

**Concept note**

International Water Management Institute (IWMI)

August, 2016

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## **GROUNDWATER SOLUTIONS INITIATIVE FOR POLICY AND PRACTICE (GRIPP)**

*A global multi-partner initiative to support and scale up practical solutions for groundwater management for sustainable development and food security*

### **WHY THIS INITIATIVE?**

Because ...

... Progress towards achieving the Sustainable Development Goals (SDGs) and adaptation to climate change hinges on managing groundwater sustainably.

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... Groundwater is a lifeline for communities, especially when rains fall short.

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... Groundwater supports global food security, contributes to public health and is a critical factor in economic growth.

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... Groundwater underpins most terrestrial and aquatic ecosystems, and the products and services they provide.

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... The strategic importance of groundwater is increasingly being acknowledged, most recently at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP) 21 in Paris, France, where groundwater and aquifers were given the highest level of attention and explicitly incorporated into the **Paris Pact on Water and Adaptation to Climate Change**.

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... Realizing the potential of groundwater to build resilient societies, livelihoods and food security requires concerted efforts, increased capacity and efficient partnerships at local to global levels.

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**GRIPP**  
GROUNDWATER SOLUTIONS  
INITIATIVE FOR  
POLICY AND PRACTICE

## THE CHALLENGE

Securing groundwater resources for this and future generations is in our hands. Current approaches are generally not sustainable. With the rapidly growing dependence on groundwater for agriculture and urban populations, a host of management challenges are pending. At the same time, there is a wealth of experience on policies and practices that can help deliver sustainable management. Harnessing, expanding, sharing and scaling up this knowledge in efficient partnerships at multiple scales is key to achieving many of the Sustainable Development Goals (SDGs).

## GRIPP

That is where Groundwater Solutions Initiative for Policy and Practice (GRIPP) comes in. Designed to co-develop solutions to the challenges of groundwater overdraft and water quality degradation, the initiative is targeted at the groundwater-dependent, food-producing areas of the world, particularly in low income and emerging economies, where it will support greater food security. Through dynamic partnerships, it will promote and adapt tested technologies and innovative policy and institutional approaches, in order to achieve the SDGs related to climate resilience, food security, livelihoods and sustainable water management.

## THE GRIPP APPROACH

India is doing it. California is starting to address it. Many other countries are now facing up to their groundwater challenges. India, for instance, is rethinking its policies on supplying subsidized power to farmers, creating a virtuous groundwater-energy nexus to effectively control groundwater over-abstraction while reducing energy footprints. In California, the new Sustainable Groundwater Management Act brings users together for the first time to discuss and decide on sustainable limits and priorities for groundwater use and allocation. The Act also aims to more fully incorporate strategies for conjunctive use and groundwater banking. Morocco has set clear targets and strategies for enhancing groundwater resources, while reducing demands through efficient irrigation technologies. Jordan is reducing its dependence on groundwater through increased import of cereals, while aiming to enforce a ban on the drilling of new wells. Even though there is still a long way to go before achieving sustainable groundwater use, these experiences illustrate that dedicated and concerted efforts are now emerging to support the achievement of sustainable groundwater use and its associated benefits. They are cases that can be adapted and replicated in other countries, especially developing countries, if the supportive and enabling partnerships, high-level buy-in, evidence and resources are made available. In sub-Saharan Africa (SSA), groundwater still has significant potential to relieve poverty through sustainable and equitable development for agriculture – again, provided that genuine commitment, informed partnerships, cross-sectoral collaboration and supportive policies are developed.

## PUTTING GRIPP INTO ACTION

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GRIPP has the committed objective of:

***‘Securing groundwater resources for livelihoods, food security, climate resilience and economic growth while sustaining the resource for future generations in developing countries’***

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GRIPP is a framework program within which the following approaches and activities will be promoted and supported:

### LONG-TERM PARTNERSHIPS

Building on existing initiatives and engaging relevant international institutions, GRIPP will re-enforce and expand country-level partnerships to address groundwater challenges related to agricultural use and its interconnectivity and tradeoffs with other sectors, such as health, energy and the environment. Where countries pledge commitment through dedicated policies and investments, GRIPP will support and further boost these interventions through capacity building, action research, technical support, policy guidance and monitoring. Such partnerships will take an extended approach, building a critical mass and a clear momentum for evidence-based and transparent collaboration from the national to the farm level.

