ensure human well-being. In this latter capacity water governance is a key to sustainability. Sustainable Water Future is a perspective, a framing of sustainability problems as seen through a water lens. The science agenda, generating new knowledge in co-production with stakeholders at and for different scales, is emphasized by global and regional foci.
- **Enhance water security.** The term "security" emphasizes the multifaceted nature of water as a highly coveted (often) internationally shared and mobile resource, its role in securing human life and well functioning of socioeconomic and environmental systems. But at the same time water can be a source of threat. A particular feature is to explore the synergies and differences between sustainability and security concepts, to develop operational targets and monitoring processes by considering security to have different meanings at different levels/scales and for different groups.
- **Support good governance.** The term "governance" stands for the essential structure and function of water-related institutions (legal frameworks, cultural norms). It also refers to agency by individual and collective actors to meet both the water-related objectives stipulated as development or political goals (e.g. MDGs, SDGs etc.) and those emerging from ethical considerations of sustainability. Good governance has a normative connotation and requires the adoption of widely shared principles. Assessing governance performance according to good governance principles (e.g. transparent, effective, efficient, accountable, equitable) represents a reality check for both (new) knowledge and the effectiveness of governance arrangements.
- **Monitor progress.** An ability to recognize sustainable practices and to attain sustainability goals requires a well-designed measuring system. The programme will support the monitoring of progress towards achieving global targets such as the SDGs. It will represent a reality check for both (new) knowledge and the effectiveness of governance arrangements with a suitably cast international reporting system, comprising focused global, national and sub-national science, social science, governance, technical capacity and economic statistics.

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1.2.1 Thematic Areas

The SWFP will be organized under three major thematic areas that resonate with a more solution and action-oriented approach and will dovetail within the Future Earth agenda (Future Earth 2013). These are:

1. Global State of Water

This thematic field produces factual knowledge concerning the global state of water, developing conceptual and methodological innovations to improve analysis and diagnostic capabilities. It supports the assessment of progress towards achieving global targets of the water related Sustainable Development Goals (SDGs), and assessing risk to humans and the global water system through appropriate risk related metrics. The programme will involve efforts to integrate and strengthen the fragmented landscape of global assessments through partnerships.

2. Governing the Transition

This thematic area concerns the dynamic society-nature interface and interactions at and across different scales in terms of governing the transition towards a sustainable water future. In this context, the segment further develops the Global Water Governance expertise of GWSP, addressing institutional landscapes, actor networks, multi-dimensional valuation of water and its services. The importance of governance reform, adaptive management, learning and negotiation processes will be reflected through a strong emphasis on policy relevant action research towards solution-oriented approaches.

3. Water as Global Change Agent

This key point focuses on the role of water as an agent of change towards sustainability. Adopting a "water lens" view supports a more integrated and sustainable perspective. In particular, it will explore the water, energy and food security nexus, the water-carbon (energy) link and interfaces with water and health, as well as water and biodiversity (ecosystem services) issues. It will highlight the role of water as an agent transmitting global change effects and its critical role in the development agenda. Climate change, population growth, changes in land use patterns influence the hydrological cycle, water related services and risks with wide ranging implications for humans and the environment. While similar perspectives were embedded within the Global Water System Project agenda [GWSP 2005], here we advocate for attribution studies that are viewed from the perspective of sustainable development.

The table below lists the research topics to be addressed under the thematic areas of SWFP. We also show how these topics could be embedded within the Future Earth initiative. In Annex 8.1, specific research questions are also listed under each of the above thematic areas. The questions and topics are derived from a comprehensive synthesis process initiated by GWSP.

Table 1: Specific research topics to be addressed under the Thematic Research Areas of the Sustainable Water Future Programme (SWFP) mapped onto the research themes of Future Earth (Please note that research areas are not exhaustive)

SWFP Theme / Future Earth Theme	Thematic Research Areas		
	Global State of Water	**Water as Global Change Agent**	**Governing the Transition**
Dynamic Planet	• Understand the connectivity across physical, chemical, biological, and human dimensions of the water cycle • Develop holistic understanding of ground- and surface-water interactions • Assess humans impact on global water system	• Assess water's fundamental role in sustaining functional socio-ecological systems • Analyze water transmitting impacts of global change across scales	• Identify regime shifts and tipping points • Investigate appropriate institutional structures for preparedness
Global Development	• Assess water quality impacts on natural systems and human wellbeing • Assess urban water systems in areas of rapid urbanization • Evaluate the impact of agro-ecosystems which must support additional billions of human population • Setting planetary boundaries for water, analyzing water related thresholds of potential concern and social-ecological interactions in the Earth system.	• Analyze role of water for societal development • Reframe dealing with uncertainty towards robust, no-regret strategies and design of resilient systems	• Develop strategies to balance patterns of scarcity and excess of water • Support participation and equity in decision-making processes • Develop strategies to balance human water security and environmental health • Analyze effectiveness of science-policy link, particularly regarding pro-poor policies
Transformation towards Sustainability	• Risk Assessment related to the achievement of Sustainable Development Goals • Evaluate impact of SDGs on the global and regional water systems of the planet	• Develop strategies for water driving sectoral integration – water-food-energy nexus • Develop and support water innovation – green infrastructure • Analyze economic factors influencing the availability and quality of water, e.g. energy production, drinking water, etc.	• Develop future water scenarios and assess trajectories towards a sustainable water future • Support design, implementation and evaluation of water governance settings at different levels • Analyze change in and role of values, ethics and beliefs on water governance • Analyze different conditions for effective implementation of water market and other innovative financing instruments mechanisms.

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1.2.2 Transition towards a Sustainable Water Future

Developing robust knowledge is necessary yet not sufficient to govern the transition towards a sustainable water future. Good governance and leadership have yet to set the stage for developing and implementing sustainable management practices, with the new challenge at the fully global scale. Enhancing water security for both humans and nature needs to be translated into operational targets that can be monitored and can guide adaptive strategies. The world looks at threshold economies. To what extent will their development follow the environmental Kuznets Curve, with rising environmental degradation until a certain income level is crossed? Or will they become the pioneers in the sustainable development agenda? We are convinced that the nature of water governance and management will be the determining factor in setting this course. Through the Sustainable Water Future Programme, the scientific community adopts an active role in shaping this course. It aims at creating a strategic partnership of scientists, public stakeholders, decision-makers and the private sector to implement a reality-based, multi-perspective and multi-scale knowledge-to-action water agenda. Greater emphasis will be required to assess how sustainability research on water can contribute to pro-poor policies.

Given its emphasis on solutions, the Sustainable Water Future Programme will aim to develop a global think-tank providing global leadership in identifying research areas and promoting the recognition of major research findings. The Sustainable Water Future Programme will develop as a bridging organization in a polycentric structure, linking the key players in the water field (like UN-Bodies- UNESCO, UNEP, WMO, FAO , Future Earth, Group of Earth Observation, CGIAR, Global Water Partnership, World Water Council, National research bodies etc.). It will combine a high level of legitimacy in knowledge generation with assuring representativeness. SWFP will also develop joint activities with other water related projects of Future Earth, including Future Earth Coasts (formerly known as LOICZ), CCAFS, GEWEX, GLP, and ESG with the aim to promote joint research activities.

The cluster on “Sustainability for Water, Energy, and Food through Integrated Water Information and Improved Governance” currently funded by Future Earth and organized by GWSP is a recent example of such collaboration. In this research cluster, GWSP is actively engaged with GEWEX, GLP, ESSP to develop a plan for research and application activities in order to improve the sustainability of water resources and the essential productivity of energy and food systems, and advance integrated application of sustainable development principles in the Water-Energy-Food Nexus at all scales.