### DOCUMENTED SOLUTIONS

GRIPP will work with existing and new partners to document and synthesize practical lessons learned from policies and practices in groundwater management at national and subnational level. This will be carried out in a framework that enables easy access for decision makers, encourages comparability, and delivers nuanced assessments of trade-offs and trends in the often long-term processes involved in progressing groundwater management.

### SCALING UP

Through adaptation and pilot testing, tested solutions will be transferred and scaled up both in-country and to other countries, based on solid documentation and rigorous assessment of the technical, economic, institutional and political enabling pathways for success. Scaling up will address over-exploitation, water quality degradation and water-related disaster risk reduction, as well as underdevelopment of groundwater resources, where relevant.

### CONTEXT-SPECIFIC RESEARCH FOR DEVELOPMENT

Alongside context-sensitive and applied approaches, GRIPP will engage with academic and other stakeholders at national and international levels to fill knowledge gaps related to groundwater management at various scales. This will support capacity development while developing cross-disciplinary teams and tools, and the improved understanding of the critical practical and policy issues for groundwater management. A list of various dimensions of the solutions space and an initial framing of research questions are given in Annexes 1 and 2, respectively.

## STAGED APPROACH

GRIPP will be demand-driven and respond to requests from countries for support on contemporary groundwater challenges. However, GRIPP will also act as a catalyst for generating attention and enhanced focus on groundwater issues through advocacy and dissemination activities that will build on the evidence, knowledge and partnerships that evolve as part of the ongoing initiative. This approach will also gradually build a portfolio of support for the initiative, demonstrating cost-effectiveness to potential donors.

Initially, GRIPP will focus on a few countries representing different geographic and socioeconomic contexts and groundwater challenges, such as India, Laos, Malawi, Morocco, South Africa, and Tunisia. Through this process, it will build a substantial wealth of scalable knowledge and evidence for further engagement in other countries (Box 1). Ensuring cross-learning and transparent sharing of successful and less-productive approaches will enrich and multiply the impact and outcome of the initiative.

The types of solutions will vary by context, but will feature institutional, social and cultural dimensions, as well as technical and economic dimensions, and will look at both demand and supply side options. GRIPP will bring together the experiences of researchers, policymakers, regulators, utilities, the farming community, development banks, the private sector and nongovernmental organizations (NGOs). It will result in easier access to information and cross-learning, better assessment of the resource and its socioeconomic contexts, and wider involvement of users in designing adaptive regulatory and management systems.

### BOX 1.

#### EXAMPLES OF ONGOING OR PAST ACTIVITIES ASSOCIATED WITH GRIPP BY IWMI AND PARTNERS

**THE JYOTIGRAM INITIATIVE IN GUJARAT, INDIA** – Until the electricity reforms in 1987, Gujarat had one of the highest electricity subsidies in India, causing heavy financial losses in the electricity industry as well as groundwater depletion. The Jyotigram scheme in 2003-2006 proposed the separation of agricultural electricity feeders from non-agricultural ones, hence proving that electricity can be used in some instances to regulate groundwater use. *(For further reference, see Grönwall, 2014 and Shah, 2009).*

**GROUNDWATER FUTURES IN SUB-SAHARAN AFRICA, GROFUTURES** – GroFutures under UPGro is a research consortium with the mission to develop the scientific basis and participatory management processes required to use groundwater sustainably and inclusively for poverty alleviation in eight different countries in Sub-Saharan Africa. The project will set up a Network of African Groundwater Observatories to promote the collection, assimilation and use of groundwater data, enable comparative analyses at multiple scales, and conduct site experiments *(For further reference see <http://grofutures.org/>).*

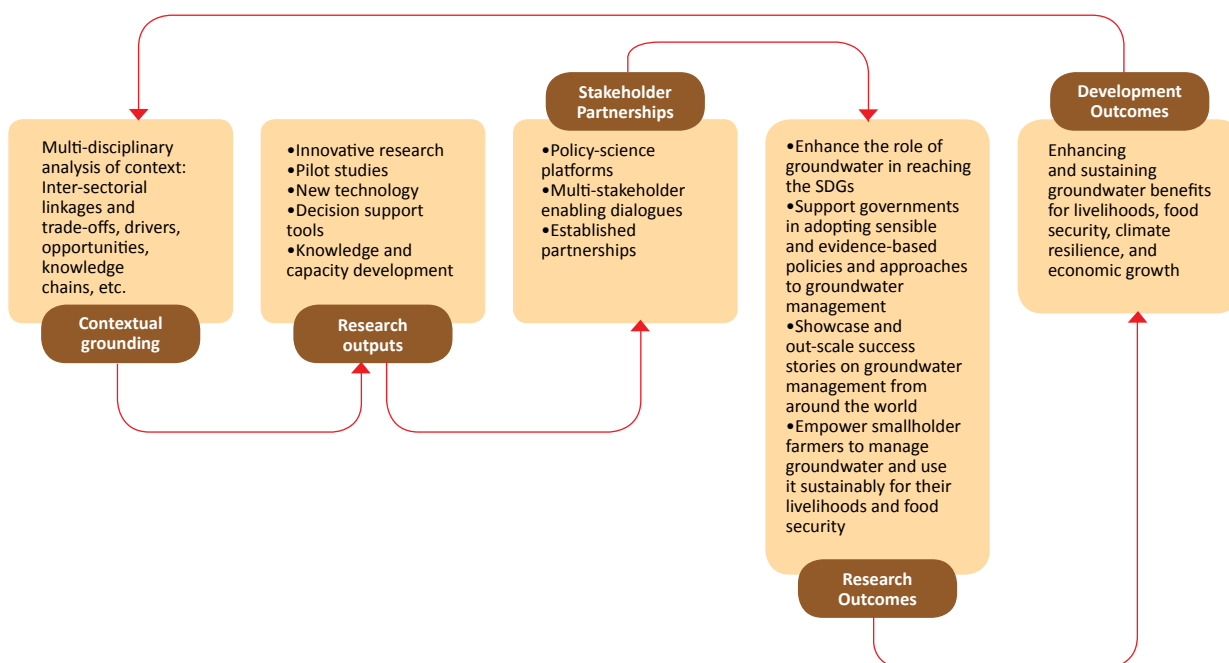
**GROUNDWATER GOVERNANCE IN TUNISIA** – Tunisia's water and food security is heavily dependent on groundwater. As part of a regional project on groundwater governance in the MENA region, a new approach to groundwater management is being tested in the Cap Bon region in Tunisia. The approach fostered the creation of a common platform for dialogue between groundwater users and state agencies in order to mitigate the crisis, by increasing awareness, knowledge sharing, and capacity building aiming to develop a convergent vision for the sustainable management of groundwater. *(For further reference see: <http://gw-mena.iwmi.org/>).*

**GROUNDWATER-BASED AGRARIAN CHANGE IN NORTH CENTRAL PROVINCE, SRI LANKA** – in the North Central Province of Sri Lanka, groundwater is being used to cultivate high value crops due to surface water scarcity during the dry season, creating high economic returns. Research uncovered that informal groundwater management produced sustainable practices, thus illustrating that the climate change resilience potential of groundwater can be combined with poverty alleviation and improved livelihoods. *(For further reference see: Shah et al., 2013).*

## GRIPP'S THEORY OF CHANGE AND IMPACT PATHWAYS

Planning for and achieving GRIPP's long term goal requires the use of a framework and roadmap for change integrating risks as well as program controllable factors and pathways. The theory of change used by GRIPP puts forward the idea that developing and managing groundwater and aquifers in a sustainable and inclusive manner will help securing groundwater resources for livelihoods, food security, environmental integrity, and climate resilience over extended temporal scales. A key assumption is that science, knowledge generation, awareness raising and co-development of groundwater solutions with a view to inform policy and practice in transparent and efficient partnerships are important pathways leading ultimately to sustainable economic growth and poverty reduction. Building on this, GRIPP will monitor its impact via a series of established targets aimed to measure the initiative's outcomes and progress. These targets will be constructed around the dimensions of groundwater resource sustainability, improved livelihoods, strengthened partnerships and capacities, and employment of improved policies, tools, and techniques for sustainable and inclusive management. Recognizing that resource governance decisions often include political economies beyond the influence of GRIPP, the monitoring framework will be used as a learning tool to regularly re-frame GRIPP strategies, thereby ensuring it is adaptive and responsive to evolving external contexts.