Global Water System Assessment Initiative

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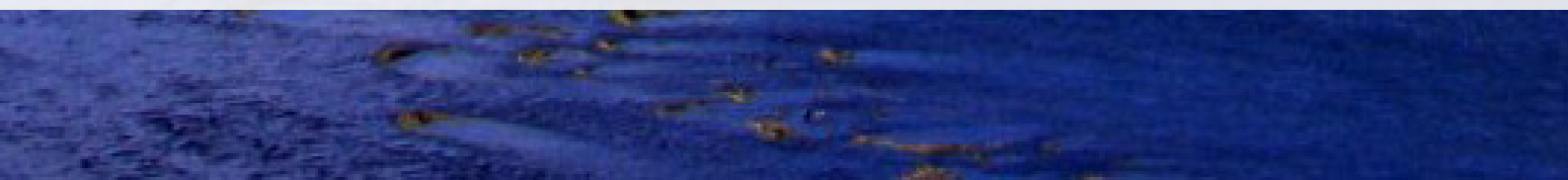


2. Global Water System Assessment Initiative

Recent global statistics have confirmed the mounting pressures on water systems across the planet, arising from non-sustainable water engineering practices, pollution, and biotic stressors. Currently, freshwater issues are embedded in nearly all of the SDGs to meet the sustaining needs of humans and ecosystems; and a good water stewardship is fundamental to their success. A challenge to the water scientific community— How do we assess and govern risk related to SDGs so that we can meet the needs of the present while safeguarding earth's life support system, on which the welfare of current and future generation relies.

It requires a comprehensive risk assessment of of an interacting global water system—defined as a global suite of physical processes in the traditional 'water cycle'; biological and biogeochemical processes supported by biodiversity; and human-mediated processes associated with water management and governance with strong links to the global economy. There is a risk of overlooking and neglecting global dynamics with large and possibly irreversible impacts on humans and nature if the focus is only on local processes (Alcamo 2008, Vörösmarty et al 2010, 2013, Haddelland et al 2013). Also, there is a particular concern that studies which attempt to assess water situations at a global scale may mask critically important and unique local contexts that influence water risk. This is why SWFP recognizes the reciprocal benefits of considering local to global scales, not as a dichotomy but as a continuum (Vörösmarty et al 2013). Through such an approach, science can also play a stronger role in facilitating the implementation of SDGs through assessments and policy engagement at all levels-global to local.

A sluggish progress in achieving water goals can produce additional risks of failure to achieve other goals like food or environmental goals. Actions are thus required to improve risk governance, which will require developing appropriate institutions and coordinated implementation plans to minimize the negative consequences of risks associated with interdependencies between different goals.

Tools like risk assessment are very useful for evidence-based risk governance, as they can contribute to assess complexities and interdependencies across the different policy domains and at the same time support the achievement of a balanced progress across all the SDGs. Embedding development and application of such tools into participatory settings assures that stakeholder perspectives are taken into account and builds capacity for adaptive governance and management. Based on GWSP's decade-long success in mobilizing leaders in the field of global water science and governance, Sustainable Water Future Programme will function as the scientific arm of a series of new global water system assessments focusing on sustainable development goals to support improved decision-making and management under increasing risk and uncertainty.

2.1 Knowledge Generators and Implementers

The initiative will unite the critical water communities of "knowledge generators" from the global water sciences and "knowledge implementers" from water policy, planning and management and practice. It will induce a broad dialogue between the communities to use scientific knowledge in policy and management domains, integrating it with knowledge on the ground to co-produce robust solutions to address complex multi-scale problems.

With the specter of major threats to the sustainability of endangered ecosystems and the accelerating and intensifying socio-economic development during the course of the next decade and beyond, it is even more critical to establish and sustain a

sound foundation for environmental observations, upon which scientific understanding of the Earth system can be improved and a knowledge-base developed to support such diverse applications as:

- feeding a large and growing population;
- providing sufficient energy needs for all;
- coping with climate change and its extremes;
- providing basic safe and clean water and sanitation services;
- managing the waste stream of a globalized economy;
- developing strategies to cope with rapid expansion of mega-cities; and
- preserving ecosystem services as a cost-saving component of the 21st century global economy.

Readers will recognize these as "nexus" issues, which the GWSP had helped to nurture. During dialogues sponsored by the GWSP (and in the community at large), it is recognized that the issues remain complex and frameworks—of the type proposed under SWFP—are essential to improved understanding.

2.2 Goals of the Global Water System Assessment Initiative

The overall goal of this initiative is:
To establish an ongoing, adaptable reporting procedure on the state of global water resources, the risk assessment and the appropriateness of governance of Global Water System, as a scientific, policy relevant and solution-oriented process for sustainable development.

The process will provide tangible outputs, organized as a series of Sustainable Water Future Reports and Topical Reports whose content is co-designed by knowledge generators and implementers. The products will center on knowledge generated by the scientific community and translated in practical terms for improved policy and management of water. The effort will focus not only on problem identification but rather opportunities for solutions and will consider issues from local to fully global domains within the sustainable development agenda.

This initiative will also provide state-of-the-science syntheses of freshwater-related knowledge related to a series of important water challenges, with direct relevance to stakeholders concerned with watershed risk and protection, food, energy and urban water. The syntheses will be theme-based, producing a series of concrete products to be evaluated through peer review and transferred into summaries for policy-makers. The effort articulates water risk issues from the perspective of human water security threats (conflict, economic, political, health, habitability, resilience) and natural system security threats (ecosystem services, biodiversity protection). The initiative will also provide comprehensive reports on global water governance, which will help to develop guidance and principles for water policy reform based on a diagnostic approach to assessing and supporting good governance.

Again, it is important to emphasize that the effort is anchored within the scientific community, yet actively engaged in a co-design process with stakeholders. In this way, it seeks to streamline and make more efficient the transfer of scientific knowledge to policy. Therefore, its focus is established through ongoing dialogue between knowledge providers and implementers, centering on the challenges and opportunities associated with fresh water resources in the sustainable development agenda. Salient details are highlighted below.

In order to establish the state-of-the-art in global water resource assessment, the initiative will focus on collecting and harmonizing existing data sets to gain a comprehensive picture of the global water system and its relation to human

water resource systems for the present and future periods. This will be facilitated by intensive collaboration amongst the current GWSP network members around the globe and supported by a series of international workshops each year. The workshops will bring together high-ranking researchers as well as other relevant stakeholders from policy and practice in order to discuss the respective issues and co-produce solutions.
The geographic perspective of the initiative will be global yet amplified with selected basin studies. A major first step will involve identifying physical or human dimension hotspots of water stress and conflict. Hotspot basins will be identified using integrated toolkits such as those from the recent GWSP-DIVERSITAS river threat analysis (Vörösmarty et al 2010), using a multi-criteria approach to deal with the challenges of rapidly emerging (or mature) economies, energy and food security challenges, unique aquatic and land-based biodiversity protection. The duality of this perspective will be fruitful as the global perspective gives context to the basin studies, while place-based analysis "grounds" and validates patterns computed over the broader domain. Individual basin studies also directly engage policy-makers at spatial scales where management decisions are taken.

2.3 Structure of the Global Water System Assessment Initiative

The effort of the initiative is organized into two phases, both of which will be embedded within the Sustainable Water Future Programme, representing the programme's centerpiece.

Phase 1: Design of a Formal Process
The goal of the Phase 1 effort is:
To coordinate a preparatory dialogue with all relevant stakeholders and leaders from the science, policy and applications communities with the aim of creating a framework

The Phase 1 effort will consider the topical scientific content, policy and management needs and administrative structure of the Global Water System Assessment Initiative. While Phase 1 is dedicated to the design of the process, it can be anticipated that the Intergovernmental Panel on Climate Change (IPCC) and the more recent Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) will be useful analogues. Arguably, these can be considered as benchmarks for the proposed process, although the Phase 1 process will explore optimized operational procedures for the Global Water System Assessment that are more effective, independent and non-bureaucratic and science driven.
The Process Design Report for developing the Global Water System Assessment aims to articulate the strategic and detailed elements of scientific assessment process, creating a practical set of steps leading to a mechanism delivering knowledge generated by global water science to policy-makers and the applications community. It will examine the current level of water knowledge and water policy, assessing gaps and suggesting future knowledge generation activities (e.g. periodical assessment report on water to be provided to water-related policy-makers) for global sustainable water management.

Phase 2: Implementation and Evolution of the Process
Phase 2 represents the execution component of the initiative, and is thus designed to implement the overall objective of the initiative. Accordingly, the Phase 2 goal is as follows:
To coordinate the assessment review, linking all relevant stakeholders and leaders from the science, policy and applications communities. In this international process the most up-to-date scientific, technical and socio-economic information on the topic of freshwater issues that is globally available will be synthesized, evaluated and analyzed.