Uptake and outcome pathways will include targeted capacity development via dedicated products and dialogue platforms as well as innovative and integrative partnerships with central and local governments, practitioners and decision-makers, research centers, international organizations, NGOs, utilities, user associations, farmers, and the private sector. These multi-stakeholder partnerships are key in facilitating joint research, science-policy dialogues, knowledge sharing, and change processes in policy and practice. With these partnerships, GRIPP attempts to co-develop solutions to groundwater over-abstraction and under-use and to test and scale-up success stories, new technologies, and innovative policy and institutional approaches in order to achieve the SDGs related to climate resilience, food security, livelihoods, and sustainable water management.



## OUTPUTS FROM GRIPP'S INITIAL PHASE

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GRIPP's expected outputs and main activities for its 2-year initial phase include:

- The launch of GRIPP at the World Water Week in Stockholm and other key events in 2016 and 2017
- A series of GRIPP flagship reports and general position documents
- A repository of GRIPP case studies focusing on relevant and tested interventions on groundwater management relevant for policy and practice, showcasing elements for replicability and upscaling, success and failures, and lessons learned
- Help sustain groundwater-dependent ecosystems and their services to people
- Production of a GRIPP website functioning as access hub for GRIPP's knowledge products and integrated news site for ongoing GRIPP activities
- The consolidation and partnership engagement of GRIPP with key institutions and selected focal countries and joint start-up initiatives
- Fundraising to expand and consolidate GRIPP reach and outcomes by building on International Water Management Institute (IWMI) and partners' significant past and current work on groundwater

## GRIPP IN THE LARGER PICTURE

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GRIPP will not work in isolation. It will build on an ever-expanding knowledge base and strong existing partnerships, drawing together technical, management, institutional and social dimensions of solutions. Key initiatives and institutions in this regard include the following:

### GW-MATE

The Groundwater Management Advisory Team (GW-MATE), a World Bank program, has been developing technical briefing notes, and documenting groundwater management cases and challenges around the world (<http://water.worldbank.org/node/83769>). It has also developed guidelines for improved groundwater governance based on a synthesis of global experience (e.g., Foster et al. 2010).

### INTERNATIONAL ASSOCIATION OF HYDROGEOLOGISTS

For more than half a century, the International Association of Hydrogeologists (IAH) has worked actively to build partnerships of professionals and document research-based knowledge around sustainable groundwater management from the local to the global level.

### INTERNATIONAL GROUNDWATER RESOURCES ASSESSMENT CENTRE

The International Groundwater Resources Assessment Centre (IGRAC) under the United Nations Educational, Scientific and Cultural Organization (UNESCO) is systematically mapping, assessing and making publicly available information on groundwater resources at the global level, as well as forging partnerships for better groundwater management. UNESCO also supports the Groundwater Resources Assessment under the Pressures of Humanity and Climate Change (GRAPHIC) project, which focuses on the role of groundwater in climate change adaptation.

## GROUNDWATER GOVERNANCE PROJECT

The '**Groundwater Governance - A Global Framework for Action (2011-2015)**' project was supported by the Global Environment Facility (GEF) and implemented by the Food and Agriculture Organization of the United Nations (FAO) together with UNESCO's International Hydrological Programme (UNESCO-IHP), IAH and the World Bank (<http://www.groundwatergovernance.org/home/en/>). The aim of the project was to raise awareness of the importance of groundwater resources, and identify and promote best practices in its governance. The first phase of the project was built on a series of case studies, thematic papers and five regional consultations. The second phase developed a Global Framework for Action consisting of a set of generic policy and institutional guidelines, recommendations and best practices designed to improve groundwater governance at local, national and transboundary levels, and a call for organizations to act.

## UPGRO

**Unlocking the Potential of Groundwater for the Poor (UPGro)** is a seven-year research program (2013-2020) supported by the UK government (<http://upgro.org/>) and focusing on groundwater in Africa. It uses an approach that integrates social and natural sciences to enable the sustainable use of groundwater for the benefit of the poor (men and women) in SSA. The five UPGro 'Consortium' research projects aim to develop a risk management tool for drinking water security, explore groundwater futures in SSA, assess the role of climate variability on groundwater availability and demand, analyze the social, technical and political issues related to sustainable urban groundwater use, and explore the reasons and remediation for failure of many rural groundwater wells.

## OTHERS

Other initiatives with various geographic or thematic foci include the Rural Water Supply Network (RWSN) (focusing on sustainable water supply for millions of poor rural communities), MetaMeta (focusing on practical interventions for groundwater governance), the African Groundwater Network (AGW-Net) and the Institute for Global Environmental Strategies (IGES) (groundwater management in the Asian region). There are numerous studies, pilot projects and full-scale programs at local, national and regional level that provide insights into groundwater management approaches (e.g., OECD 2015; Megdal et al. 2014; EC 2008; IGES 2007). Also relevant is the ongoing work of IWMI and its partners to better understand what works in groundwater management (WLE 2015; Pavelic et al. 2013a, 2013b; Shah 2009; Mukherji et al. 2009; Giordano and Villholth 2007). Both technical and institutional solutions for the management of groundwater in agriculture in developing countries have been developed and disseminated during the past couple of decades (e.g., IWMI 2010; Shah et al. 2008).

## ADDED ADVANTAGE OF GRIPP

The distinctive benefits and added advantages of GRIPP are as follows:

### THE LONG-TERM HORIZON (10-15 YEARS)

GRIPP takes a long-term perspective. This is critical because any interventions with negative impacts on groundwater can be far-reaching and long-lasting. Avoiding this will require concerted and long-term (often inter-generational) planning, prevention and governance. GRIPP engages in 9 enduring partnerships with national stakeholders to foster informed and tested approaches that are accepted (and hence complied with) by users and society at large. To support resilience, economic growth, livelihoods and food security, GRIPP accepts that there may be difficult trade-offs and works towards productive compromises for sustainable groundwater development.

## INTERDISCIPLINARY AND MULTI-PARTNERSHIP APPROACH

GRIPP works with national partners as well as international initiatives, organizations and donors to create a strong global network and community of practice around groundwater management, building on concrete experiences from both developing and developed countries. It also engages experts and practitioners from various fields and backgrounds to ensure the assessment and consideration of multiple dimensions and integrated and transboundary issues of groundwater management, bringing the science of hydrogeology to bear while addressing groundwater in multi-stakeholder and multi-disciplinary dialogues.

## DOCUMENTATION AND EASY ACCESS TO CASES AND TOOLS

GRIPP will continuously document topical groundwater issues, cases, experiences and tools for the broader community and public good. This is carried out from the outset, drawing on established knowledge and expanding this as the program develops. Documentation will be done in an easily recognizable and consistent format as part of national engagement and monitoring processes, and in partnership with key stakeholders. The documentation will be tailored in such a way that it is directly useful for achieving the SDGs.

## EXPECTED DEVELOPMENT OUTCOMES

GRIPP intends to promote and secure investments, commitments and partnerships that contribute towards significant development outcomes, which include the following:

- Reduce the number of people currently facing unsustainable groundwater use by 10% by 2030; presently, around 200 million (mostly in Northwest India, Pakistan, and the Middle East and North Africa [MENA] region).
- Improve groundwater access for an estimated four million rural households in SSA by 2030, increase the irrigated land area by 600,000 ha and support the raising of USD 1 billion in investments over the period 2022-2030, supporting the adoption of sustainable groundwater irrigation development for better livelihoods, poverty alleviation and food security.
- Large-scale adoption and practical implementation of various managed underground storage solutions for increased water supply, disaster risk reduction, climate adaptation and for offsetting groundwater exploitation by influencing policy change. In parts of South and/or Southeast Asia, by 2022, this may lead to estimated increases in irrigation water supply (around 0.4 billion m<sup>3</sup>/year), gross irrigated area (3 million hectares [Mha]) and agricultural output (USD 8 billion), and also a decrease in the damage caused by floods (USD 1.5 billion) and the number of people affected by it (1.5 million) (Amarasinghe et al. 2015; Pavelic et al. 2015).<sup>10</sup>
- Reducing the carbon footprint of Indian agriculture and bolstering the country's role in mitigating climate change by using solar power for irrigation pumps.<sup>1</sup> By using solar power for extracting groundwater and with the right incentive frameworks to promote sustainability, India's annual carbon dioxide (CO<sub>2</sub>) emissions can be reduced by nearly 8%.
- By 2020, the capacities of 200 key national and river basin managers on technical and non-technical issues related to groundwater management will be developed, building on an increased resource base of options and best practices.



- Creating a knowledge hub on groundwater and food security by 2020 that will influence international negotiations on curbing over-exploitation of groundwater in major food production areas of the world. GRIPP will result in an increased number of countries/states subscribing to sustainable integrated groundwater management through explicit strategies, implemented regulatory measures, action plans, monitoring and evaluation, engagement processes and direct investments.