2.4 Working Groups

The dialogue in Phase 1 will commence with the convening of Working Groups (WGs) who will participate in a series of major workshops to design the Global Water System Assessment. During each workshop, a framework outline will be presented and used to organize the discussion and formulate WG-specific outputs. The organization of each WG dialogue is envisioned as follows:

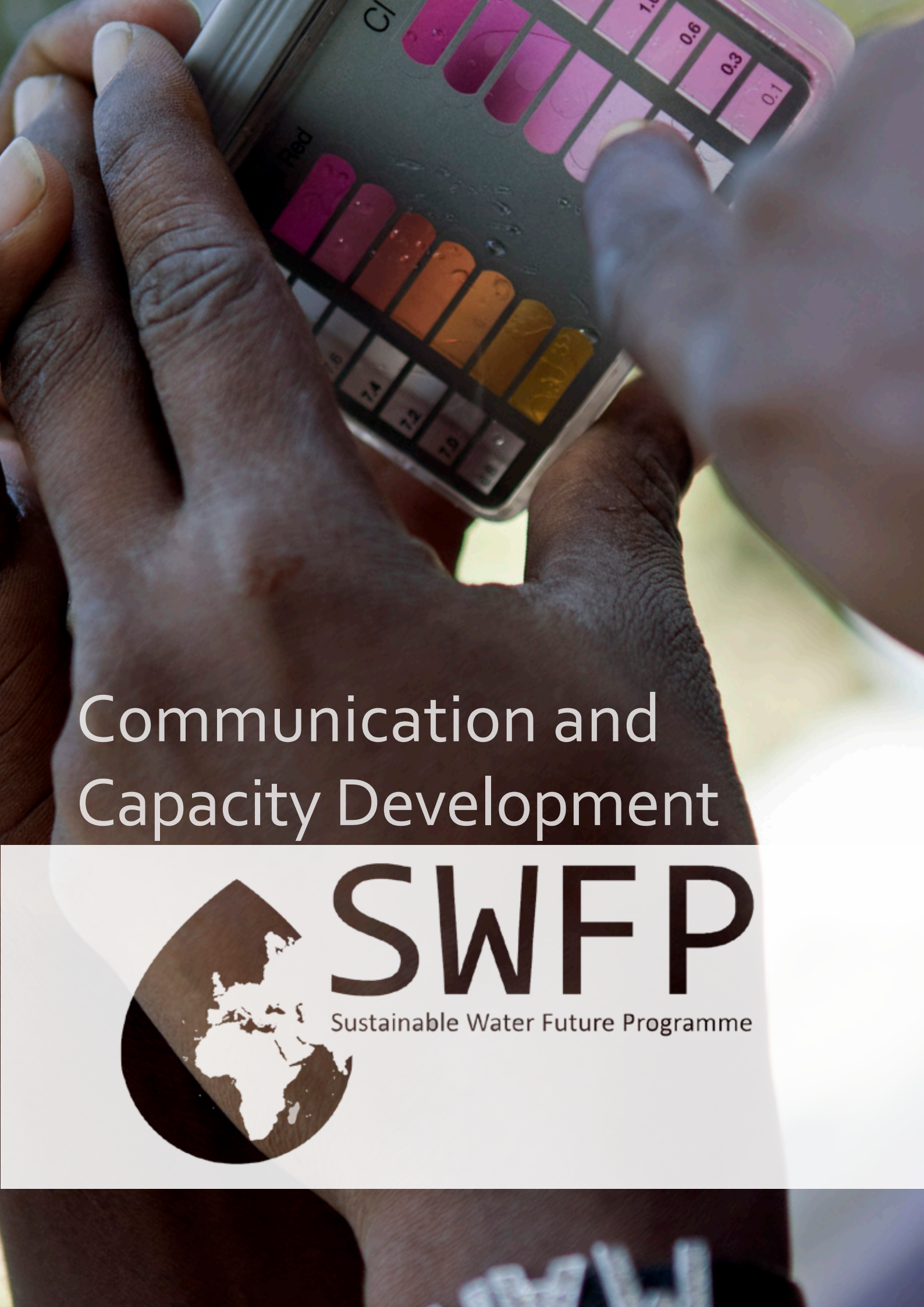
- Science-policy-practice discussion to identify essential issues on the topic at hand
- Formulation of clearly-stated, jointly crafted research questions
- Fast-track assessment of current state-of-the-art science to answer the questions posed, including any potential need for new research
- Fast-track assessment of gaps in knowledge
- Formulation of assessment plans for Phase 2
- Identification of additional, affiliated members for Phase 2 analysis
- Drafting of workshops, reports and communiqués

The Working Groups will be convened several times during the project design phase.

Based on the outcome of Phase 1, theme-based working groups will be assembled during the implementation of the initiative in Phase 2. Furthermore, task forces will be established if needed, in order to respond to emerging challenges and policy needs identified during the project implementation. The initiative will produce factual knowledge on the global state of water, developing conceptual and methodological innovations to improve analysis and diagnostic capabilities. It will support the monitoring of progress towards achieving global targets of Sustainable Development Goals.

The initiative will be product-oriented, delivering peer-reviewed papers, databases and policy briefs. Ample use will be made of online-platforms to make insights accessible to different user communities. Facilitation and scientific networking will be provided by a coordination office in Australia and other countries, capitalizing on well-established capabilities of the current GWSP and the Future Earth network. Each of the teams will include a science officer based in the Programme Secretariat and other regional centers, forwarding and coordinating the research activities of the group.

The programme will create a systematic mechanism for providing advice from an independent science and technology community to policy-makers concerning the state of the world's water resources and water-related development interventions.



Communication and Capacity Development

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Sustainable Water Future Programme

3. Communication and Capacity Building

There is a well-recognized lack of scientific information and concepts that are directly useful for policymaking. Thus, an important role of the Sustainable Water Future Programme will be to assess and articulate the information needs of policymaking to support the development of this information and communicate it through an active dialogue between scientists, policy-makers, water managers and the general public.

Despite the need to think across sectors, scientific, policy and professional communities are still organized through sectoral and disciplinary structures. The Sustainable Water Future Programme will develop an interface to and with these communities, explicitly focusing on, formulating and transmitting the message about the role of water, its governance and management as well as transformations in other sectors, such as energy and agriculture.

Dialogue implies learning on both sides, with policy-makers and planners needing to be informed about water problems and sustainable solutions, while scientists need to learn more about the urgent problems of society and the information needed to solve them.

The Science Policy Dialogue will be achieved through:

- Bringing together academic, practitioner and policy experts from different countries to study complex water issues, assess potential developments and generate planning and decision alternatives;
- Creating a web-based platform to engage in dialogue which public and private sectors as well as NGOs as the basis for a dynamic communication structure;
- Engaging a broad community of stakeholders, including management agencies, NGOs and industry partners in identifying and crafting innovative and lasting solutions to regional water challenges; and
- Providing better information-sharing on critical water issues through summarizing research outputs for decision makers, subsequently opening them for discussion within a broader audience;
- Engaging decision and policy-makers in getting their inputs in water research, for instance in the formulation of future scenarios, the discussion of results with the policy partners and the further iterative re-design of those scenarios; and
- Promoting water science literacy to media, as well as disseminating research through wider international global media outreach.

Young Scientists Trainings:

An important capstone of the Sustainable Water Future Programme will be the advanced training of students and young water professionals to build capacities among young scientists for successful science-policy interactions. It will train the next generation water scientists and practitioners, who will focus together on key planning challenges, adopting and capitalizing on the best state-of-the-art science, technology and water assessment tools and promoting an expanded use of integrated and ecosystem-based approaches for the design of future water security systems. The training is targeted at creating self-sufficient, in-country capabilities to monitor, assess and apply water-related sustainable development goal interventions. The objective here is three-fold: (i) to secure technical and facilitation support using individuals with a high degree of prior professional readiness, (ii) to provide a reciprocal experience, fostering their long-term professional growth, and (iii) train a next generation, much-needed element of the global water sciences community—the interdisciplinary research and knowledge facilitator.

The main professional development goal for the mentoring plan is to produce well-rounded yet technically proficient leaders in the field of interdisciplinary, policy-relevant earth system science. This essentially constitutes an acculturation process. Such training on the social side of scientific research is not yet common,

but is increasingly important for research mastery as well as professional networking.