## INVITATION TO JOIN GRIPP

IWMI believes that achieving the SDGs related to groundwater and integrated water resources management for resilience, food security and livelihoods requires concerted and long-term team building, interdisciplinary research and development, and intelligent communication and dissemination strategies. By creating GRIPP, IWMI seeks to strengthen, expand and bridge present initiatives and partnerships in a fruitful and mutually beneficial collaboration. GRIPP will build on the extensive experience of IWMI in key regions around the world, such as Asia and Africa, and will also broaden its reach through new partnerships.

### Why get involved with GRIPP? To:

... Effectively advance and influence the agenda of sustainable groundwater management at a global scale for SDG achievement.

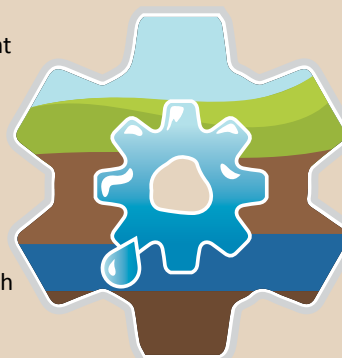
... Support and be part of partnerships with critical mass and sufficient capacity to confront today's groundwater issues for the benefit of future generations.

... Enhance the development and implementation of tested, multi-agent solutions based on best current knowledge, genuine partnerships, and integrated approaches.

... Enhance the synthesis and efficient capture of lessons, and the easy access, dissemination, adaptation and sharing of knowledge.

... Provide a platform for approaching and guiding groundwater research and management more cohesively, context-specifically, and with a longer term vision.

... Enhance the potential to attract funding.







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<http://gripp.iwmi.org>

## CURRENT STRATEGIC PARTNERS

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|--|---|
| <ul style="list-style-type: none"> <li>International Groundwater Resources Assessment Centre (IGRAC)<br/>under the United Nations Educational Scientific and Cultural Organization (UNESCO)<br/><a href="http://www.un-igrac.org">http://www.un-igrac.org</a></li> </ul> |    |
| <ul style="list-style-type: none"> <li>International Association of Hydrogeologists (IAH)<br/><a href="https://iah.org/">https://iah.org/</a></li> </ul>   |    |
| <ul style="list-style-type: none"> <li>CGIAR Research Program on Water, Land and Ecosystems (WLE)<br/><a href="https://wle.cgiar.org">https://wle.cgiar.org</a></li> </ul>   |    |
| <ul style="list-style-type: none"> <li>CGIAR Research Program on Policies, Institutions and Markets (PIM)<br/><a href="https://pim.cgiar.org">https://pim.cgiar.org</a></li> </ul>   |    |
| <ul style="list-style-type: none"> <li>Water for Food Robert B. Daugherty Institute<br/><a href="http://waterforfood.nebraska.edu">http://waterforfood.nebraska.edu</a></li> </ul>   |    |
| <ul style="list-style-type: none"> <li>The World Conservation Union (IUCN)<br/><a href="http://www.iucn.org/">http://www.iucn.org/</a></li> </ul>  |  |
| <ul style="list-style-type: none"> <li>The Nature Conservancy (TNC)<br/><a href="http://www.nature.org/">http://www.nature.org/</a></li> </ul>   |  |
| <ul style="list-style-type: none"> <li>Institute for Global Environmental Strategies (IGES)<br/><a href="http://www.iges.or.jp/en/">http://www.iges.or.jp/en/</a></li> </ul>   |  |
| <ul style="list-style-type: none"> <li>National Ground Water Association (NGWA)<br/><a href="http://www.ngwa.org/">http://www.ngwa.org/</a></li> </ul>   |  |
| <ul style="list-style-type: none"> <li>National Centre for Groundwater Research and Training (NCGRT)<br/><a href="http://www.groundwater.com.au/">http://www.groundwater.com.au/</a></li> </ul>  |  |

## CURRENT IMPLEMENTING PARTNERS

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|---|---|
| <ul style="list-style-type: none"> <li>MetaMeta<br/><a href="http://metameta.nl">http://metameta.nl</a></li> </ul>  |  |
| <ul style="list-style-type: none"> <li>KickStart International<br/><a href="http://kickstart.org">http://kickstart.org</a></li> </ul>                         |  |
| <ul style="list-style-type: none"> <li>Smart Water Metering Inc.<br/><a href="http://smart-water-metering.com">http://smart-water-metering.com</a></li> </ul> |  |
| <ul style="list-style-type: none"> <li>African Groundwater Network<br/><a href="http://www.agw-net.org">http://www.agw-net.org</a></li> </ul>                 |  |

## ANNEX 1

### *Various dimensions of the solutions space – a preliminary set for discussion*

**Groundwater and food security.** As groundwater becomes progressively depleted in critical food-producing areas around the world, understanding the link between groundwater and food security becomes increasingly important. This involves working at various scales to understand the national, regional and global implications, and possible scenarios of, and responses to, decreasing food production due to dwindling groundwater resources. It includes an analysis of actual food production from groundwater as well as virtual water flows associated with trade. Options to enhance sustainable groundwater development, with the untapped potential, for irrigation and food production in SSA and other regions of the world will also be examined. The diversity of roles, and consequences for men and women mean that addressing gender and other disparities is critical in this context.

**Groundwater and sustainable development.** Groundwater underpins a multitude of ecosystems in most parts of the world. Understanding these linkages and using them to enhance the sustainable use of groundwater is critical in the balancing of trade-offs between 'in-stream' (inherent) benefits and 'off-stream' (extractive) values. Payments for ecosystem services (PES) is one such approach that needs better understanding in a groundwater context, but could support more sustainable development. Another angle to this component is the better definition and assessment of the 'environmental groundwater reserve' – an equivalent of environmental flows in rivers. In addition, degradation of water quality (as a result of groundwater contamination) and its impacts on human health, and terrestrial and aquatic ecosystems is becoming critical. GRIPP will support adequate accounting of the role of groundwater in the context of the SDGs, e.g., by developing/ informing appropriate indicators that ensure sustainable groundwater withdrawals alongside other water sources. GRIPP will also advocate for greater emphasis on the often neglected issues of groundwater quality in agriculture, how it is addressed in management and policies, and included in assessments and research.

**Groundwater, water security and climate change adaptation.** Groundwater is central to water security, resilience and drought mitigation around the world. Domestic water supply and potable water sources are often based on groundwater and must not fail. At the same time, aquifers are not only a source of water, but are also a potential space for controlled water storage and retrieval. Aquifers can be the means of conjunctive management of floods and droughts – at basin scale – and for mitigating the risks of both. Harvesting water and storing it underground through managed aquifer recharge (MAR) seeks to utilize excess runoff or other sources of water, such as treated wastewater, more effectively through interventions that facilitate groundwater storage. While MAR has been practiced in different forms for decades, there is still a huge potential for enhancing water security and resilience in many water-deficit or flood-prone areas. Under

progressive climate and demographic change, the use of natural (versus built) infrastructure, such as subsurface storage, will receive even more prominence. GRIPP will seek to raise awareness of the opportunities available by better understanding the complex social, institutional and technical aspects that need to be addressed in any policy solution for approaches such as MAR.<sup>13</sup>

**Groundwater and energy.** Energy is generally needed to extract groundwater. The increasing dependence on groundwater leads to a decrease in its levels, which increases the cost of abstraction. Conversely, in certain less-favored regions, energy access may be a constraint to groundwater development. Energy sources, themselves, are increasingly under scrutiny in an era of the SDGs to promote appropriate and efficient technologies. The issue here is how energy may be used to indirectly influence groundwater use and development, e.g., through incentives, technology development, rationing, pricing or other means. Solar power, as an option of growing importance, is increasingly being used to promote sustainable groundwater use, provided that measures are incorporated to minimize the risk of uncontrolled pumping. There is a direct linkage between water-use efficiency and energy efficiency, and also between water productivity and energy productivity in groundwater use for agricultural systems, which needs to be explored further. In terms of climate mitigation, the relative carbon footprint of groundwater is of increasing significance and needs further study. GRIPP will bring together expertise and experience on these critical issues that are at the heart of the water-energy-food-climate nexus.

**Transboundary aquifers.** Groundwater is geographically crosscutting, and is shared across borders in many places. While the impacts and potential conflicts may be local, issues often need to be addressed at higher international levels to ensure long-term sustainability, cooperation and good relations among states. Cooperating on groundwater development and monitoring across borders, and jointly developing a better understanding of the resources and capacity to manage them will optimize limited financial and human resources, while creating much improved conditions for sustainable development and coordinated management approaches. GRIPP aims to elevate cooperation on groundwater to an international level, focussing on significant transboundary aquifers and the current impetus on international water cooperation as a leverage for investments, and to position groundwater in support of broader water and food security challenges and adaptation to climate change.