Identifying and crafting innovative and lasting solutions to regional water challenges will require the engagement of a broad community of stakeholders, including management agencies, NGOs, Industry and the private sector. The Sustainable Water Future Programme will be uniquely positioned to catalyze such an engagement. Through ongoing GWSP events, we have recognized a growing demand for knowledge from the non-researcher community concerning the state of regional environments, impacts on specific economic sectors (e.g. energy production, employment levels) and their potential future trajectories. SWFP will foster new and adaptive planning and water system design principles through interaction between students, researchers, entrepreneurs and community representatives. It will draw on the latest developments from the water sciences and technology, placing them into a planning and design process for water solutions and engaging the private sector with different partners as a combined force for innovation in a solution lab. Challenges will be cast and solved at multiple scales, from individual sites to fully regional human-environment complexes.

4. Water Solutions Lab Network

The Water Solutions Lab Network (WSLN) will be part of the SWFP regional centers, and will be particularly based on existing knowledge of global best practices of environmental service innovation, understanding of the demand and supply side of environmental services, as well as its benefits and costs. This knowledge will help to assess the environmental service innovation potential of the regions, including forming a platform for creating options for conserving biodiversity and enhancing sustainable usage of water. The Water Solutions lab Network will be developed in cooperation with local stakeholders, national and international academic, industrial and service sector partners in order that the knowledge and use of service innovation can be effectively disseminated. Details of the Water Solutions Lab Network are provided in Annex 8.3.

Programme Governance and Implementation

SWFP

Sustainable Water Future Programme

5. Programme Governance and Implementation

To ensure an effective and inclusive governance of the programme, we propose the following management structure as a basis for discussion:
The decision-making body of the programme is designed to be both user- and science-driven. Therefore, the relevant stakeholder communities (see Figure 2) will be systematically involved in the programme design and guidance. By including members from the UN system, global and national scientific platforms, NGOs and the private and public sector, the Programme's Advisory Board (AB) embraces a wide horizon of stakeholders' perspectives in order to understand the demand for knowledge among knowledge-implementing communities.
The Scientific Committee (SC) will provide scientific guidance, fine-tune the broader research themes defined by the Advisory Board and translate them into cutting-edge research questions and projects. The coordination between the two bodies will be synchronized by the International Secretariat, which also guarantees a smooth implementation process for the overall programme and the effective communication with all stakeholders, including the broader public.

5.1 Advisory Board

In order to implement the broad focus and scope of the programme, an Advisory Board (AB) will be established as the programme's decision-making body. While the SC focuses on the science pillar of the programme, the Advisory Board will provide guidance and planning on the overall programme. The 10 members of the Advisory Board will comprise of representatives from Future Earth, a representative of host Institute (Australian River Institute-Griffith University), others sponsors of the programme, regional/national committee chairs as well as other stakeholders (UN, NGO, civil society, and private sector). Initially, the current co-chairs of GWSP will also be members of the advisory board to provide guidance, oversee the implementation of the programme scientific, and facilitate the design of global water assessment process. The Chair of the Scientific committee and Executive Director will be the Ex-officio members of the advisory board.
The primary functions of the members of Advisory Board are:

- Review and advise on the implementation of the programme, and make recommendations to the Scientific Committee on research initiatives and matters of a more practical nature.
- Provide advice and constructive criticism on the means to achieve the priorities of the Programme
- Help to identify and propose appropriate research and implementation working groups at national, regional and international levels to contribute to the Programme.
- Provide a platform for cooperation between the participating Organizing and Bodies, and the Scientific Committee.
- Promote and increase awareness of the programme and its sponsoring working groups amongst both scientific and stakeholder communities.
- Evaluate proposals for new working groups under the Global water system Assessment Initiative.

The Advisory Board shall normally meet at least once in two year. The dates and place of an ordinary meeting of the Advisory Board shall be communicated at least six months in advance. Items proposed for inclusion in the Agenda must be received by the Executive Director at least three months before the ordinary meeting of the AB.

5.2 Scientific Committee

The 15 members of the Scientific Committee (SC) provide scientific guidance on all aspects of the SWFP and are responsible for the release of the

results. The SC Chair and the Executive Director (ED) focus on the programme's implementation, making decisions on managerial, administrative, and/or financial matters in consultation with the full SC. Each SC member will be required to lead a working group under the Global water System Assessment Initiative. The SC members will self-select through applying to periodic (6-monhtly) proposal calls for working groups. The proposals will be assessed (approved/rejected) by the Advisory Board. The requirement for geographic, gender balance of the SC group as well as balance of research priority topics will be taken into consideration during the proposal selection phase. In addition to the self-select SC members, there will be regional node representatives in the SSC designated by respective national / regional committee. The term for these appointments will normally be three years, renewable once subject to the formulation of a new (or continued) working group. The term of SC Chair may be extended to maximum 5 years (excluding years served as an ex-officio member). The primary functions of the members of Scientific Committee are:

- Develop a Science Plan and Implementation Strategy for the working group of the Global Water System Assessment Initiative.
- Execute such plans on behalf of the designated Working Group.
- Encourage collaboration between the working group and any other relevant work, both within and outside of the programme
- Work closely with the Executive Director and other Programme Officers in implementing the objective of the programme.
- Report annually the development and implementation of the working group
- The SC members meet physically in average and at least once per year for a 3-day SSC meeting. The dates and place of the SC meeting shall be communicated at least six months in advance.

5.3 Secretariat

The Sustainable Water Future Programme Secretariat, consisting of the Executive Director together with scientific and administrative staff, will facilitate the expeditious and orderly development, implementation and evaluation of the programme. Its main functions are to implement the strategic priorities of the programme and facilitate communication processes. It builds on the successful implementation of the GWSP through its International Project Office (IPO) in Bonn, Germany. In the past, with the help of a wider network of more than 3000 members from the water science and policy community (see Annex 8.2), the GWSP IPO has organized several level meetings events, international conferences and produced highly relevant scientific publications, dissemination of results, policy documents and engaged in awareness-raising.

As a result of the Sustainable Water Future Programme network character, the Secretariat will function as a node and information hub, collecting information, ensuring communication flow and organizing events relevant to the entire programme.

The Secretariat is further responsible for the dissemination of outcomes and results of the Programme's activities. Staff members represent the programme at important scientific and programmatic meetings, lobbying and initiating new activities and partnerships and fostering research activities. Equally importantly, the Secretariat serves the Advisory Board and Scientific Committee in coordinating and implementing their decisions. In collaboration with the SC and its broader network of scientists, the Secretariat is responsible for attracting third party funds and preparing research proposals. Communication and outreach activities for the programme are concentrated within the Secretariat, which also supports selected activities of the projects in this realm. The Secretariat organizes both the SC and

AB meetings as well as various science meetings, such as the programme's triennial conferences and the annual summer academies. The Secretariat`s main responsibility is to provide services of cross-cutting interest for the entire programme.

5.4 Regional and Thematic Centers of the Programme

Throughout its implementation phase, the GWSP well-recognized the need for sub-global analyses and this reality does not disappear with the inception of the SWFP. Thus, regional and thematic centers of the programme will play an important role within knowledge production domain in contributing in global water system assessment process, in implementing the water solution lab.

River basins capture both global influences such as climate change as well as encountering local and regional water management issues. Therefore, regional impacts and reactions to global change are considered as key to enhancing our knowledge of the global water system's functioning as they verify global insights on the local level, or vice versa. The connection between changes in a region and its driving forces often originates outside of the region, e.g. the impact of climate change on river basin water availability, the influence of international food trade on land use and resulting hydrologic changes within a region, or the impact of international financial institutions on the development of water infrastructure within a particular river basin.

Thematic centers will promote and coordinate international research activities in domains of specific importance for the SWFP. Currently it is envisaged to have thematic centers for global water governance and risk governance with specific emphasis on the water-energy-food nexus. Further thematic areas will be identified during the implementation process.

The regional and thematic centers will advance the scientific understanding of the global water system by providing regional and thematic knowledge for comparative studies of catchments, bringing forward best practices and expanding the viewpoint of river basin research and management to include a global perspective. The goals for the centers include the exchange

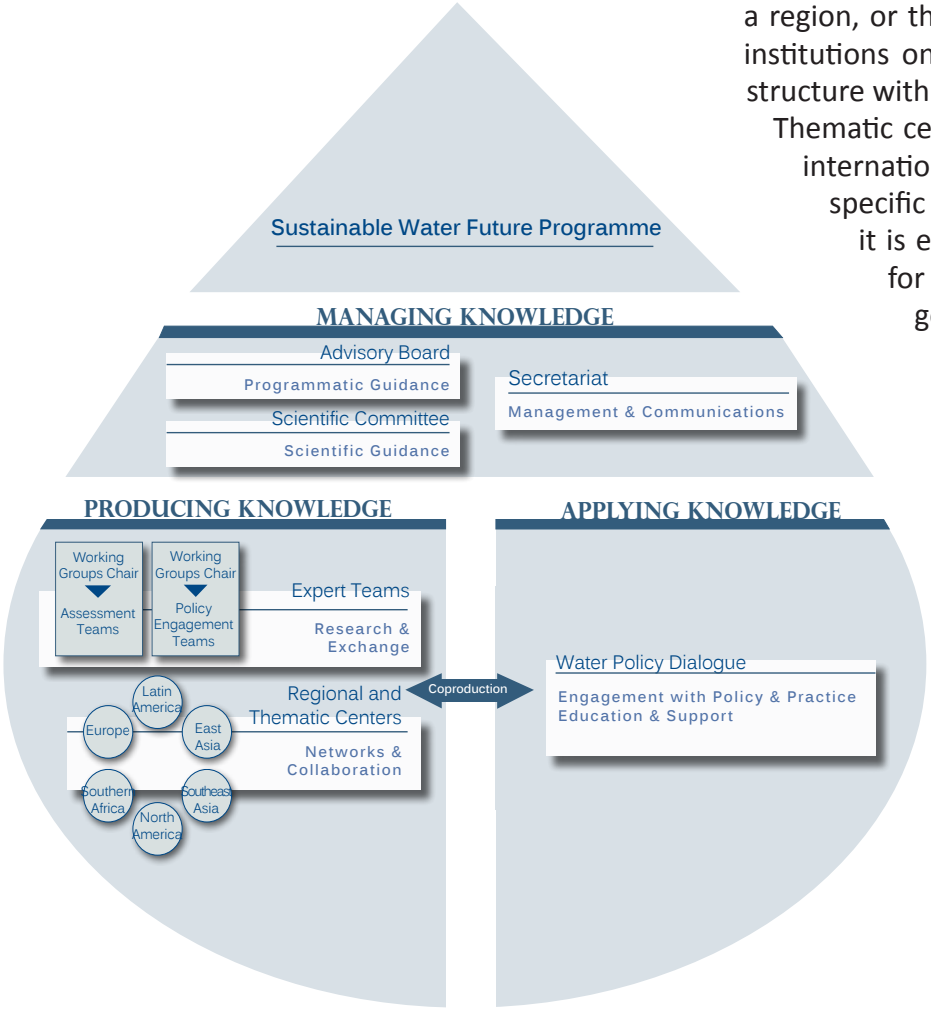

Figure 2: Governance Structure of Sustainable Water Future Programme

of knowledge and scientists, water managers and other stakeholders concerning the impact and importance of global factors on watershed management. Through this co-production of knowledge, involving researchers and practitioners in different catchments, the regional centers will help to develop novel approaches to adapt to global changes.

Regional and thematic centers will manage and govern themselves, yet will develop research strategies and regional activities in accordance with the Programme's objectives. The centers are meant to bring together stakeholders to address regional water issues with global implications, allowing for analyzing interdependencies and linkages between site-specific phenomena, regional observations and global processes. Understanding the relation between the regional and global helps to find solutions that fit local conditions while "getting the big picture", banking on the experiences and expertise of the global GWSP network.
In collaboration with the Secretariat of the programme, the specific activities of regional and thematic centers include the following:

- coordinating and implementing programme activities in collaboration with regional institutions and science communities;
- organizing workshops in the region;
- assisting in the dissemination of key results in the region;
- promoting awareness of programme activities amongst the relevant science communities and funding agencies in the region;
- developing joint research proposals; and mobilizing external research funding.

Thematic Centers, in particular will provide an important cross-cutting function and will unite the research interests of particular regions, link scales (from local-up-to-global) and provide focal points for more elaborated analysis of particular topics. For example, thematic centers on aquatic biodiversity, the economics of water, water and urbanization, energy security, food production systems could be created. In the end, however, these become the raw material for "grand nexus" topics, that today focus on water-energy-food. This would be an important next phase in the nexus agenda.

5.5 Funding

The International secretariat of Sustainable Water Future programme will be located in Brisbane, Australia with the support of a consortium of universities and organizations led by Griffith University. Griffith University has already committed to funding the positions of Executive Director and Research officer in addition to Secretarial, Finance, Human Resource and strategic research support.
From the outset, the governing bodies of the Sustainable Water Future Programme will attempt to mobilize additional funds from National Governments, International Agencies, development foundations, and private sectors for the following activities.

Global Coordination:
SWFP requires additional funding to successfully coordinate and implement SWFP activities at the International Secretariat. It requires support for Communication and Network activities, coordination of different working groups under Global Water System Assessment initiative, as well as for reporting of the Sustainable Water Future and Thematic reports.

Global Cooperation:
The programme will build a coherent global network of regional and thematic centers in different parts of the world to support the entire programme by providing leadership, coordination, inter- and trans-discipli¬nary research that cannot be executed by an individual institute/ organization or at a national level;

Research under Global Water System Assessment Initiative:
SWFP will have research teams across countries and across disciplines for the implementation of Global System Water Assessment Initiative. The Initiative will be highly dependent on the continuity of focus afforded by dedicated staff and advanced professionals. In this Initiative, the emphasize will be on the use of young, energetic, and bright post-doctoral scholars to help execute core elements of the initiative. Several post docs are to be hired to facilitate research at different universities and institutes located at different regional and thematic centers.
Global Data Base: An important element of SWFP will involve creating a dedicated, state-of-the-art science and technology information component from the Earth systems science and technology communities. Funding will be mobilized from several sources for the development of such technology backbone.

Water Solutions Lab Network:
SWFP will raise funding to implement Water solution lab Network (WSLN) whose main objective is to identify and crafting of lasting, feasible innovative solutions to address regional water related challenges through engagement of a broad community of stakeholders with a strong emphasis on accompanying research before and after the development of an innovation. Implementation research and knowledge exchange are the key components of the WSLN.

Deliverables and Products

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6. Deliverables and Products

The following selected products can be expected from the Sustainable Water Future Programme.

6.1 Sustainable Water Future Reports

The sustainable water Future Reports will be science based, feeding the newest state of the scientific knowledge into the assessment of global water system. The Sustainable Water Future Report (~triennial) and Topical Reports (~annual) will be produced to reach a broad audience of relevant stakeholders who will be informed about global water trends challenges and opportunities of current period with future projections. The release of the reports will be synchronized with relevant high profile stakeholder events to the greatest degree possible. An overall assessment of the global water system will be conducted approximately every 3 years, synthesizing the research findings and lessons learned. The content and scope of the main Sustainable Water Future Report will be co-determined by consensus of knowledge providers and implementers within the Advisory Board and Scientific Committee. The initiative will develop a quick response capacity to deal with emerging challenges and information needs from the global policy process. Each year will be dedicated to one of the key research areas to address an important topic in detail, producing a theme-based report (e.g. on energy-water issues, water-health, economic constraints of water scarcity). These will be organized as Topical Reports, which offer the advantage of being "laser-focused" on relevant topics that are directly called for through our discussions with users/stakeholders.

The final report and assessment phase in 2025 will synthesize findings, assess progress in implementation, compare and derive solution-oriented conclusions. This will help to institute a formal process and mechanism for translating research into policy that is ultimately designed to create a lasting legacy of the funds provided by the sponsors.

6.2 Earth System Science and Technology Component

A fundamental design requirement of a multi-scale, multi-sectoral water assessment and planning tool is a capacity to geospatially capture the nexus of climate, environment and infrastructure needs relating to freshwater ecosystems and the human water resource base. A wide array of critical economic development objectives are in play, including: maximizing the benefits of specific infrastructure investments with respect to poverty alleviation; identifying the benefits to target populations served; and sustainability, including the long-term protection of source areas and inland waterways supplying water provisioning services.