**Groundwater governance.** Groundwater governance is integral to, and at the core of, achieving sustainable and equitable management of the resource. Since groundwater is a distributed, invisible source with individual and incremental access, its use is often skewed to those better able to afford or coerce access to it. This is inherently difficult to monitor and control. Furthermore, its general 'common pool' character invites free-riding and un-cooperative behavior by its users. Likewise,

contamination of the resource by pollutants is difficult to identify and track, and has potentially far-reaching and long-term impacts, leaving the liability issue difficult to resolve. The challenge is to incentivize users to prevent hazards, to collaborate and share, and find ways to hold them accountable and interested in management regimes that aim for the best interests of all over the individual, including use of the resource by future generations. The cooperative Groundwater Governance project addressed groundwater governance as one of the key components and prerequisites for sustainable groundwater management (<http://www.groundwatergovernance.org/>). GRIPP will build on the global awareness and synthesis of challenges and framework for action created, and will engage with established and new partnerships to further develop and embed principles of good groundwater governance into sustainable water management efforts in a number of critical areas, showcasing good examples to replicate and learn from elsewhere. 14

## ANNEX 2

### Research questions

#### 1. Knowledge of the resource and its use

- a. What are the most critical changes taking place in groundwater availability (storage, quality and ecosystem interactions) in different regions and countries? How are these being mapped and responded to (if at all)?
- b. How can knowledge and mapping of groundwater resources be better consolidated, shared and used more effectively to inform users and decision makers at different levels?
- c. How is groundwater appropriated and used, and what are the trade-offs between various uses and possible entry points for optimizing the benefit sharing and management across varying agro-ecological and sociopolitical contexts?
- d. How do existing agrarian structures and current trends influence who accesses groundwater and invests in optimizing its productivity while conserving its viability?
- e. What are the roles of historically and culturally embedded identities at farmer, national and other levels, farmer and farming community capacities, and broader national and transboundary political economies in shaping existing groundwater use regimes? What does this analysis suggest about key institutional challenges and entry points?
- f. What are the gendered dimensions of current groundwater access and use? What values do they provide to men and women? How is groundwater use and management perceived by men and women based on possibly differentiated dependencies?

#### 2. Managing and supporting sustainable and equitable use

- a. Can we identify cases from around the world with successful sustainable management? What are the best practices to follow and the worst practices not to follow? What are the enabling conditions that made them work and what are the best methods to out-scale them? In what agro-ecological and sociopolitical context is each practice most likely to be workable and appropriate? What would be the key trade-offs at household, national and intermediate scales (e.g., food security versus aquifer levels; monocrops versus food diversity, etc.)? What are the gendered implications, especially in relation to women's reproductive and productive roles, and women's agency?
- b. Which indirect approaches to control groundwater use can be developed, e.g., through energy control that also enhances energy efficiency?
- c. What are the best solutions for MAR in different contexts, and how can we operationalize better conjunctive use and management of surface water and groundwater?
- d. What types of technologies (e.g., information technology, remote sensing, in-situ sensors, media and mobile phones) can be used/developed in order to improve control, monitoring and regulation of abstraction and quality of groundwater? 15
- e. How can we ensure checks and balances when implementing groundwater development and use, which carries a risk of compromising small users with low institutional and investment capacity?

#### 3. Groundwater futures

- a. At scale, what are the likely impacts of current trends in international trade, and how can (international) trade be used proactively to curb further groundwater depletion?
- b. Can international cooperation on groundwater and transboundary aquifers help elevate the role and importance that is accorded to groundwater management?
- c. Given the risk to their businesses, can the private sector engage meaningfully in sustainable groundwater management? If so, how?
- d. Can PES support more equitable and sustainable use of groundwater?
- e. How can groundwater figure better and more explicitly in integrated strategies for water and food security, disaster risk reduction, livelihood improvement, health and drought resilience?

- f. Can the concept of groundwater footprint and water stewardship be applied and promoted to incentivize rich consumers to reduce reliance on, or use of, groundwater-intensive products?
- g. How can the role of groundwater in climate change adaptation and mitigation be highlighted and better accounted for, e.g., through the implementation of the UNFCCC and associated COP meetings?16

## ANNEX 3

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