Therefore, an important element of the proposed effort will involve creating a dedicated, state-of-the-art science and technology information component from the Earth systems science and technology communities. This pillar will be built on the successful GWSP Global Water Atlas (atlas.gwsp.org)[1] and freshwater threats analysis data compendia (www.riverthreat.net), uniting high resolution geospatial data and information systems, including: (i) remote sensing and in-situ data archives and operational products; (ii) simulation models and „projection systems" to infer current trends and extrapolate into the future; (iii) a core web-based information portal for distributed knowledge generation with online communication tools and derivative products; and (iv) a tradeoff assessment tool, enabling planners to create scenarios of future system states, diverting negative trends into more benign outcomes. The

1 The purpose and intent of the Digital Water Atlas is to describe changes in the state of the Global Water System and show the interlinkages of its elements by creating a consistent set of annotated maps and data visualization. Currently, the GWSP Digital Water Atlas consists of 69 global maps and provides 141 web links to other info/data sources, serving more than 5,000 registered users from 45 countries.

integrated information system will provide: queryable meta-data; baseline spatial mapping; derived indicators organized in meaningful geophysical space (i.e. river networks, basins) and administrative units for management (i.e. provinces, nation-states); affiliated information resources (i.e. economic statistics, legal frameworks, governance indicators); scenario design; and tradeoff assessment tools. The programme will also develop a global database on water governance systems. To date, no global database exists that covers all relevant aspects of water governance system. An inventory and the harmonization of available databases and data collection efforts are required to overcome the fragmentation of knowledge on water governance. Such an inventory would enable the design of a protocol for further data collection.

BOX 1: Specific Deliverables

The following lists the specific deliverables that the Sustainable Water Future Programme aims to produce and deliver within the next ten years.

1. A process design report for the Global Water System Assessment, to be delivered by 2016.
2. Sustainable Water Future Reports, co-designed by knowledge providers and implementers, every three years (2019, 2022, 2025), summarizing the most important insights.
3. Theme-based policy reports produced at approximately annual intervals, featuring the most up-to-date scientific insights, technological and institutional advances as well as best practices from around the world.
4. A process final report and assessment phase to synthesize a decade of findings, assess progress in implementation and compare and derive solution-oriented conclusions by December 31, 2025. This report will explore the feasibility of a next potential phase beyond 2025, and if deemed viable, will be provide a design blueprint for this.
5. An ongoing and comprehensive outreach strategy that makes use of the appropriate communication channels, including print, web and social media.
6. Organization of international conferences (triennial)
7. Training process for young water scientists, engineers, practitioners, decision-makers and managers, including the organization of annual summer academies.
8. Set up and regularly update a geospatial data and information system.
9. Set up and regularly update a global water governance database.
10. Implementation of the Water Solutions Lab Network

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8. Annexes

Annex 8.1 Sustainable Water Future Programme: Research Questions

Overarching Questions

The following overarching questions are presented to illustrate potential research priorities of the Sustainable Water Future programme that can be addressed through international research collaboration:

1. What kind of knowledge should theories and approaches of global water research produce in the next decade to support the economy and society and move on a trajectory which ensures resource-efficiency, sustainability and well-being?
2. How could research results gained from a global perspective be transferred to regional and local levels for practical solutions?
3. How could we better conceptualize and explain the interaction of functioning of global water system and socio-ecological systems to assess the success of SDGs?
4. What changes in water governance are required at different (global, regional, local) levels to support sustainable development?
5. What could be understood and projected about the condition of future trade-offs between human water security and biodiversity threats?
6. How could fresh water related ecosystem services be sustained for present and future generations following a Water –Energy -Food nexus approach?
7. How could we stimulate technological, social and institutional innovations for a sustainable water use, drawing on global patterns and context-specific experiences at the same time?
8. How could we measure and govern the risk to humans and the global water system while quantifying the role of bio geophysical goods and services conveyed by the Earth System in sustaining the human well-being of present and future generation?
9. How human perceive of, economically value, and manage or discard planetary and fresh water ecosystem as assets, and if they are indeed lost how society invests in their replacement to guarantee future well-being.
10. What could be understood and projected about the condition of future trade-offs between human water security and biodiversity threats?
11. What are the drivers for behavioral change towards sustainability that is based on informed understanding of the effects of human activities on freshwater ecosystems?
12. How could we improve the quality and reliability of water supply in cities that seeks to make greater use of local resources in a sustainable way?
13. In the framework of green economy, how could we minimize the cost of having non increasing threats to human and environmental security by choosing the optimal combination of grey and green investment at a spatial and temporal scale?
14. How could we capture the relevance of water quality in the context of anthropogenic activities and its effects on human health and wellbeing of present and future generations?

Theme 1 - Global State of Water

The following research questions under the theme -Global state of Water are presented to illustrate potential research priorities of the Sustainable Water Future programme that can be addressed through international research collaboration:

1. What kind of global hydrological models can help to assess future demands of irrigation that address the issue of uncertainty in models, greenhouse gas emission pathways and sensitivity of the irrigated systems?
2. What kind of global hydrological data is needed and analyzed at a combination of basin and country scales?
3. How could we integrate climate change, sub-annual variability as well as socio economic drivers within projections of future resource availability and distribution at global and regional scale?
4. What are the risk implications of transgressing the planetary boundary for water regarding the other planetary boundaries and how do these interdependencies vary spatially and over time?
5. What are different options for tradeoffs and synergies among different planetary boundaries?
6. How could human interventions in shaping and transforming deltas help to mitigate degradation?
7. How could possible tipping points in ecosystem functioning be linked to global biogeochemical cycles and assessed?
8. What is the role of urbanization regarding the achievement of the SDGs and how tradeoffs between human needs and conservation can be tackled in the context of urbanization?
9. What are the links between the global carbon, water and nutrient cycles and the anthropogenic changes within these cycles?
10. How could we better understand water-related ecosystem services, accounting for both biophysical and economic controls on services?
11. What are potential and limitations of current integrated modeling and monitoring approaches, especially with regard to non-linearity, dynamic behavior, feedbacks and tipping points?
12. What are the drivers for tradeoffs between water quality and quantity with regard to human and ecosystem well-being?
13. How could we quantify green water beyond its direct appropriation for plant growth regarding a planetary boundary for land use?
14. How could we integrate/harmonize green and blue water footprints to better capture our understanding of interdependencies?

Theme 2 – Water as a Global Change Agent

The following research questions under the theme –Water as a Global Change Agent are presented to illustrate potential research priorities of the Sustainable Water Future programme that can be addressed through international research collaboration:

1. Which governance and management practices reduce tradeoffs and produce synergies across the Water-Energy-Food Security Nexus?
2. How to establish a comprehensive theoretical framework that assesses the costs of tradeoffs and the synergies across different resource uses?
3. What drivers of change support or constrain a nexus approach, including social, economic, political and cultural aspects that are influenced by the management of resources at different scales?
4. How could we link alterations in glacial systems with human security, such as energy and food production?

5. What is the role of glaciers and ice caps regarding the planetary boundary for water?
6. What are the interdependencies between glaciers and ice caps and other planetary boundaries (besides climate also phosphor and nitrogen)?
7. How could the concept of environmental flows be used as a tool to integrate human wellbeing with environmental conservation?
8. How could environmental flow research address the future challenges of accounting for climate change, advancing global modeling and incorporating the governance context?
9. How are issues related to the Water-Energy-Food Security Nexus affecting large river basins?
10. Which aspects of global change are most critical to the water resources of specific geographic regions and scales?
11. What are the interactions between global change and drivers of local change on a region`s water resources and how do these affect the vulnerability of societies?
12. How could the different types of information that exist on urban water systems and related data such as housing and health be linked and integrated?
13. How could we capture the relevance of water quality in the context of anthropogenic activities and its effects on human health and wellbeing of present and future generations?
14. What kind of systems analysis do we need in water quality research?
15. What could be the potential role of citizen scientists in water monitoring and management?
16. What are possible macro-scale impacts that may occur if critical green and blue water thresholds are crossed synchronously and assess to what degree such impacts be tolerable?
17. What are the links between the water and phosphor, nitrogen and carbon cycles and other pollutants such as heavy metals, plastic, and pathogens and what is the magnitude and the impact of these pollutants on water quality and how could these impacts be reduced/controlled?
18. How is the linkage between water resource use and household well-being affected by asset endowments and other socio-economic attributes?
19. How does the relationship between water resource dependence (income derived from natural resource) and human and societal wellbeing vary with changes in the state of water resources?
20. How could investment in other forms of capital (human, social and physical) influence water resource dependence of the farmers/households, mitigate the intensification of natural resource use and also lead to higher welfare over time?

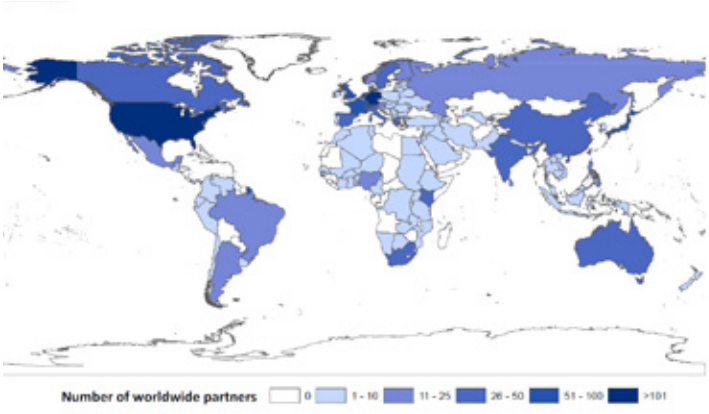
Theme 3 – Governing the Transition

The following research questions under the theme -Governing the Transition are presented to illustrate potential research priorities of the Sustainable Water Future programme that can be addressed through international research collaboration:

1. Which participatory processes could help to identify tradeoffs between different management actions to co-balance human and ecosystem needs?
2. What are the obstacles and the requirements for governance systems to implement water quality guidelines?
3. How could we develop a set of prescriptive, normative principles regarding water uses and policies which support the goals of sustainable development?

4. How could we establish a consistent framework for ecosystem services that could be applied across studies in different areas?
5. How could the concept of ecosystem services become a powerful tool to communicate the value of natural capital to a broader public?
6. What are the major challenges for sustainable pathways to enhance water security and how have their nature, the perception and framing of the societal discourse changed over time?
7. Which indicators for the trade-offs between different water security dimensions would be needed to enable assessment of multi-criteria policy goals?
8. How could adaptive water management act as a guiding principle to achieve water security at global as well as regional scale?
9. What are the challenges in pursuing water security via adaptive management when analyzing selected water policies?
10. What are the relevant discourses and principles as well as instruments, organizational structures, and best practices in current water governance science?
11. How could we establish a normative framework that recognizes the multiple efforts of actors and networks at all levels of governance; and may serve as a catalyst to enhance coherence between levels and actors?
12. What is the potential of capacity building for and participation of local communities in conservation of water resources to support positive outcomes?
13. How could we integrate approaches in disaster risk reduction approaches with climate change adaptation approaches?
14. How could we link water quality as a focal component of water security to the SDGs?
15. What are the missing links to economic theory when analyzing the optimal use of water resources and direction of trade flows to frame appropriate policy advice?
16. How could we consider different values of water quality based on culture and ethics, while developing a scientifically-sound regulatory set of guidelines for water quality?
17. What options exist or could be implemented for improved equitable and sustainable access to groundwater resources?
18. What are gainful and productive ways to utilize groundwater that enhance the resilience of the resource?
19. What are new management strategies that enhance the sustainability of the global water system over a long time?
20. How could we improve the role of water quality within IWRM?
21. How could we improve collaborative modeling in IWRM to bridge the gap between science and policy?
22. How could we develop IWRM towards an adaptive management approach?
23. How are river basins being managed to deal with challenges arising from the Water-Energy-Food Security Nexus?

Annex 8.2
Geographical Distribution of the Global Water Research Community



Annex 8.3
Water Solutions Lab Network

The water Solutions Lab Network will balance technological, social and institutional innovation and benefit private small and medium industries by exploring the demand side for innovative products and services by facilitating dialogue between the private sector and local actors/communities. This will help to stimulate the diffusion process by identifying demand pulls instead of creating a supply push. Communication with the public sector will open the discussion about funding and investment opportunities and support the creation of a business environment which encourages green innovations. By providing a platform for exchange, the lab contributes to the development and assessment of the feasibility, profitability and sustainability of innovative ideas and products in a holistic way, addressing the multidimensional character of innovation.
The framework of the Water Solutions Lab Network (WSLN) recognizes the barriers and challenges that innovative approaches to solving water related issues are facing. The proposed framework of the WSLN will integrate scientific and practical knowledge and support a demand driven innovation process that will result in lasting, efficient and effective solutions to water related problems on the local, regional and global level. Optimal solutions can only be achieved when as many different perspectives as possible are taken into account, discussed and considered. The WSLN aims at fostering, informing, moderating and structuring dialogue between representatives from the scientific community, public and private sectors, civil society, NGOs and other relevant parts of society. The following section will give an outline of the process design and governance structure of the WSLN.

Process Design
The WSLN will cover three major tasks:
1) Creating and maintaining a network of relevant individuals and organizations,
2) Organizing, moderating and structuring dialogue between different stakeholder groups, and
3) Collecting, synthesizing and providing relevant data and knowledge.

Efficiency and effectiveness of the WSLN will be assured by a unique, iterative process. The process of the WSLN is divided into three phases: the pre-lab phase, the lab phase and the post lab phase (Figure A1). A “lab” in this context refers to a workshop type event and will be described in more detail later in this section. The three phases of the WSLN will continuously (simultaneously) take place for different regions or problems. This way knowledge generated and experiences made in one lab can be used and benefit the process of a different lab.

1. Pre-Lab Phase:
In the Pre-Lab Phase knowledge and data from both the global partners as well as from local change agents will be collected and communicated to establish a knowledge base to work from during a specific Water Solutions Lab. In the Pre-Lab Phase, the following actions will be undertaken:

- Environmental and human water security problems will be identified, and defined from a regional and local perspective. Information repositories, such as the RIMS (Rapid Indicator Mapping System), a successful model of geospatial water indicators, developed over the last decade to assess freshwater ecosystem services in the Millennium Ecosystem Assessment will be used. RIMS is a tool for display of water data sets and accompanying ancillary data, and it functions as an operational, digital information system for water resource assessment cast within a geographic information system framework. The system includes a broad suite of spatial and statistical data encompassing point scale and gridded socioeconomic and bio- geophysical products for data exploration and download. This data are organized according to water indicator themes and is

presented in the spatial context of the river basin to analyze the changing nature of water in relation to human needs and activities at the regional and case study scales.

- The RIMS will emphasize a co-balance of a state-of-the-art technical platform comprising mapping software and digital data, policy and stakeholder engagement, and a training program.

demand of an innovation and hotspot areas. Using a geospatial framework at a regional scale, a broad suite of individual stressors will be merged to produce cumulative threat indices for human water security as was done earlier in the global study in assessing the threat to human water security and river biodiversity (CJ Vörösmarty et al., 2010).

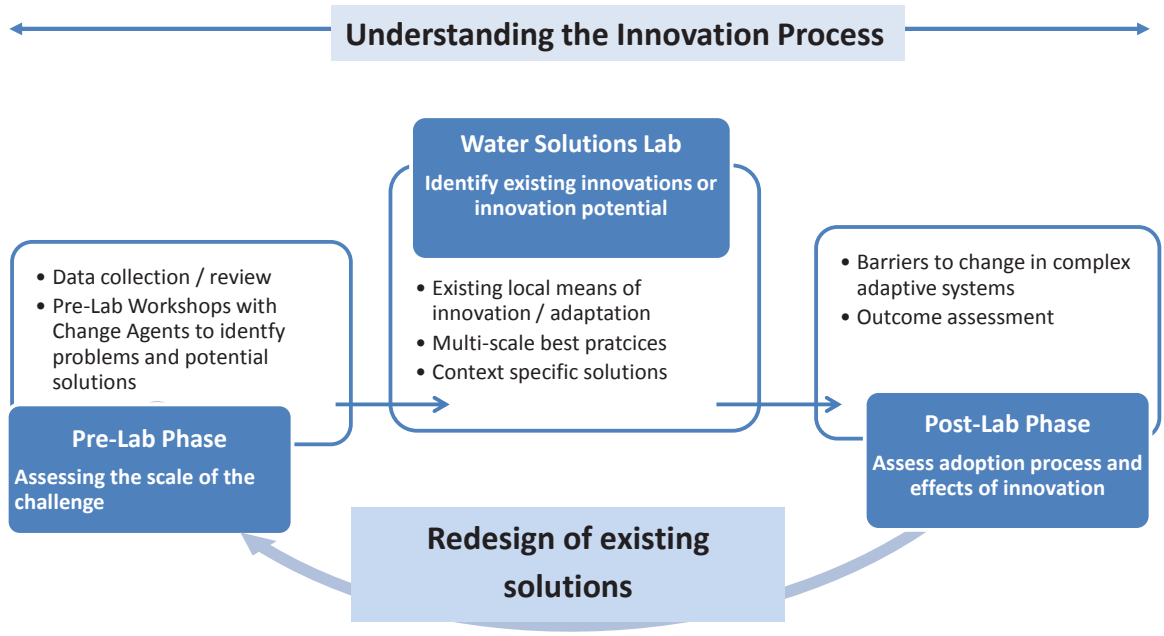


Fig. A1: Process Design for the Water Solutions Lab Network

- The system will be designed for customized applications and configurability to particular regions and to topics of timely and/or strategic interest.
- Further a multi-criteria approach, using integrated toolkits (such as the recent GWSP-DIVERSITAS river threat analysis), will be followed to identify the hot spot areas. This will help to understand the state of the systems (water and ecosystem, socio-economic and political system), and to further identify the

A series of future scenario projections of the stressors producing human water security threats and prompting engineering, economic response and/or governance interventions will be formulated. Analysis will include sensitivity tests to identify which variables, parameters, and regions are most sensitive to the state of freshwater resources, which produce the greatest feedbacks and exhibit the most sensitive thresholds.

- Potential case study areas or sectors will be identified and data on existing innovations, techniques, and approaches that are currently used globally, regionally and locally to address the problem will be collected, and synthesized. This includes data about efficiency, cost, environmental impact and social acceptance regarding different innovations.

The core task for the pre-lab phase is to collect and synthesize data and knowledge and provide it in an understandable form to relevant individuals and organizations. This way the WSLN will increase the accessibility to such knowledge and ensure that all involved parties have similar insights in and knowledge base of the specific region or problem.

2. Water Solutions Lab Phase:
The lab phase represents the core of the WSLN. In this phase dialogue between different stakeholder representatives will take place and a feasible, efficient and effective set of innovative solutions to specific water related problems will be identified.
The following actions will be undertaken:

- Presenting the findings from the pre-lab phase to provide all participants with the same, relevant knowledge base and insight into the specific topic. The following work can build on these findings and open the topic for innovative approaches to be developed during this phase.
- Supporting the identification and formulation of subjective perspectives from different stakeholder groups (science, industry, NGOs, government, civil society) on a particular topic and the different solutions identified in the pre-lab phase. This will happen in homogenous breakout groups (science, industry, NGOs, government) to formulate the subjective point of view for each group.
- Each group will then present their perspective with concerns, problems and solutions in a plenary. This is where the knowledge transfer happens and where conflicts and discrepancies between different groups will become apparent and can be addressed.
- With the identification of conflicting opinions and goals the innovation process begins and solutions can be discussed, for example in small, mixed groups. This will help identifying feasible and applicable solutions to a particular problem from different perspectives. The groups will identify the gaps or deficiency of the current best practice solutions for application in the local setting, and innovative ways to reduce those gaps can be developed.
- At the end, the participants will decide on a small set of feasible, innovative solutions that could be implemented in a controlled setting.

3. Post-Lab Phase:
The post-lab phase is another unique and integral component of the WSLN-process. In this phase the Water Solutions Lab will be evaluated, solutions will be implemented and the implementation will be monitored. Monitoring and assessing the implementation process and success of a solution is crucial to understanding the innovation-process. This way the results and experiences of one Water Solutions Lab will feed into the process of subsequent labs and the process can be iteratively optimized.
The following actions will be undertaken in the post-lab phase:

- Implementing selected innovations in a controlled setting and accompanied by implementation research. In this phase, pilot studies using randomized control experiments (RCTs) will be conducted to understand the implementation process. Using RCTs, the outcomes of a feasible solution will be compared with the human well-being (e.g. health parameters) as well as ecosystem threat outcomes that would have resulted in the absence of the innovation by randomly assigning innovations to either the treatment or the control group. RCTs have already been proved as an effective tool for evaluating the impact of change from implementation of feasible solutions under different environments. Apart from RCTs, other

methods of experimental research (or quasi experimental) may be used. The experimental methods to be adopted will depend on the selected innovations during the lab phase and others considerations, such as strength/combination of the impact assessment team (study design, treatment/experiment implementation and data collection/analysis etc). Innovation specific non-experimental observational data may also be used in the post-lab phase. The related econometric analytical methods in the impact evaluation literature are propensity score matching method (PSM), double difference, instrumental variable method, regression discontinuity design and pipeline methods, etc. The qualitative methods of data collection/investigation may also be useful to identify mechanisms through which the selected innovation might be having an impact.

- There will be interactions with different stakeholders and collaboration on iterative re-design of the outcomes. Efforts will be undertaken in collaboration with relevant stakeholders (industry, respective national government) to scale up the adoption of feasible innovation.

Presentation Platforms

To achieve maximum attention and implementation, the outcomes and results of the labs will be delivered and presented in four different platforms:

- Conferences and workshop will serve as a first communication tool, targeting individuals and organizations from the public and private sectors relevant for the implementation of innovations.
- An active online platform will serve as a major communication tool. Developed innovations will be presented and can easily be accessed by experts and the broader public. It will also facilitate the communication between participants of different labs and enhance the exchange about obstacles and successes between different participants.
- A Water Exploratorium/Museum will be established where projects, processes and innovations can be experienced by the public, industry and experts alike. Firstly, traveling exhibitions, which will display innovations and water innovation related topics, will be organized. This level of mobility ensures that a broad public from different places can be reached. Secondly, a museum will be established. Here permanent and changing exhibitions will be organized and it will serve as a place for exchange between scientists and practitioners and thereby enable ongoing development and implementation of water related innovations.
- Handbooks and reports will serve as a platform to present in depth information and provide background knowledge on the need for innovations and the innovation process itself. Here different perspectives from different fields and disciplines can be emphasized and enhance understanding and interaction between them.

SWFP
Sustainable Water Future Programme

Annex 8.4 List of Acronyms

BMBF	Federal Ministry of Education and Research
CCAFS	Climate Change, Agriculture and Food Security
CGIAR	Consultative Group on International Agricultural Research
DFG	Deutsche Forschungsgemeinschaft (German Research Council)
DIVERSITAS	International programme of biodiversity science
ESG	Earth System Governance
ESSP	Earth System Science Partnership
FAO	Food and Agriculture Organization
GEWEX	Global Energy and Water Cycle Experiment
GLP	Global Land Project
GWSP	Global Water System Project (2004-2014)
IGBP	International Geosphere Biosphere Programme
IPBES	International Platform for Biodiversity and Ecosystem Services
IPCC	International Panel on Climate Change
IHDP	International Human Dimensions Programme (of GEC)
IWRM	Integrated Water Resources Management
LOICZ	Land- Ocean Interactions in the Coastal Zone
MDGs	Millennium Development Goals
NGO	Non- governmental organization
PSM	Propensity- Score Matching

RCTs	Randomized Control Experiments
RIMS	Rapid Indicator Mapping System
SDGs	Sustainable Development Goals
SWFP	Sustainable Water Future Programme (SWFP)
UN	United Nations
UN Water	Collaborative mechanism of 28 UN agencies and their global partners on fresh water issues and their respective programmes
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCRP	World Climate Research Programme
W-E-F	Water-Energy-Food (Security Nexus)
WMO HWRP	World Meteorological Organization, Hydrology and Water Resources Programme
WSLN	Water Solutions Lab Network

Sustainable Water Future Programme

Report
No. 1

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